

MANUAL OF DAIRY FARMING



W. K. CLARE



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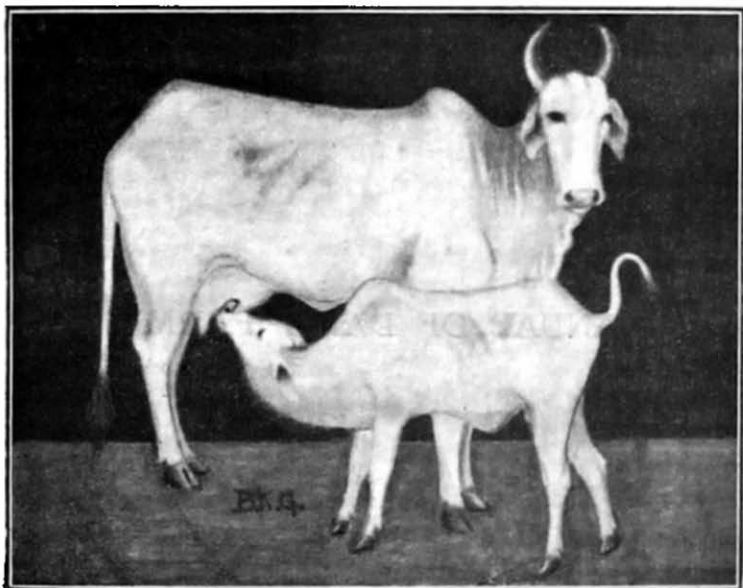
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MANUAL OF DAIRY FARMING

MILK IS VITAL TO NATIONAL HEALTH



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अभि राष्ट्रेण वर्धताम् ।

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MANUAL OF DAIRY FARMING
FOR INDIAN STUDENTS

BY

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LECTURER, AGRICULTURAL COLLEGE, CAWNPORE.
(Retired)

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**IN MEMORY
OF
MY DEAR DAUGHTER
LEELAVATI**

Born 31st October, 1914.

Died 14th September, 1928.

PREFACE TO THE FIRST EDITION

LITERATURE is positively correlated to the collective thought and action of a country and hence it is taken as an index of the progress the country has made in any particular line of work. Dairy literature published in our country is very poor and this fact alone is quite sufficient to show how far our country is lagging behind other nations in the science and art of dairying. Fortunately, however, efforts are being made in several directions to improve the present deplorable condition and to add to the present literature is one of these. The publication of this little book is an humble attempt to give only the rough outlines of such a vast and vitally important subject and it does not aspire to any thing beyond this.

In our country, dairying on modern lines is at present in its infancy and hence this little book may have its own weak points ; but it is hoped that the very defects may give impetus to progress in dairy farming and if fortunately such an impetus be given, my object in publishing this book would be amply fulfilled.

I acknowledge my indebtedness to Professors R. V. Damle and M. G. Phatak of the Agricultural College, Cawnpore, and to S. T. Gadre, Esqr., Industrial Chemist to Government, U. P., for their valuable help and friendly encouragement, without which, the publication of this book would not have been possible.

AGRICULTURAL COLLEGE, }
CAWNPORE, }
10th July 1923. }

AUTHOR.

PREFACE TO THE SECOND EDITION

SINCE the publication of the first edition some progress has been made in the science and practice of Dairying and in this regard the feeding experiments taken up by our Agricultural Departments, the establishment of the Imperial Institute of Dairying and Animal Husbandry at Bangalore and the Central Cattle Bureau are worth noting.

In bringing out this second edition an attempt is made to keep pace with the progress recently made in Dairying in our country by making ample use of the latest available information.

Three new and important chapters on (1) Feeding Experiments, (2) Dairy Bacteriology and (3) Dairy Economics have been added in the present edition and it is hoped that they will not only make up the deficiency in this regard in the first edition, but also be found very useful.

In this added portion, though more technical, the same easy style of expression has been maintained as in other chapters to render the subject matter readable without overtaxing the reader. Sufficient scope and margin, however, will yet be found left for the teacher and professor of the agricultural institutions where the book will be used as a text to elucidate the subject by throwing further illuminating light on it while teaching.

The progress in the science and practice of Dairying so far made in our country is decidedly hopeful, yet it would be found to be much too little if only a glance is given at the vast area that still remains uncovered in the field of Dairy-

ing. It is, therefore, with a deep feeling of constraint that I again repeat the sentiment and hope to which I had given expression in the first edition that the very consciousness of our backwardness in Dairying may itself be helpful in giving a strong and sustained impetus to the desire of accomplishing that progress with rapid strides in the near future.

I have to acknowledge my indebtedness to Dr. Clouston, C.I.E., M.A., D.Sc., Agricultural Adviser to the Government of India, for allowing me to quote the summaries of the Feeding Experiments carried on by our Agricultural Departments and to Mr. William Smith, the Imperial Dairy Expert, for kindly sparing a portion of his valuable time to go through the manuscript and then consenting to write his weighty introduction to this edition of my humble book on the subject which he loves so dearly and in which, concerning India, he is an authority.

I have also to thank him for making some very valuable suggestions regarding the subject matter dealt with in the book and further for putting me under personal obligations by sending me photos of typical Dairy animals.

Many thanks are also due to all the Dairy and Cattle-Farm Managers who were kind enough to send their replies in response to my questionnaire for collecting correct data on Dairying.

POONA:
May, 1928.

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AUTHOR.

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INTRODUCTION

Of late years the thinking public in India have begun to take a live and ever increasing interest in such questions as public health, the raising of the standard of living of the ryot, and the progress of agriculture, and there is no specific question bearing on these subjects so important as the question of the improvement of Indian cattle. The cattle question is of course the milk question, and milk supply is one of the factors which has a very direct bearing on public health. The cattle question also directly affects every phase of agriculture and thereby the prosperity and well being of the cultivator, the real wealth earner in India. The cultivation of every crop depends to some extent on the efficiency of the ryot's working cattle. Then the cattle question in India is one which must be of extraordinary interest to the economist in that India by reason of the sentiments of her people does not, generally speaking, kill and eat her surplus cattle population, and the country is therefore called upon to maintain enormous herds of useless cattle, cattle who by reason of advanced age are unfit to work and to give milk, and cattle which were at no period of their existence good enough to be used either as workers, stud animals or milk producers.

Seeing that India does not rear cattle for the product of beef, she only demands two qualities from her cattle population; *vis.*, draught efficiency from the male and milk yielding capacity from the female. It is now generally admitted that these two qualities can be combined in any of the types required for the varying conditions of different parts of the country, and so the cattle question in India is and must be the dairy question. It naturally follows that

the country needs light and leading on a subject of such universal importance and in this the second edition of his work, Mr. Ghare makes an honest and comprehensive attempt to deal with the situation.

India is a vast country and within its bounds are found numerous types of cattle and many and varied conditions under which they live and work and breed, so much so, that I believe it is impossible for any one living person to write a detailed and accurate account of Indian Dairying as now carried on in every part of the country ; but this book, so far as I am aware, is the only modern publication which attempts to deal with the dairying problem from an all India point of view and for this reason it will meet an ever increasing demand as a text book, and reference work regarding Indian Dairying. While in the main I agree with the conclusions drawn by Mr. Ghare in the work, I do not hold myself responsible for any of his opinions nor for any of the figures, records or results he has compiled. The importance of the subject demands that we shall have reliable dairy literature dealing with Indian Dairying conditions and Mr. Ghare's work is a sound and comprehensive attempt to deal with the subject within the limits imposed by a readable text book and as such I confidently recommend it to the Indian public.

BANGALORE :
December, 1927. }

WILLIAM SMITH,

*Imperial Dairy Expert &
Secretary, Central Bureau
of Animal Husbandry.*

MANUAL OF DAIRY FARMING

PART I

RUDIMENTS OF AGRICULTURE

CHAPTER I

THE SOIL

1. Dairying and Agriculture :—

In dairy farming, proper feeding of cattle is a very important item, because dairy profits are partly balanced by the expenditure on cattle foods ; economy in this respect, therefore, is of material importance. Growing fodder on dairy lands is the first item to be considered in this connection. Fodder can be grown on dairy land merely for the cost of cultivation which amounts nearly to nothing when compared with the high market prices of fodders. Other advantages accruable from this source are (1) that the green fodder supply can be maintained all the year round and consequently full milk yield can be ensured, (2) that any variety of fodder crops or their mixtures can be grown according to the feeding requirements, (3) that the quality and wholesomeness of the fodder will be ensured as the dairy farmer himself would supervise its cultivation, and its subsequent treatment on harvesting to make it ready for feeding, and (4) that all the solid and liquid excreta of dairy cattle can be most profitably utilized by giving them to the

land and thus ensuring heavy fodder yields. Successful crop growing is dependent upon the soil and its treatment and hence the dairy farmer should be acquainted with the rudiments of agriculture.

2. The Soil :—

Soils are formed from rocks by the action of natural weathering agencies. Rain, seasonal and daily variations of temperature, mechanical and chemical action of plants and the activities of lower animal organisms contribute jointly to the disintegration of rocks and the formation of soils. The weathered material of rocks together with the organic matter derived from the remains of plant and animal life makes up the soil. Soil contains (1) inorganic matter in both soluble and insoluble form, (2) organic matter in both soluble and insoluble form and in living and non-living state, (3) moisture, and (4) air. There are two main types of soils (1) Sedentary *i.e.* formed from the underlying rock, and (2) Transported or Alluvial *i.e.* formed by deposition of the weathered rock-material carried away by running water from sloping and water drained regions. Sedentary soil is closely related to, and contains the same minerals as, the rock underlying it. Any slight difference which may be caused, however, will be due to weathering, during which process some of the constituents are rendered soluble and are partly washed away by percolation and overflowing. Thus it will be noticed that the percentage composition of sedentary soil and the underlying rock will not be identical even after making necessary allowance for organic matter which is derived from the remains of plant and animal life. In transported soils on the other hand no such close relation is noticed between the underlying rock and the soil, in mineral contents and the percentage composition. The lower layers of alluvial soil

and the underlying rock of sedentary soil serve as the store of plant food and water.

All soils, whether sedentary or alluvial, contain sand (coarse or fine), clay, lime and organic matter but these are present in varying proportions in different soils. Each of these constituents of the soil possesses distinct properties. Clay is hard when dry and plastic and sticky when wet, while sand behaves very differently. Organic matter can absorb and retain moisture, and hence it affects the retentiveness of the soil. It is, therefore, evident that soils will vary in their physical characters according to the predominance of one or more of these "proximate constituents." Soils are usually classified and named according to their percentage of sand, clay etc. as under :—

1. Sandy Soil	containing over 90 % sand
2. Sandy loam	" 80 to 90 % sand
3. Loam	" 70 to 80 % sand
4. Clay loam	" 30 to 50 % sand
5. Clay	" over 50 % clay
6. <i>Kankari</i> or calcareous	" over 20 % lime
7. Humus Soil	" over 5 % organic matter

All soils contain a very very small amount of soluble matter which roughly amounts to about 0.25 per cent. in ordinary soils. This is an important constituent of the soil because it supplies the plant with ready food material.

3. Some Physical Properties of Soil :—

Porosity of the soil depends on the size of soil particles. It is not the total pore space in one unit volume but it indicates the relative size of the pores. Clay soils contain more total pore-space than sandy soils but the latter are more porous than the former because the pores of sandy

soils are bigger in size. Percolation of water depends on the size of the pores in the soil and hence sandy soils are more easily drained than clay soils. The ease in ploughing depends on porosity and that is why sandy soils are very easy to plough. Moreover the aeration of soil and the free-growth of roots of crops are affected by porosity. The texture, stiffness and stickiness of the soil depend upon the relative proportion of sand, clay and organic matter in the soil. Clay soils have a finer texture and are more stiff and sticky than sandy soils. Organic matter has got the property of modifying these qualities. It moderates the stiffness and stickiness of clay soils and improves the texture and compactness of sandy soils. In preparing a field for sowing, these properties of soil go a long way in determining the amount of labour necessary for ploughing and the proper time for tillage. The relative proportion of sand, clay and organic matter affects the retentiveness of soil. Retentiveness indicates the amount of plant food retained and it depends upon the amount of water which can be held by the soil and its rate of percolation through the soil. Sandy soils are less retentive than clay soils because they contain a very high proportion of sand. Plant food is retained in the soil in two ways viz., (i) mechanically i.e. by cohesion between soil particles and plant food; (ii) chemically i.e. by chemical combination with soil minerals. Surface area of a soil also plays an important part in these processes, and it varies with the size of soil particles. The greater the surface area the greater is the amount of plant food retained in the film of water adhering to the soil particles.

4. Soil Moisture :—

Moisture helps to dissolve plant food and make it easily assimilable by the crop. It also moderates the:

soil temperature, helps chemical changes usually taking place in the soil and helps the growth and activity of soil bacteria. But, there are limits of safety, for the moisture content of soils, which, when exceeded render them either too dry or too wet, both being harmful to cultivation. The chief source of soil moisture is the rain (leaving aside the case of irrigation). Only a fraction of the total rain water is retained by the soil and its underlying material and the rest is lost through percolation, overflowing and evaporation. Percolation of water through the soil mainly depends upon the relative proportion of sand and clay. In clay soils percolation is very slow as the particles are very-very fine and the pore spaces consequently are very small; in sandy soils percolation is very rapid because the pores are comparatively very large. Thus percolation of water to a greater or less extent is responsible for the retention of plant food in soils. Percolation in sandy soils can be moderated by the use of organic and lime manures. Loss of moisture through evaporation takes place all the time except when the atmosphere is thoroughly saturated. If there be any standing crop moisture is lost through transpiration. The rise of water by capillary action is very helpful in the nourishment of crops as the rising moisture brings with it plant food in solution from deeper strata of the soil which are usually beyond the reach of roots of crops. This ascent of moisture is dependent on the relative proportion of sand and clay in the soil; the larger the proportion of clay the greater is the capillarity. Clay soils, therefore, show the greatest capillarity and sandy soils the least. Evaporation accelerates capillary action, because the loss of water by evaporation from the surface is made up by water derived from lower layers of the soil. In saline lands where

the lower layers contain an excessive amount of salts, incrustation of salts on the surface is formed mainly through capillary ascent of water from below and its evaporation from the surface. If there is high capillarity and low percolation, crops on heavy clay soils suffer the most in wet seasons and the least in dry seasons and vice versa in the case of sandy soils. Clay and organic matter have the property of absorbing a certain amount of moisture from the air and this absorption depends on the surface area exposed to air, especially during night time. This explains why in preparing fields for *Rabi* crops, the soil is left ploughed during night and rolled and levelled early in the morning.

5. Soil Aeration :—

This refers to the circulation of air in soil. The texture of the soil is an important factor in soil aeration. Sandy soils are coarser and more porous ; hence these are better aerated than clay soils. Percolation of water also helps in taking air to deeper layers of soil. Soil aeration is very important for the supply of oxygen to the soil, as this element is very essential for all sorts of chemical changes taking place in the soil e. g. weathering of minerals, decomposition of organic matter, nitrification etc. It is also very necessary for the germination of seeds and for the vigorous growth of the roots of crops. Field operations like ploughing, cultivating, harrowing and hoeing, help in aerating the soil. Standing water cuts off air from the soil and thus leads to the bad effects, generally observed on crops in wet lands. In badly drained soils aeration is defective. Roots of plants, holes made by worms, the cracks produced in soil and underground drainage help in soil aeration. Soil air differs from ordinary air in having a high percentage of carbon dioxide. This high percentage of carbon

dioxide is very useful in bringing about chemical changes in soil minerals.

6. Plant Food in the Soil :—

The ultimate elements found in the plant body are Carbon, Oxygen, Nitrogen, Hydrogen, Calcium, Potassium, Magnesium, Iron, Phosphorus, Sulphur and Chlorine ; and these are derived from the media in which the plant grows. The air supplies Carbon and Oxygen principally, while the other medium, viz. the soil, supplies the rest to the crop in the form of soluble salts. We have already seen that the soil material with the exception of organic matter is derived from the rock through the weathering process and only a very small fraction of the soil material is in a soluble condition. This soluble portion of the soil supplies the necessary requirements of the crop because only in a dissolved condition can the plant make use of the food material. We have also seen that the amount of soluble food material retained in soil varies according to the physical properties of the soil, the physical features and the nature of the underlying strata. There are other sources of gain and loss of plant food. The food material is removed partly by cropping, percolation and overflowing, but the soil also gains in available plant food in other ways. (1) It gets from rain water: nitrates, nitrites and ammonia. (2) Clay and humus of the soil absorb ammonia in small quantities directly from the atmosphere. (3) The soil minerals weather and liberate more soluble plant food. (4) Manuring adds more plant food to the soil and restorative crops, like the pulses, enrich the soil with available nitrogen. (5) Nitrifying bacteria work on the organic matter of the soil and form nitrates. Though the soil contains only 0.25 per cent. of soluble matter, as mentioned before, the requirements of the

crops seem to be amply supplied by this amount of food material. It may be noted here that the productive power of soil depends partly upon this small amount of soluble matter and partly upon the insoluble portion which acts as the store of dormant food material. If the soil contains a very large quantity of soluble matter the crops do not thrive in it because the available food material is taken up by the crops in a very dilute solution. Saline soils contain a very high percentage of soluble matter which may also contain harmful salts and thus render the soil practically barren. In saline lands the harmful salts commonly found are carbonates, sulphates and chlorides of potash and soda, the carbonates being the most harmful. Out of the various plant food materials supplied by the soil Nitrogen, Potash, Phosphoric acid and Lime are the most important and hence these are taken into account in the consideration of the plant food material in soil, while others are left out of account as they are present in all soils in sufficient quantity.

7. Nitrification in Soil :—

The organic matter added to the soil becomes useful to the crop only after it undergoes the process of fermentation and decomposition. Proteids cannot be assimilated as such, but must be broken up, so that the nitrogen contained in the proteid material is transformed into an assimilable form and made available to the plant. This transformation is brought about through the agency of Bacteria and the process is known as "Nitrification." The process of nitrification exhibits three distinct stages. In the first stage the organic matter is decomposed by the putrifying bacteria and many bye-products are liberated, the chief of which are CO_2 , CH_4 and NH_3 , and of these the ammonia is

the most important. In the second stage the ammonia is changed into nitrous acid, which in its turn gives nitrites, and hence the bacteria bringing about this change are termed "Nitrous Bacteria." In the third stage the nitrous acid or nitrites are changed into nitric acid or nitrates and the bacteria doing this work are called "Nitric Bacteria." The nitrifying bacteria are present in nearly all soils; but they are active only when conditions are favourable for their proper growth. The presence of moisture, in the right proportion, is required for the growth of these bacteria. If the soil is water logged their activity is decreased because with the soil in that state practically no free air and, therefore, oxygen, which is one of the essential requisites of nitrification, would be accessible to them. If the soil is quite dry, the bacterial activity is stopped, because the bacteria cannot live in the absence of moisture. There is always some moisture in soils which are apparently dry, and under these conditions the soil bacteria remain in a dormant condition. Presence of food material for the bacteria and of Bases for neutralization of the Acids formed by their activity are also necessary conditions of Nitrification. Direct exposure to sunlight has also a retarding influence.

8. Soil Fertility :—

Fertility, or the productive power of a soil, depends upon the following factors: (a) Chemical composition (b) Physical constitution (c) Manuring (d) Field operations (e) Cropping (f) Climate (g) Water supply (h) Labour and Capital.

(a) The chemical composition of the soil has a direct bearing on the amount of plant food in dormant and available conditions. It gives a correct idea of the sufficiency or deficiency of plant food in an available form and indicates whether

the soil contains any harmful material. If the soil is deficient in plant food the deficiency can be made up by manuring etc. If there be excess of soluble salts as in the case of saline lands, these can be removed by overflowing, drainage etc. If there be some harmful salts these can be made less harmful or neutralized by use of chemical reagents to some extent; e. g. Soda Carbonate is changed into Soda Sulphate by using Ammonium Sulphate as manure, sulphate being less harmful than the carbonate; but if Calcium Nitrate is used as manure, soda nitrate is formed which is taken up by the crop as food material. But in bad types of saline lands improvement of soil in this way becomes practically impossible.

(b) Physical constitution of the soil plays a very important part in connection with soil fertility. The relative percentages of sand, clay and organic matter determine the physical properties of soil such as the nature of seed bed, ease in working it, its water-holding capacity, natural drainage, capillarity, stickiness, aeration etc. Soil may contain plant food in an available form and in sufficient quantity too, but may not be sufficiently fertile on account of bad physical properties. In heavy clay and sandy soils some physical properties reach maximum limits and others their minimum; and hence they are rendered soils of an inferior type. Loamy soils are of superior type and more fertile simply because the physical properties reach their most advantageous limit. The physical properties of soil, however, can be moderated by judicious treatment of soil by way of applying suitable manures, by carrying on proper field operation, by improving drainage, by silting and burning it.

(c) Manuring has much to do with soil fertility. Manures help in maintaining or improving the productive power of

soil in three ways; (i) they supply plant food and make up for its deficiency in the soil, (ii) some manures improve the physical condition of soils, and (iii) organic manures help the growth and activity of soil bacteria. The food material supplied in the form of manure is not in all cases in a readily available condition. Nitre is readily soluble and available to the crop and if, therefore, it is not applied at the proper time it is likely to be drained away in deeper layers; hence the improvement in productive power by the application of this manure is restricted to particular seasons and crops. But in the case of cow-dung manure some time is required to liberate plant food in available form because it has to undergo the process of decomposition and nitrification in the soil before the plant food becomes available, and that is why its good effect lasts for two or three years. Further the manure may be a general manure supplying all requirements; or, it may be a special manure supplying special food material. Organic manures like cow-dung manure, night soil etc. are general; and Nitre, Ammonium Sulphate and Bone preparations are special manures. Organic manures, in general, serve to open up soils and render them more freely workable, while sandy soils are made more compact and retentive by their use. Organic manures also help the growth of soil bacteria. Among inorganic manures lime manures improve the physical state of clay and sandy soils. The bacteria require some organic matter to feed upon and their necessity is supplied by the application of organic manures. The humus and the organic matter of the soils act as the best medium for the growth of the bacteria which are so very essential in bringing about the chemical changes in the soil and thus liberating more available plant food.

(d) Field operations like ploughing, harrowing etc. help in improving the fertility of the soil. Ploughing brings lower portions of the soil to the surface so that the weathering of minerals may have its full sway. By ploughing, re-arrangement of soil particles takes place, water holding capacity is increased and preparation of a proper seed bed is made possible. Harrowing and hoeing bring about these changes but their work is restricted only to the upper few inches of the soil. These operations ensure finer texture of the soil and also help in the collecting of weeds and also in conserving moisture. The log of wood or roller used in crushing clods ensures a finer texture of the seed bed and also helps in conserving moisture in the soil. The collective effect of all field operations, when carried out at the proper time, is very marked in improving the soil fertility and that is why their value is equal to that of manuring.

(e) Judicious cropping helps in maintaining the soil fertility. The requirements of different crops are different and hence if the same crop is grown year after year in the same field the soil becomes deficient in that food material which the particular crop requires in excess. This process impairs the fertility of the soil. In order to avoid this bad effect proper rotation of crops has to be followed. Pulse crops enrich the soil in nitrogen and take up more potash while cereals consume nitrogen especially. Thus, in respect of nitrogen, cereals are said to be "exhaustive", and, pulses "restorative". In order, therefore, to maintain the fertility of the soil cereals should be rotated with pulses or they should be grown mixed. The habit of growth of different crops is different. Some send their roots deep into the soil and thus derive a part of their food from deeper layers while in others the root-system is restricted only to upper lay-

ers of soil and hence such crops are surface feeders only. Surface feeding crops should, therefore, be rotated with deep feeding crops. Keeping the field fallow during one or more seasons according to requirements is very helpful in renovating the condition of the soil, as during the resting period weathering of minerals takes place and more available plant food is liberated. Fallowing shows best results if the soil is ploughed several times during the fallow period. Some times growing "catch crops" during fallow period is found beneficial. A catch crop is a crop of secondary importance, which is grown in a field left fallow, in order to "catch" or prevent from waste the fertility of a field instead of keeping it "bare fallow" i. e. without any crop. This is cut and fed to cattle or ploughed back into the field.

(f) Climatic conditions affect soil fertility. If the conditions are unfavourable, the crop yield is decreased, while under favourable conditions from the same land we get heavy yields. Of the climatic conditions, rainfall is the most important in India. In years of regular and well distributed rainfall we get a heavy out-turn from our lands, while when the rains are irregular i.e. in bad years, the crop yield is not sufficient even to pay off the cost of cultivation. Conditions are different, however, in areas which are provided with artificial irrigation facilities. In such areas, bad effects due to scanty and irregular rains are not felt to the same extent as in unirrigated areas.

(g) The importance of water in crop growing is self evident. The soil may have all facilities, other than water supply, in its favour but all these favourable points are of no use in making it productive, water being quite essential. In tracts with irrigation facilities the land gives more crop.

returns per year per acre when compared with those without irrigation facilities. But in some tracts, by introduction of canals, the productive power of soil is lowered after some years because liberal irrigation with canal water for a long and continuous period serves to raise the general water table, which brings up the saline matter stored in lower strata and thus renders the soil saline and less productive. Bad underground drainage also contributes to this effect.

(h) The supply of labour and capital affects the productive power of soil indirectly. Without labour and capital the land cannot be made to produce any thing but natural vegetation. With necessary capital and labour the productive power of soil can be raised.

CHAPTER II

MANURES

9. Manuring :—

We have already seen that manures are very useful in maintaining and improving the productive power of soil. In selecting manures for application we should take into account the nature of the soil to which a manure is to be applied, the nature and requirements of the crop to be sown, previous manurial treatment of the soil and the previous crop taken, the composition and availability of manurial constituents of the manure, the probable effect of the manure

on soil, the nature of season and the prevailing climatic conditions, irrigation facilities and water supply and lastly cost of manure. Nitrogenous manures help the vegetative growth, manures supplying potash help the growth of stem, fibre and roots, while phosphatic manures specially help the growth of fruit and seeds and hasten flowering and fruiting time. If all the plant food requirements are supplied, the crop can better withstand attacks of disease and gives a heavy yield. Most of the common fodder crops belong to N. O. Graminaceæ and Leguminosæ and the special requirements of these crops, i. e. of cereals and pulses, are nitrogen and potash respectively.

10. Cow-dung manure :—

It is chiefly composed of solid and liquid excreta of cattle together with the sweepings and other refuse collected on the farm. The manure is best preserved in a pit because by this method there is a minimum loss of manurial ingredients. The pit should be dug at a distance from the cattle shed so that it may not be too close or too far from the buildings. The sides and bottom of the pit should be made quite hard and compact and impervious as far as possible by covering them with tank clay and then pressing with a wooden rammer. A dam should be prepared round the pit to avoid overflowing with rain water. When the pit is prepared on high level ground the dam is not quite necessary. If possible the pit should be covered with a *Chappar* so that the manure may not be exposed to the sun and rain. The drain of the cattle-shed should open into the pit. This will carry the urine and cattle-shed washings to the pit. There should be a number of pits for storing manure, the size and number varying according to

the number of cattle on the farm. The pit should be filled uniformly and when it is full, the manure should be covered with a layer of earth or a layer of spoiled litter. In hot seasons a small quantity of water should be sprinkled over the manure in order to keep it moist and to lower the temperature. This checks to a certain extent the loss of ammonia in hot season. The manure preserved in this way becomes ready for use in six or seven months. When there is no *pucca* floor for the cattle-shed, a layer of earth, sand or dry leaves or any other suitable material should be spread on the floor in order to collect the cattle urine, and this layer should be scraped off periodically and added to the manure pit. In this way the most-valuable part of manure, the urine, is not lost. The quality of the manure depends upon the method of preservation—manure preserved carelessly and exposed freely to the sun and rain is inferior in quality. The quality of cattle dung manure depends upon the richness of the food given to the cattle. In the case of adult cows nearly 30% of the total nitrogen taken in the form of food appears in dung and nearly 50% appears in urine and this explains why cattle getting rich food also yield rich manure. The quality of manure yielded by young and growing cattle is inferior to that yielded by adults simply because in their case a greater part of the nutriment is digested, assimilated and thus retained as a part of their body. The quality of cow dung manure also depends upon the amount of water and earth present in it. Well decayed manure is dark brown in colour and crumbles easily between fingers without showing any undecayed fibre. The manure should be uniformly distributed over the field and should be ploughed in as soon as possible. Uniform distribution ensures uniform growth of the crop and

early ploughing checks the loss of useful matter from the manure. For fodder crops 10 to 20 cart-loads per acre of cow-dung manure is a good dressing under ordinary conditions. The effect of heavy dressings lasts for 3 or 4 years. The percentage composition of cattle-dung and urine and manure is given below :—

	Water %	Organic matter %	Ash %	N (in Organic M)
Cattle dung air dry ...	20·0	59·0	21·0	0·7
Cattle urine ...	92·0	5·0	3·0	0·8-1·0
Ordinary cattle , d u n g (fresh).	75·0	14·5	10·5	0·27
Well-fed cattle-dung (fresh).	73·5	11·0	15·5	0·35
Dairy cow-dung manure preserved in pit with litter and urine.	36·0	26·0	38·0	0·8
Farmyard manure preserv- ed in a pit.	28·0	21·0	50·0	0·7

11. Sheep and Goat dung manure :—

The droppings of sheep and goats are in the form of small balls and the fibre is far finer when compared with the fibre of cattle-dung. The percentage of water is also less. In permanent folding places the daily droppings should be collected and preserved as cattle-dung manure. In order to collect the urine a bedding of dry leaves should be given and periodically this should be removed and thrown into the manure pit. If leaves and straw cannot be had a layer of ordinary earth would serve the purpose. This is necessary for the preservation of urine. Some times the sheep are folded in the fields themselves during the night time in order

to manure them uniformly. By folding the sheep in the field urine is not lost and there is even distribution of their droppings. The portion of the field thus manured is ploughed as soon as possible and the same process is continued till the whole field is manured. The method is very economic and gives the best results, but it is possible only where large sheep flocks can be had. A flock of about 200 sheep manures one acre in about 8 or 10 days in this way. Sheep and goat dung manure is richer than cattle-dung manure and becomes more readily available. The rest of the properties are the same as those of the farm yard manure.

12. Night soil manures :—

Night soil can be applied to the field in three different ways, (I) fresh (II) as poudrette (III) as sewage. (I) Night soil without any treatment may be applied to sandy soils alone, but if it is applied to clayey soils, it produces bad results because it is not readily decomposed. In some cases fresh night soil is buried in shallow trenches and the field is cultivated in the next season. The effect of such manurial treatment lasts for 4 or 5 years. (II) The manure prepared from night soil by treating it either with ordinary earth or ashes of the town sweepings is called Poudrette. The general properties of poudrette are the same as those of cattle-dung; the only difference is that it is more readily available. It requires a liberal supply of irrigation water and is applied to irrigated crops. (III) In sewage works the diluted night soil is admitted into a reservoir after straining through sieves. The solid portion thus separated is turned into poudrette and the liquid in the reservoir is allowed to pass very slowly through a series

of tanks or through one tank with intervening walls. Anaerobic bacteria do the work of decomposition and dissolve a greater portion of the solid matter. The solid particles settle at the bottom of the tank and there they are decomposed. The liquid coming out of the tank is directly applied to the field as manure. Sometimes the liquid is given Aerobic treatment. In this method several tanks are filled with over-burnt brick pieces. These tanks are alternately filled with the liquid, emptied, and kept exposed to the air in order to gain proper aeration and thus help the growth of aerobic bacteria. After this treatment the liquid is applied to the field as manure. Sewage prepared by anaerobic treatment contains ammonia compounds and the sewage prepared by aerobic treatment contains nitrites and also nitrates in small quantities. Sewage is given to the fields as irrigation water. Fields should not be irrigated with sewage water constantly, but there should be one irrigation with fresh water for every two or three irrigations with sewage. Sewage irrigation is not given to recently germinated seedlings. Sewage irrigation is better suited to all irrigated and heavy feeding crops.

13. Green manure :—

In green manuring, a crop is sown in a field and ploughed in when it is about to flower. The ploughed in crop decays in the field and enriches it. A crop vigorously growing in nature and fleshy in character is chosen as a green manuring crop, generally a crop of the pulse family is used, because such crops have the power of absorbing nitrogen from the atmosphere through the medium of bacterial nodules that are found growing on their roots. If the field is to be

prepared for *rabi*-season crop, the green manuring crop should be sown in *kharif*-season i. e. in June and July. The crop should be ploughed in and sufficient time should be allowed between ploughing the manuring crop and sowing the main crop so that the buried crop may decay properly. A period of 4 to 6 weeks gives best results. The success of green manuring depends chiefly on proper rotting of the crop ploughed in and the weather conditions. A sufficient quantity of moisture in the soil is necessary for the proper decay of the crop. If a longer period passes, denitrification may take place resulting in the deterioration of the manure. Plenty of fresh organic matter in the soil and deficient aeration help denitrification and loss of nitrogen. In green manuring 300 to 500 maunds of the crop are added to the soil per acre.

14. Saline manures :—

Nitre or Potassium nitrate is very useful as manure because it contains potash and nitrogen and is very easily available to crops. Nitre is very soluble in water and hence great precaution is required to be taken in its application. It is readily washed away by overflowing and percolation and for this reason the total quantity of nitre should not be applied all at once but in 2 or 3 lots. In applying nitre it should be well powdered, mixed with double or treble the quantity of ordinary soil, well mixed and then uniformly spread. Potassium nitrate should not be applied to the field before sowing the crop, but when the crop has grown to some extent and when it is in a position to utilize it. It is useful for all crops having a special need for potash and nitrogen. Commercial nitre contains about 90% of pure KNO_3 . It is applied at the rate of three maunds per acre.

Sodium nitrate is very useful for cereal crops especially when there is a deficiency of rainfall; hence it is better suited for *rabi*-crops. The method of application etc. is the same as in the case of nitre.

Ammonium sulphate is useful for cereals as it contains a higher percentage of nitrogen. It is readily soluble in water but it is not washed away easily and for this reason it is better suited for *kharif*-crops. Ammonium sulphate is comparatively more slowly available because it undergoes the process of nitrification in the soil before becoming available. For this reason it should not be applied just when the crop requires it but a little earlier than the actual period of requirement by the crop. The quantity and method of application is the same as that of nitre. It may be applied even before sowing the crop. Ammonium sulphate should not be mixed with lime to prevent the loss of nitrogen.

Gypsum is very useful in supplying lime and bringing about chemical changes in the soil minerals and thus liberating potash. It also improves the physical condition of the soil (especially clay) and hence acts as a direct manure as well as an indirect one. This manure is very useful for leguminous crops such as the pulses. It is also used for improving the condition of saline lands. It is slightly soluble in water and hence it is more readily available. From 5 to 10 maunds per acre of this manure is found to be a suitable dressing.

Potassium sulphate is very useful for its potash and it may be applied even before sowing, as it is retained in the soil and not washed away in drainage. This is better suited for sandy soils. Clay soils naturally contain large quantities of available potash and hence this manure is not suitable for such soils.

CHAPTER III

CULTIVATION

15. Land for fodder and preliminary work:—

As far as possible the soil for growing fodder should be loamy, as heavy clay and sandy soils are not so suitable for the purpose. If the land, intended to be purchased for such a purpose, is virgin or has not been under cultivation for a long period, a general inspection of the whole area should be made. This will enable a rough idea to be formed as to the quality of the soil. The natural vegetation in the area will speak of the fertility of the soil. If the vegetation should be poor, and only few kinds of shrubs and trees and only coarse grass should be found to be sparingly growing and the growth of them in general be poor and stunted, the soil will be classed as of an inferior kind. If, on the other hand, natural vegetation in the area should be luxuriant and of a varied type, the soil will be classed as superior and fertile. In case the area contains *nalas* traversing it or running by its sides, an examination of the sides and bottom of the *nalas* will reveal the nature of the soil, subsoil and lower strata. In the absence of *nalas*, however, trial pits taken in several places, within and on the sides of the area should be examined. Cracks in the soil will point to its clayey nature, while soil lumps easily crumbling into coarse grains will indicate its loamy nature. Irrigation facilities and water supply will be the next important points to be taken note of, as green fodder supply cannot be maintained all the year round without a good water supply and irrigation facilities; and green fodder is an important item in

the feeding of dairy cattle. Canal or river irrigation will be the best arrangement. In the absence of these facilities one will have to depend on rain and wells. The depth of a water-table from the surface of the land is an important point to be considered in digging wells. A depth up to 20 feet is most convenient.

If the land should not be under cultivation, the natural vegetation in it should be cut down, and roots and stumps taken out leaving the portion on the boundary line uncut so that it may form a boundary mark and serve in making a fence. If the land has ups and downs, scouring bunds should be prepared in places for reclamation, and the whole area should as far as possible be levelled. The whole area may be divided into square plots, the size of each plot varying from half an acre to two acres. In laying out the plots, roads or paths and irrigation channels should be provided for. In surveying the whole area a record should be made of the total area, area actually under cultivation, area occupied by roads and channels, area under buildings and area left for grazing. Chemical and physical examination of the soil will be necessary to ascertain its content of plant-food and physical properties. But if this should not be possible actual cultivation tests may be carried out instead. Thus, by growing a mixture of cereals and pulses an idea can be obtained of the deficiency or otherwise of plant-food in the soil. If both the crops should do well and give their normal yields, the soil will be taken as possessing normal fertility and no deficiency. If the cereal crop should be stunted and pale and the pulse-crop comparatively vigorous, a deficiency of nitrogen and a sufficiency of potash will be indicated. Should the crops, though stunted in growth, bear inflorescence at the right time and produce

normal seeds, though small in quantity, sufficient amount of phosphoric acid in the soil will be indicated.

16. Farm buildings, cattle and implements :—

As far as possible the farm buildings should be in the central portion of the estate in order to save time and labour. The most essential farm buildings are : bullock-shed, implement shed, fodder house, store-room and quarters for farm employees. In building bullock-sheds the same precautions should be taken as to convenience and sanitation as in building cow-sheds (Chapter IV). However, we may increase the breadth of the floor and do away with the side foot-path. The implement shed should be spacious and should be open on the sides to allow of implements being taken in or out with ease. The fodder house should be sufficiently large to contain 2 or 3 months' provision of *bhusa* store and to allow space for chaff-cutters and preparation of daily rations. The store-room is required for storing seeds and other miscellaneous stores. Quarters for farm employees are quite necessary for proper working because all the field operations can only then be carried out at the proper time, thus increasing the general efficiency of the farm labour. For every 6 to 8 acres one pair of bullocks is required. The point to be borne in mind regarding farm live stock is that they should have regular and full employment in farm work. Besides the usual agricultural work, the farm bullocks should also be engaged in carting fodder from field to cowshed, carrying cow-dung from cowshed to the manure pits, working the chaff-cutters and bringing concentrated foods and other supplies from the market. The point to be kept in view about the farm cattle is that as far as possible they must not remain idle because in that case the expense of their feeding would be

without any return. Bullocks will have to be purchased at the outset, but the stock can be reimbursed later from dairy herds.

Farm implements should be strong, durable, easy to handle, not complicated and easy to repair locally. As far as possible they should be of the type used in the locality, as these will be better suited to the local conditions. In addition modern and improved implements which can be used to the best advantage in the locality should also be stocked, e. g. soil turning ploughs for deep and ordinary ploughing, harrows or cultivators of two or three types and hoeing implements. Water lifts like *Moht*, chain pump etc. are required if water has to be lifted for irrigation, and if necessary an oil engine for pumping water from deep wells should also be provided. The engine can be used for cutting chaff for daily use or for silage and for crushing grains and oil cakes. A stock should be kept of those parts of implements which are likely to wear away, so that the field work may not suffer. Implements should be kept in good condition by oiling, cleaning and proper handling. The farm should also, if possible, be supplied with a set of tools needed for ordinary repairs and fitting.

17. Preparation of seed bed :—

For preparing a proper seed bed the land is required to be ploughed and harrowed several times. If there be many weeds the soil should be ploughed deep and the weeds buried, but if the weeds are obstinate the land will have to be hand-dug to get rid of them. After ploughing, the clods must be crushed by means of a clod crusher or roller and then the field should be worked with a cultivator or harrow and the weeds and the roots should be collected. Some soils become very hard on drying and the field should,

therefore, in such cases, be irrigated before ploughing in order to soften the soil and enable the plough to be worked at the proper stage, which is easily ascertained by crushing a wet lump of the soil between the hands; if the lump crumbles without adhering to the fingers the field may be taken as ready for ploughing. Sometimes the field is required to be rolled or worked with a log of wood for breaking irrigation bed ridges and stumps of the previous crop in order to facilitate the work of ploughing. In some soils the upper layer becomes hard and in such cases the land is required to be harrowed before ploughing in order to prevent the formation of big hard clods. According to the type of plough, the ploughing may either begin at the circumference and end in the mid portion of a plot or vice versa. If several ploughings are to be given, every second ploughing should go crosswise to the first so that the soil may be thoroughly stirred and no portion of land left unploughed. The corners of the field cannot be ploughed properly in many cases and hence these should be hand-dug with a spade. In the case of a fixed mould board type of plough either a ridge or a furrow is left in the mid-portion of the field according to the method of ploughing, but this will be corrected by opposite ploughing a second time. This is not the case with the other type. Sometimes the ploughing of a field is not done in every season but several harrowings instead are given for preparing the field. The preparation of fields for *kharif* crops begins as soon as the *rabi* crops are harvested and that for *rabi* crops as soon as the *kharif* crops are removed. If *rabi* fields are kept fallow ploughings are to be given whenever the climatic conditions are favourable. If cow-dung manure is to be given it should be applied at the time of preparing the seed bed and it should be uniformly spread and thoroughly

incorporated with the soil by ploughings and harrowings. Uniform distribution of manure will ensure uniform growth of the crop. The boundary dams of the field should not be too high but broad enough for a person to walk on. When all the field operations are properly done and at the right time, a good seed bed will have been prepared. For good germination the seed bed should be loose, friable, well aerated and should have sufficient amount of moisture, all of which conditions should be ensured by the various field operations done in season. No hard and fast rules can be laid down in this connection, but the condition of the field and other circumstances will show what steps should be taken at a particular time.

18. The seed and sowing :—

The seed should be of the best quality and not damaged by insects or in any other way. It is always better to grow one's own seed stock than purchase it from the bazar since the latter may not be of a reliable quality and is apt to be very costly. Bazar seed is often found to be the source of fungus diseases in farms. The seed should not be taken from heaps of grain on the threshing floor but its collection should be made in the field itself from healthy plants showing a good growth and bearing plump seeds. Such select plants should be cut and threshed separately and the seed should be stored carefully so that it does not get damaged in any way. When large quantities of seed are required, diseased plants and rogues should be removed from the field before harvesting. This precaution is necessary to keep the variety pure and to keep plant diseases off. The quantity of seed required for sowing one acre will vary

According to the nature of the crop and size and weight of the seed. If a crop should be sown for fodder the quantity of seed used will be nearly double of that required for a crop for grain. If early germination is desired the seed should be soaked in water and then sown. Sowing of seeds is done in various ways e. g. it is drilled or sown behind the plough, or it is dibbled or sown broad-cast. In some cases the seed is sown in nursery beds and then the seedlings are transplanted in the field. Each method has its own advantages and disadvantages; for instance by drilling much time is saved but the quantity of seed, distribution of seed and the distance from plant to plant cannot be regulated. In the dibbling method uniform distribution, the quantity of seed and the spacing of plants can be regulated, but this requires a lot of time and labour. In the broad-cast method there is least expenditure of time but good and uniform germination cannot be assured. If the seed is very small in size its uniform distribution in the field can be ensured by mixing it up with double or treble its quantity of loose soil. Again there are two more methods of sowing seeds—(1) sowing in flat beds and (2) sowing on ridges. In the drilling, dibbling, transplanting and ridge methods of sowing, interculturing is easy while it is rather difficult in other methods. All sowing operations should be done at the proper time in order to ensure good growth of the crop; too early or too late sowing will produce a low yield. Care should also be taken to put the seeds at the proper depth in the soil, since too deep sowing is liable to affect germination by making the soil above the seed hard and compact and thus impairing proper aeration, while too shallow sowing might

expose the seed so much as to be picked up by birds and not allow enough moisture for germination.

19. Irrigation :—

In dairy farming good irrigation facilities are a necessity in order to maintain the green fodder supply all the year round. Canal irrigation may not provide water just when the crop may be in need of it, but it can certainly afford sufficient water and will make for economy in time and labour and enable large areas to be put under fodder crops. Well-irrigation can provide water at all times, however, at the expense of more time and labour besides restricting the area required to be put under fodder crops. Canal water brings silt and seeds of weeds to the field and the latter sometimes becomes a source of trouble. Some well waters contain salts in solution and if these contain nitre heavy out-turns of crop may be expected. With sewage irrigation heavy crop yields are obtained simply on account of its manurial value. But much circumspection has to be exercised in the application of such manurial irrigation. Sewage should alternate with fresh water irrigation and should not be given to freshly germinated seedlings or to very young crops. The time of preparing irrigation beds varies according to the method of sowing the crop. In the ridge method of sowing, the beds are prepared before sowing the seeds while in the flat bed method irrigation beds are made after sowing the seed but before germination takes place. The head or main water channel should be at the high level side of the field to ensure proper irrigation. We should have the least number of irrigation channels as would be consistent with the nature and size of the field. As to the size of irrigation channels and beds there is no fixed rule but the supply of water, level of the field, and nature of the crop determine it.

Generally speaking for canal irrigation and for large-sized and level plots the irrigation beds should be larger when compared with those meant for well-irrigation and uneven plots. The condition of the soil and the crop shows whether irrigation is required or not and if irrigation can be given whenever required the crop will grow very vigorously. As said before the field is also required to be irrigated in some cases at the time of preparing the seed bed for softening the soil and importing sufficient moisture for germination. The quantity of water given at each irrigation varies according to the nature of the soil, crop and climatic conditions, but it should usually be the equivalent of 1 to 2 or 3 inches of rainfall. The interval between two waterings also varies according to these conditions. Sandy soils are drained very freely and hence they require more water. The interval also is short when compared with clay soils, the latter being more retentive and having low percolation. With a supply of flush water the only labour required is for guiding the water in the fields, but when water has to be lifted suitable water lifts and extra labour are required. Generally speaking for a lift up to 5 feet chain pumps are better and for a lift up to 20 feet *mohit* is convenient for small holdings, while for greater depths and large areas power pumps are more suitable. When the crop is manured liberal irrigations should be given otherwise it is likely to give a low yield. When saline manures, like nitre, are applied irrigation should not be given just after the application, as the soluble salts are likely to be washed away with the percolating water beyond the reach of the roots of the crop.

20. Crop harvesting and threshing :—

Fodder crops that are intended to be fed green to cattle should be cut when they are just in flower because at this

stage the crop contains the maximum amount of nutritive matter, the greatest number of green leaves, the stalks are sufficiently soft and fleshy and also the crop yield is greatest. For making hay or *karbi* the crop may be harvested at "milk stage". But when the crop is to be reserved for seed or grain the stalks should be cut as soon as the ears are harvested on ripening. Crops like wheat, barley, oats etc. are to be harvested when they are ripe, but barley and oats should not be allowed to become dead ripe as many of the grains are dropped while harvesting. The best portion of the day for harvesting is in the morning as then the crop is sufficiently moist for harvesting without loss of seed. Threshing should be begun when the harvested stuff is quite dry so that the stalks may be crushed or broken and the seed may be extracted easily. Threshing should be done in the middle of the day as the stalks become damp early in the morning and late in the evening and hence difficult to crush or break. If the threshing is not finished in one day the half-finished stuff should be heaped up so as to leave the least possible surface exposed to the damp night atmosphere. By using bullocks for the threshing operation fine *bhusa* can be obtained but the operation is prolonged, while if machine threshers are used the resultant *bhusa* is coarse though the work can be finished in comparatively a very short time. The best time for winnowing is the middle part of the day because the wind is then strongest and the operation can be done in a short period. If the wind is very strong winnowing should not be done as a large quantity of *bhusa* is likely to be carried away by the strong current. Winnowing by machine can be done at any time provided the necessary power is available. Rain at the time of harvesting and threshing is very harmful.

21. Arrangement for fodders :—

The area meant for fodder growing should be divided into several convenient blocks which may be cultivated, according to the cropping scheme, with fodder crop. The whole area meant for a particular crop should not be sown at one time but should be divided into 3 or 4 parts and each part sown with the crop at an interval of 10 or 15 days. This arrangement will tend to maintain the green fodder supply for a longer period, and at the same time the first sown plots can be prepared for sowing the next fodder crop. In the case of *kharif* fodder crops the plots should be sown in May, June and July while the early sown plots should be sown with *rabi* fodders in October and November. In this way a continuous supply of green fodder is maintained and too much fodder does not become ready for cutting at one time. For supplementing these *Rabi* and *Kharif* fodder crops, some plots of lucerne and guinea grass should be sown. The surplus of green fodder of *Kharif* season should be put into a silo for preparing silage (See Art. 55) in fair weather in the month of September or October, while the extra *rabi* fodder should be preserved in the silo in the month of February. Wheat *bhusa*, if it has to be purchased, should be bought in the months of May and June and *Karbi* should be bought in the months of October and November, because these are cheapest at those times. Green grass should be cut for making hay in the latter part of September or first part of October. Green *jowar* should be cut for *karbi* making in the month of September or October. Green oats should be cut for hay making just after the flowering, and lucerne should be cut for hay making when it is in full flower. In hay and *Karbi* making, special precautions should be taken not to lose any of the leaves which should, in the further process of drying the

fodder be saved from damage by showers of rain. All fodder should be stored in a safe place so that it does not get damaged in any way. *Bhusa* should be stored in rooms or in stacks and should be protected by means of some cheap sort of *chhappar* from showers of rain. Hay and *karbi* should be stacked on a high level place so that rain water may not damage these. The following calendar and table will be useful in making fodder arrangements.

JANUARY.—*Rabi* crops :—weeding and watering.

Carrots :—harvesting for feeding.

FEBRUARY.—*Rabi* crops :—watering.

Rabi fodder :—silo filling.

MARCH.—*Rabi* fodder :—silo filling.

Rabi crops :—watering and harvesting.

APRIL.—*Rabi* crops :—harvesting and threshing.

Kharif fodder crops :—sowing and watering.

MAY.—*Rabi* crops :—threshing.

Bhusa :—purchasing.

Kharif fodder crops :—watering sowing.

Rabi crop fields :—ploughing.

JUNE.—*Kharif* fodder crop :—sowing, watering, etc.

Bhusa :—purchasing.

Rabi crop :—threshing etc.

Rabi crop fields :—ploughing.

JULY.—*Kharif* fodder crop :—sowing.

Rabi crop fields :—ploughing.

Kharif fodder crop :—cutting for feeding begun.

Guinea grass :—transplanting.

AUGUST.—*Kharif* fodder crops :—weeding, hoeing.

Kharif fodder and grass :—silo filling.

SEPTEMBER.—*Rabi* fodder plots :—prepared for sowing.

Kharif fodder put in silo, grass cut for hay making.

OCTOBER.—*Rabi* fodder :—sowing begun.

Grass :—cut for hay.

Lucerne fields :—prepared for sowing.

Carrots :—sowing.

Kharif fodder crop for seed :—watched.

NOVEMBER.—*Rabi* fodder :—sowing, watering, harrowing and weeding.

DECEMBER.—*Rabi* fodder :—cutting for feeding begun.

Rabi crops :—watering, weeding, hoeing, harrowing.

Karbi purchased.

Sowing, Harvesting and Out-turns of Common Fodders :—

Crop.	Sowing.	Harvesting.	Out-turn.
<i>Jowar</i> ...	May-July	August-October	250-400 Mds.
Maize ...	Year round	Year round	" "
<i>Guari</i> ...	May-July	August-October	150-250 "
Oats ...	October-Nov.	January-March	200-300 "
Barley ...	"	"	" "
Peas ...	"	"	75-100 "
Rape ...	"	"	100-150 "
Carrots ...	September-Oct.	January-Feb.	200-300 "
Guinea grass ...	July-Aug.	Year round	100-250 "
Lucerne ...	October-Nov.	"	250-400 "

PART II

CATTLE MANAGEMENT

CHAPTER IV

HOUSING OF CATTLE

29. Cattle Sheds:—

The chief object in building cowhouses is to protect the cattle from extremes of climatic conditions. Cattle are naturally hardy enough to bear ordinary heat and cold, or showers of rain, hence they do not mind these when they are out for grazing, and do not require special shelter for protecting themselves. But when these conditions go beyond ordinary limits, cattle, especially dairy cattle, require comfortable housing, and this must be given them in order to maintain their health and prevent a reduction of their milk yield. In modern dairying the construction of good sanitary cowsheds is one of the most important items because the health of animals chiefly depends upon the comfort they get and the sanitary conditions under which they are kept. Hence a part of the dairy profit is dependent upon the condition of the cowhouse. To build ideally comfortable, sanitary, convenient and good looking cowhouses is very very expensive indeed; but those who want to do dairying as a business cannot afford to mind a little extra expense to make them so. A little extra expense in that direction at the start, is sure of more than repaying itself in the long run.

23. Site for Cattle Sheds:—

The cowshed should be built on a specially selected site. It should be on high, level ground, and in an airy place. It should not be built in a marshy locality or where water is likely to remain stagnant for a long time. This precaution is necessary to prevent contagious diseases from spreading among the cattle and thence infecting the milk. The cowshed should not be built by the side of thoroughfares, which are a sure source of contagion carried by the passing cattle that are brought from big cattle fairs, and reaching the shed together with the dust blown along by the wind. Away from a high road the cattle get a calm and quiet place to live in. There should be plenty of good water near by. Plenty of water is required in cattlesheds for drinking and for washing cattle and cattlehouse. There should be pasture land near by for grazing. Plenty of grazing ensures economy in the feeding of cattle and it keeps the animals in good condition as they can thus remain in the fresh air for several hours, can run and jump and thus obtain sufficient exercise. From a business standpoint it is better to choose the site for a dairy within a radius of four or five miles from a city in order to have a good market for milk and its products, to get the land, labour and fodder comparatively at a cheaper rate and to facilitate the punctual delivery of products to customers.

24. Types of Cattle Sheds:—

There are two main types of cattlesheds. (1) "single-row" cattlesheds and (2) "double-row" cattlesheds.

In single-row sheds cattle are tied in a single row. This is advantageous when the number of cattle is small, but when the number is large enough double-row cattlesheds are required to be built. In double-row sheds the animals

are tied in two rows. They may be tied "face to face" or "tail to tail," of course varying the relative position of drains, food-troughs etc., according to the arrangement adopted. In the face-to-face method there is a central foot path and on each side of this there are the food-troughs, then space for tying the animals, then drain and then foot-path; while in the "tail-to-tail" method on each side of the central foot-path there is first the drain then space for tying the animals, then food-troughs and last of all footpath again. Each method has its own advantages and disadvantages. In the face-to-face method the distribution of food and fodder and the inspection of food-troughs is most convenient; while in the tail-to-tail method the inspection of drains and floor and the supervision of milking is most convenient. As regards the inside view of the cow-house preference for the one or the other depends on personal opinion.

25. Floor of Cattle Shed :—

The floor of the cattleshed should not be kept *kachcha*. It should be paved either with bricks or with stone slabs. As bricks are always cheaper brick pavement is more convenient under ordinary circumstances but they should be well burnt and hard. A paved floor can be kept quite clean by washing it every day. The washing of the floor ensures good health of the cows and at the same time the urine and other manurial substances are not wasted but they can be taken to the manure pit with the floor washings through the drains. The floors of the cattleshed should be sloping towards the drains. This ensures the proper drainage of urine and cow-shed washings to the drains, through which the liquid is carried to the manure pit thus keeping the floor dry. A slope of 2 to 3 inches for every 10 feet is

quite sufficient for the floor and for drains 2" to 3" in 20' to 40' is quite enough. The pointings of the floor and drains should be done with Portland cement to make them watertight. If the drains are plastered with cement ideal cleanliness can be maintained with comparatively little trouble. On no account should there be *kachcha* drains as they are most insanitary and wasteful. According to local conditions each animal should have a floor space of 4' to 5' by 6' to 8'. This space ensures easy and comfortable standing and lying down for the cows when they are tied in the shed; while the animals do not come too close to each other and are not troubled by their neighbours.

26. Walls and Roof:—

Cowsheds may be built in two ways; one with walls and the other with pillars only. Walled cowsheds are better if there is proper ventilation, as such cowsheds are more comfortable, especially in the cold season. If, however, the cowsheds have only pillars and no walls there will be ideal ventilation in the shed, because the maximum amount of sun-shine and air in the purest possible condition will be available. The floor will remain dry and the drains and the food-troughs can be kept clean, and one can at a glance find out whether the shed has been properly cleaned or not. But it will be necessary to make some arrangement for protecting the animals from hot and cold winds. A simple *purda* or *tatti* arrangement can protect the animals from gusts of wind, and keep the shed warm in winter.

In order to ensure proper ventilation in walled cowsheds, there ought to be at least one window 1' 6" x 3' for every two or three animals. There should be ground ventilators in the walls and there should be a riding roof. The ground ventilators should be 6" x 10" or 12", one for every 3 or 4 animals, and the space between the two roofs

should be about 1'. In the absence of these or similar arrangements it will not be possible to get enough light in the shed or to ensure that the inside air is sufficiently pure. Also the floor may remain damp, and urine and organic matter may decompose and give out bad smells; and it will not be possible to see at once whether or not the shed has been properly cleaned. In European countries an inlet area of 30-40 sq. inches and an outlet area of 40-50 sq. inches per head is recommended for proper ventilation. In walled cow-houses the doors should be at least 5' broad in order to facilitate the coming in or going out of the animals. The best form of roof to the walled cowshed is the riding-roof. The space which is left between the upper and the lower roofs helps in keeping the air of the cowshed quite pure and thus a continuous current of fresh air is maintained. This removes the bad expired air and supplies fresh air instead. In the case of a shed with pillars and no walls a riding-roof is not necessary.

27. Food troughs :—

The food-trough of the cowshed should be built with good bricks and its inside should be plastered and made water tight. Cement is the best material for these purposes as it sets very hard and becomes quite impervious to the passage of water and at the same time the surface can be made quite smooth. There should be a proper slope in the food-troughs. This ensures easy removal of water that is used for cleaning. No sharp corners should be left in the food-troughs but these should be rounded so that we can clean the food-troughs easily and perfectly. The height of the food-troughs should not exceed 2'. If the food-troughs are higher than this the cattle cannot eat their food comfortably. The width of the food-troughs should be 1½' to 2' and the depth 1' to 1½'.

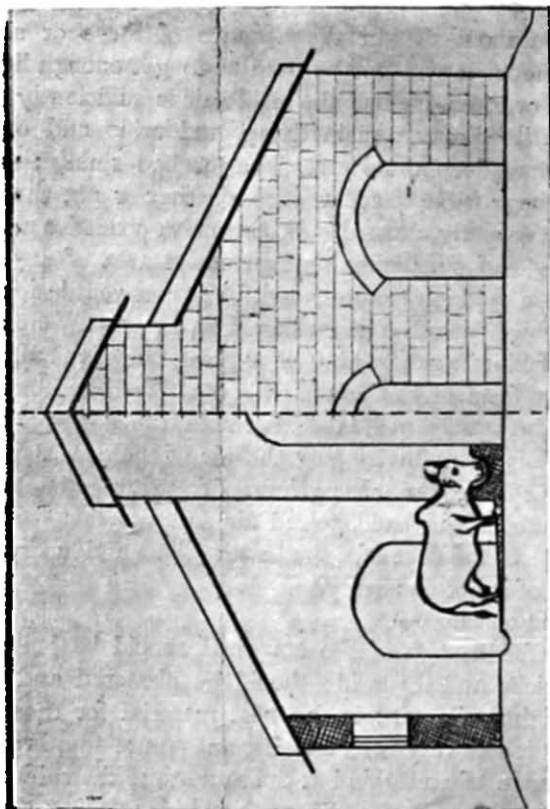


Plate No. 1.—Face-to-face cowshed partly in section.

28. Air-Space :—

In order to keep the animals in sound health there should be about 1000 cubic feet of air space for each animal. This will ensure the purity of air in the shed if there is good ventilation. A young cow respire from 18 to 20 times per minute and at each respiration the air of the cowshed is made more impure. The following table shows the difference between the inspired and expired air :—

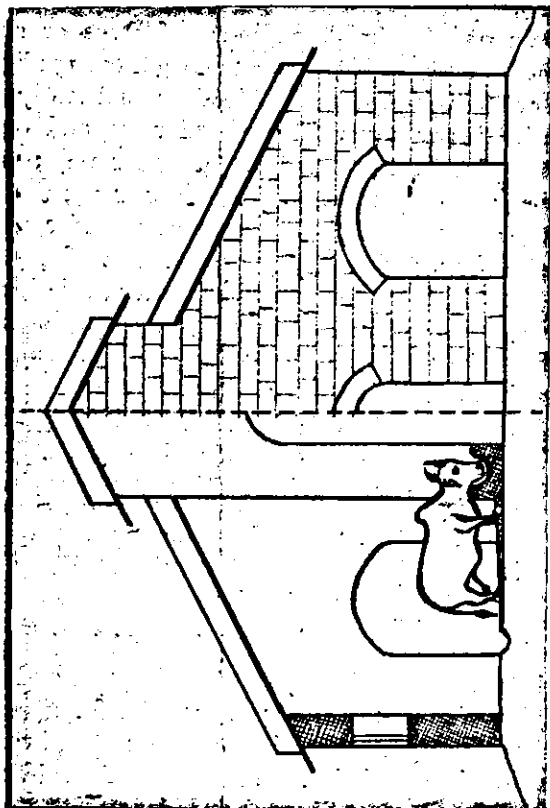


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Air.	Oxygen.	Nitrogen.	CO ₂
Inspired	20·81	79·15	0·04
Expired	16·03	75·55	4·38
Difference	-4·78		+4·34

The table shows clearly how by exhalation air is denuded of its oxygen which is nearly replaced by carbon dioxide. Air is thus rendered poor for purposes of respiration; but it is renovated by diffusion, the excess of CO₂ being reduced by a current of fresh air. In an ordinary room, an atmosphere, in which the proportion of oxygen is reduced while that of carbon dioxide is increased, is said to be contaminated and therefore liable to produce bad effects on the health if it should be inhaled. If air that is taken into the lungs contains less oxygen and a greater quantity of CO₂, as compared with fresh air, the impure blood in the system is not properly purified. This shows clearly why there should be sufficient air-space and proper ventilation in the cattleshed for removing the excess of CO₂ and the bad vapours of the cattleshed by freely inletting volumes of fresh air. The following experiment* is very instructive and shows how much air-space should be given for each animal. A cow weighing 990 lbs. inspired 2782 cubic feet of air in 24 hours, and during that period she consumed 122 cubic feet of oxygen and produced nearly the same of CO₂. This shows that a cow should get about 3000 cubic feet of fresh air in 24 hours. In a double row cow-house each animal will get about 1200 cubic feet

*Smith's Veterinary Physiology.

of air space if the following measurements are adhered to—viz. breadth of path, drain, floor, food-trough, 3, 1½, 7, 3 feet respectively and the mean height of the shed 15 feet and the distance between the tying rings 5 feet. Supposing the air of the cow-house is replaced under ordinary conditions at least three times in 24 hours each animal would get 3600 cubic feet of fresh air to breathe.

29. Other buildings:—

There should be a separate shed for calves. The calves and cows should not be tied in the same shed because the calves are likely to get loose and drink milk and the adults are likely to cause injury to the calves by trampling over them or fighting with them. The same precaution, as regards cleanliness, ventilation etc., should be observed as in the case of cattlesheds. The following measurements are convenient for a calfshed.

Floor space	4' X 3' for each calf.
Feeding trough	12"–14" high, 1' broad inside and 9" deep.
Drain	9" broad.

For very young calves a simple enclosure is best where they should be kept loose and never tied. There should be a separate building for keeping sick animals. It should be far away from the main buildings. The same precautions as above about cleanliness and ventilation should be observed. If the sick cattle are kept in a separate place and quite far away the disease will not spread among the healthy animals and hence the importance of separate sick quarters. Besides these, other buildings and constructions are required in connection with cattle, e. g. : silo, manure pits, water tank, bull house, fodder house, implement shed, store room and quarters for dairy servants. The quantities of building material required for buildings may be worked out from the figures given in Appendix F. See also Art. 180.

CHAPTER V

FEEDING OF CATTLE

30. Feeding :—

Food is a necessity for all living beings, and it is as essential for the body growth of growing animals as it is needed to make up for the wear and tear of those fully-grown. An animal may be compared to a steam engine, doing work which according to the law of nature is impossible without the expenditure of energy—supplied by the fuel in the case of engine and by food in the case of the animal. The nature of the work of cattle is varied. For example, the work of body growth in the case of young calves, the work of milk production of milch cows, the work of the development of the foetus in the case of pregnant cows etc. The work of animals requires food and obviously their efficiency depends on their feeding. Further, as the efficiency of a machine is measured by the ratio between the energy spent and the work done, similarly the efficiency of milch cattle is indicated by the ratio between the food consumed and the milk produced. This efficiency of the cows has much to do with the profits in dairy business and hence the importance of proper feeding. This is all the more reason why the dairy farmer should know the principles underlying the feeding of dairy cows.

31. Foods and Fodders :—

In India it is possible to obtain in plenty a variety of fodders and foods sufficient to supply the demand of cattle doing any kind of work. But their distribution throughout the country is not equal owing to diverse climatic and other conditions and hence every part has its own supply of foods and fodders.

In general the cattle foods and fodders may be classified into two main groups (1) bulky and (2) concentrated. Under bulky foods come green fodders like green grass, *jowar* and maize fodders, lucerne, silage etc. and under dry fodders come *bhusas* of wheat, barley, oats etc. hays, and *karbi* of *jowar*. Under concentrated foods come various oil cakes, grains, *chunis* and *bhusis*. Besides these two main groups we have a third one of "food adjuncts" or "condiments" and under this come such substances like common salt, *gur*, *sonf*, ginger, *huldi* etc. A list of common foods and fodders is given in Appendix A together with their percentage composition.

32. Constituents of foods and fodders :—

The chief constituents of foods and fodders are water, carbohydrates, oils, proteids, woody fibre and mineral matter. These are sometimes called "Proximate Constituents." The relative proportion of these constituents varies according to (1) the kind of food and fodder, (2) the stage of growth at which the fodder is cut, (3) the part of the plant used, and (4) the method of preservation. The proportion of the constituents differs in different foods. Take, for instance, Lucerne and *Jowar Karbi*: Lucerne is rich in proteids, while *Jowar Karbi* is poor in this constituent. The percentage of these constituents varies even in the same fodder according to its stage of growth, for instance, green *Jowar* cut two months after sowing is poorer in proteids and carbohydrates than when it is cut at its flowering stage. Leaves and growing tops contain a larger percentage of proteids than the stalks; grains and seeds are richer in proteids, than any other portion of the plant. Method of preservation also affects the percentage of these constituents as for instance in silage which differs from the

original fodder. In making hay, many of the nutritious leaves are likely to be lost or the stuff may lose some feeding material through exposure to rain. Average percentage composition of some of our Indian foods and fodders is given in Appendix A which will make this point clear. From the feeding standpoint, the proteids, carbohydrates and oils are most important and hence the percentage of these alone is taken into account in judging the quality of the feeding stuff. These feeding constituents have their special functions to perform and each one, therefore, has its own value in feeding.

33. Functions of food constituents :—

OILS and **CARBOHYDRATES** are useful for supplying heat and energy to the animal. They save the albuminoids from oxidation and are used up in supplying fat to the body. One pound of digestible oil supplies 4,220 major calories*. **ALBUMINOIDS** are used up in building the muscles and fat of the body. They also supply proteid matter to the glandular secretions and when necessary they supply heat and energy. One pound of digestible albuminoids or carbohydrates supplies 1,860 major calories of heat; but the

*The unit of heat measurement is called calorie and it represents the amount of heat required to raise the temperature of 1 c. c. of water from 0° to 1° C. In feeding calculations "Major Calorie" is used to show the heat production value of food stuffs.

This "Major Calorie" is equal to the amount of heat required to raise the temperature of one kilogramme of water through one degree centigrade or 1 lb. of water through 4° F. The relative heat and energy values are as under :—

1 gramme of Proteid	} 4.1 Cal (Maj) = 6.3 foot-tons
or 1 " " " Carbohydrates	
1 gramme of Fat or Oil	9.3 " " = 14.3 " "

In British measure 1 oz. of Proteid or Carbohydrates raises the temperature of 113 lbs. of water through 1° F and 1 oz. of fat or oil the temperature of 256 lbs. of water through 1° F.

nourishing value of the albuminoids is regarded as 1.26 or 2.5 times as much as that of the carbohydrates. The feeding value of oil is taken as 2.3 or 2.5 times the value of starch. The MINERAL MATTER of food is used-up in building up the bony structure of the body and also supplies the mineral constituents of the glandular secretions. WOODY FIBRE may be neglected from the standpoint of nourishment; but it has another function and that is the one of increasing the bulk of the food. Cattle will have no satisfaction unless their big capacious stomachs are properly filled up. Colin found 145 lbs. of fodder in the stomach of a cow which is a clear example of the large capacity of cattle stomachs, and why the bulk of food is an important item in cattle feeding. The remaining constituent of food, viz. WATER, which is also taken as a drink, has also many other important functions to perform. It serves to dissolve the soluble portion of food in the process of digestion and thus becomes a medium for its transference into the blood. It maintains the proper fluidity of blood and proper elasticity of cells and tissues. It removes poisonous and harmful substances from the animal body in various ways and further it helps in moderating the body temperature. According to Kellner 46.3% of water appears in the dung and 29.2% and 24.5% is lost in urine, and respiration and perspiration respectively.

34. Digestion of food constituents :—

The digestion of food begins in the mouth when it is mixed with saliva. SALIVA contains the enzyme "Ptyalin" which converts Starch into the form of soluble sugar. When food goes into the stomach, the proteids are acted upon by the GASTRIC JUICE and changed into soluble form. Gastric juice contains the ferment "pepsin" which brings about the change. When the food enters the intestines the

PANCREATIC JUICE and BILE mix with it and digestion is carried on. Pancreatic juice contains 3 or 4 distinct enzymes out of which one (amylase) acts on starch, another (trypsin) acts on proteids and the third (steapsin) acts on the fat and oil. The juice also contains "rennin" which acts on milk and curdles it. Bile emulsifies fats and oils and renders them fit for absorption by the lacteals. Further bile acts as a preservative on account of its antiseptic properties. Thus it will be seen that digestion of starch begins in the mouth through the action of saliva and is continued in the intestines with the farther help of pancreatic juice. Digestion of fats and oils begins in the intestines and is continued there with the help of pancreatic juice and bile. In the large intestines organised ferments, that is bacteria, act on the fibre of the food and partly decompose it. Generally marsh gas and other gases are produced but these are ejected as having no feeding value. Hence woody fibre is not taken into account in connection with the feeding value of food.

Each and every food constituent is never completely digested during the period the food remains in the alimentary canal but some portion always escapes digestion and is thrown out along with the solid excreta. From the digested portion of food constituents its "co-efficient of digestibility" is worked out by feeding experiments. Such experiments have shown that the digestibility of the same constituents varies according to (1) kind of animal, (2) kind of fodder, (3) stage of the growth of fodder, (4) method of preservation and curing, (5) method of preparing food, (6) age of animal, (7) health and condition of animal and (8) in the case of bye-products the effect of various processes on the stuff during the manufacture of the main product. The co-efficients of digestibility are very useful in properly

balancing the rations of cattle and also in purchasing the feeding stuffs. In the first edition of this book it was regretted that the digestion co-efficients for our food stuffs and our cattle were not available. Since then, however, it should be noted with pleasure that our Agricultural Departments have begun feeding experiments the results of which, in course of time, should help us considerably in solving the problem of cattle feeding. In the meantime we have to use the American Digestion Co-efficients in working out the rations. The digestion co-efficients obtained so far from the above-mentioned experiments are as under :—

Bangalore and Lyallpur Experiments.

	Wheat Bhusa.	Rice Straw.	Baled Hay.
Dry Matter	58'44	53'54	50'32
Ether extract	48'09	43'41	39'12
Crude fibre	68'95	70'43	62'72
Protein	39'10	11'17	1'88
N. free extract	57'91	57'71	50'42

35. Comparative feeding values of Food Stuffs :—

The feeding value of a food stuff is worked out from its percentage composition, the digestibility of its constituents and the use of the respective constituents in animal metabolism. In all calculations starch is taken as the standard, and in converting food constituents into starch units* their heat values are taken as the basis of compari-

* Kellner's Starch values are as under :—

1 lb. Dig.	Protein.	Carbo- hydrates.	Fat in bulky food.	Fat in Cereals.	Fat in Oilseeds.
Starch Value...	0'94	Sugar 0'76 Starch 1'00 Fibre 1'02	1'91	2'12	2'41

son, (market values being also taken into account in some cases). The relative feeding values of food-stuffs are worked out by means of :—

- (a) their Albuminoid ratio,
- (b) their Starch value expressed as "Starch equivalents",
- (c) their Heat value expressed as "Major Calories" or "Therms",
- (d) their Potential energy value expressed in "Work units",
- (e) their Food units expressed as "Food units".

These are calculated as follows :—

- (a) Alb. Ratio = $\frac{\text{Dig. Proteid.}}{\text{Dig. Oil} \times 2.3 + \text{Dig. Carbohydrates}}$
- (b) Starch Value = $\text{Dig. Oil} \times 2.3 + \text{Dig. Proteid} + \text{Dig. Carbohydrates.}$
- (c) Heat Value (Major Cal.) = $\text{Starch Value} \times 1860.$
If the quantities are in lbs.
- (d) Potential Energy Value = $\text{Heat Value in Major Calories} \times 1.53 \text{ Foot-tons.}$
- (e) Food Units = $\text{Dig. Oil} \times 2.3 + \text{Dig. Prot.} \times 1.26 + \text{Dig. Carbohydrates.}$
or = $2.5 (\text{Dig. Oil} + \text{Dig. Prot.}) + \text{Dig. Carbohy.}$

The use of these formulae will be made clear by the following examples :—

EXAMPLE I.

To find out the Albuminoid ratio of Grass Hay.

If we refer to Appendix A and B, we find that grass hay contains 4.54% Proteids, a negligible quantity of oil and 46.47% Carbohydrates, and their co-efficients of digestibility are 57.51 and 64 respectively. Then by the rule of three we find that grass hay contains

2.58% Dig. Proteids
and 29.74% Dig. Carbohydrates.

By substituting these values in formula (a) we get
Alb. Ratio of grass hay = Proteids : (Oil \times 2.3 + Carbo.)

$$\begin{aligned} &= 2.58 : 29.74 \\ &= 1 : 11.5 \end{aligned}$$

The albuminoid ratio is termed "Narrow" or "Wide" according as there are less or more than 5 carbohydrate equivalent units for every proteid unit in the ratio respectively. Ratios between $\frac{1}{5}$ and $\frac{1}{3}$ are called "Medium" ratios.

EXAMPLE 2.

To find out the starch value of Lucerne.

Suppose the percentage of digestible Proteid, Oil and Carbohydrates in lucerne is as under :—

Dig. Proteid	Dig. Oil	Dig. Carbohydrates.
2.75	0.34	8.31

Then substituting these in the formula (b) we get starch value per 100 as under :—

$$\begin{aligned} &\text{Starch Value per 100.} \\ &= \text{Oil} \times 2.3 + \text{Proteid} + \text{Carbohydrates} \\ &= 0.34 \times 2.3 + 2.75 + 8.31 \\ &= 11.84. \end{aligned}$$

EXAMPLE 3.

To find out the Heat Value and potential energy value of Lucerne per 100 lbs.

Taking the starch value of Lucerne as per Example 2 and substituting it in the formula (c) we get the heat value as under :—

$$\begin{aligned} &\text{Heat Value of Lucerne per 100 lbs.} \\ &= \text{Starch Value} \times 1860 \text{ Cal. Major.} \\ &= 11.84 \times 1860 \text{ Cal.} \\ &= 22022.40 \text{ Cal. Major.} \end{aligned}$$

and the potential energy value according to formula (d)

$$\begin{aligned} &= \text{Major Calories} \times 1.53 \text{ Foot-tons} \\ &= 22022.4 \times 1.53 \text{ Foot-tons.} \\ &= 33694.27 \text{ Foot-tons.} \end{aligned}$$

In this way we can find out the food units in any food-stuff and the same method is followed in working out the feeding values of any ration as well.

EXAMPLE 4.

To find out the Alb. Ratio of the following Ration:

- 10 seers grass hay
- 5 „ Lucerne
- 1 „ Cotton seed
- 2 „ Wheat bran
- 2 „ Til cake.

Suppose the percentage of digestible constituents is as under in these feeding stuffs :—

Stuff.	% Dig. Protein.	% Dig. Oil.	% Dig. Carbohy.
Grass Hay	2.58	...	29.74
Lucerne	2.75	0.34	8.31
Cotton seed	11.77	16.22	15.57
Wheat Bran	9.28	2.60	43.64
Til Cake... ..	27.50	11.25	16.66

The amount of digestible constituents in the respective quantities of these food stuffs works out as under :—

Stuff.	Dig. Proteid Sr.	Dig. Oil Sr.	Dig. Carbohydrates Sr.
10 seers Grass hay ...	0'258	...	2'974
5 ,, Lucerne ...	0'137	0'017	0'415
1 ,, Cotton Seed ...	0'117	0'162	0'155
2 ,, Wheat bran ...	0'195	0'052	0'872
2 ,, <i>Til</i> Cake ...	0'550	0'225	0'333
The whole ration ...	1'257	0'456	4'749

Then by substituting these quantities of digestible Proteids, Oil and Carbohydrates in the respective formulas we get the feeding values of this ration as under:

Albuminoid Ratio	1 : 4'6	Potential Energy Value	40148'5	Foot-tons.
Starch Value	7'054	Food Units	7'38...	I Formula.
Heat Value	26240'8	" "	9'03...	II "
Cal. Major.				

The market rates of the various foods and fodders may be taken into account to find out the relative cost of food units or starch equivalent units for the sake of comparison. In England the "Unit values" are calculated according to the following formula :—

$$\text{Unit Value} = \frac{\text{Price per ton of the stuff}}{\text{Food units per 100}}$$

36. Balanced Ration :—

When the different feeding stuffs forming a ration are well-proportioned with reference to the flesh-forming

and heat-producing constituents according to the requirements of an animal, the ration is called a "balanced ration". The work of each individual is different and so the food requirements with reference to the flesh-formers and heat-producers will be different—e. g. the young calf is to grow in body, a pregnant cow has to build up the body of the young one in the womb, a milking cow has to give milk every day, a bullock has to plough or to drag a cart etc. In all these cases the nature of the work is different and so their food requirements are also different. The object of balancing or properly proportioning the food constituents is that the valuable constituents should not be wasted but should be utilized fully in the animal body, and there should be no under-feeding. From this it will be seen that the balanced ration is that ration whose nourishing value has been determined with reference to the requirements of the animals. The ration given to an animal at rest is called the "maintenance ration" since it is expected to keep the animal in health without any increase or decrease in its body weight. In feeding dairy cattle the ration should be prepared first for the maintenance according to the body weight, and then adding concentrated food as special ration according to the milk yield. According to Armsby a cow should get for every 1000 lbs. body weight 0.5 lbs. of digestible proteids and 6.0 therms energy for maintenance and for every lb. of milk 0.05 lbs. digestible proteids and 0.3 therms energy. Kellner's figures differ slightly from these. He suggests that for a dairy cow weighing 1000 lbs. there should be for maintenance 0.75 lbs. digestible proteids and 6.0 lbs. digestible carbohydrate equivalents and for every pound of milk 0.056 to 0.067 lbs. proteids and 0.24 to 0.27 lbs. of carbohydrate equivalents. His feeding standards are

commonly used and hence they are given below. (For other standards see Appendix C.)

FEEDING STANDARDS (KELLNER)

For 1000 lbs. live Weight.	Dry matter lbs.	lbs. Digestible.		
		Proteid.	Fat or Oil.	Carbohydrates.
Full grown at rest ...	15-21	0·7	0·1	7·5-9·5
Light Work	20-25	1·3	0·3	10·6
Medium Work	22-28	1·7	0·5	12·2
Heavy Work	25-30	2·2	0·8	14·2
Cow giving milk 10 lbs.	22-27	1·2-1·6	0·3	9·8-10·2
" 20 ..	25-29	1·9-2·3	0·5	11·5-12·8
" 30 ..	27-33	2·6-3·0	0·6	12·9-14·7
" 40 ..	27-34	3·3-3·8	0·8	13·9-15·3
Calf 2-3 months 150 lbs.	23	3·7	2·0	13·0
3-6 .. 300 ..	24	3·1	1·0	13·0
6-12 .. 500 ..	26	2·6	0·6	12·7
12-18 .. 700 ..	26	2·2	0·4	12·4
18-24 .. 900 ..	26	1·6	0·3	12·0

The figures mentioned above are applicable to Western countries and cannot be applied wholly in preparing rations for our Indian cattle as the breeds, climatic conditions and foods and fodders differ so very widely. Bangalore feeding experiments go to show that in computing rations Armsby's standard of 6 Therms energy for maintenance per 1000 lb. body weight

ensures the closest agreement with the actual requirements of our cattle. For milk production American digestion co-efficients may be used provided that the total nutrients are computed according to Haecker's standard, and that a liberal amount of protein is allowed in the ration.

Comparing Indian rations with those of other countries we find that the ratio of concentrated food to milk yield is wide in the case of American and English rations and very narrow in the case of Indian rations. This will be evident from the following :—

(1) American ration for a cow giving 40 lbs. of Milk.

Corn Silage	15 lbs.	} 30 lbs. roughage total.
Alfalfa hay	15 "	
Corn meal	3.5 lbs.	} 12 lbs. concentrated total.
Bran	3.5 "	
Oats	3.5 "	
Oil meal	1.5 "	

Ratio :—Milk : Con. Food :: 3.3 : 1

(2) Bombay bulletin No. 31 (1908)

For a cow giving 15 to 20 lbs. of milk.

Hay	20 lbs.	
or Green Fodder	50 lbs.	
Bran	4 lbs.	} 14 lbs. concentrated total.
Chuni	2 "	
Cotton Seed	4 "	
Oil Cake	4 "	

Ratio :—Milk : Con. Food :: 1.4 : 1

(3) Military Dairy, Cawnpore.

For a cow giving 13 lbs. of Milk.

Silage	35 lbs.	} 45 lbs. Bulky food total.
Bhusa	10 "	
Mustard Cake	1.5 "	} 12.5 lbs. conc. food total.
Linseed Cake	2 "	
Arhar Bhusi	8 "	
Bran	1 "	

Ratio :—Milk : Con. Food :: 1'04 : 1

- (4) Ration for a buffalo giving 18 lbs. of milk.
(J. Mollison Agr. Ledg. No. 6, 1895.)

Dry Fodder 18-20 lbs.

Cotton seed	4 lbs.	} 14 lbs. concentrated food.
Bran	4 "	
Oil Cake	3 "	
<i>Bhusi</i>	3 "	

Ratio :—Milk : Con. Food :: 1'3 : 1

- (5) For 20 lbs. of milk (Military Dairy, Kirkee.)

Hay 35 lbs.

Cotton seed meal	2 "	} 12 lbs. total concentrated food.
Cotton	6 "	
Groundnut Cake	2 "	
<i>Chuni</i>	2 "	

Ratio :—Milk : Con. Food :: 1'6 : 1

We can prepare a balanced ration for a cow yielding a given amount of milk. Let us take the ration as in article 35, Ex. 4 and see whether it is suitable for a cow weighing 700 lbs. and giving 16 lbs. of milk daily. The ration will be arrived at as under :—

Food Stuff	Quantity seers.	Containing seers of		
		D. Prot.	D. Oil.	D. Carbohy.
Grass Hay ...	10	0'258	...	2'974
Lucerne ...	5	0'137	0'017	0'415
Cotton seed ...	1	0'117	0'162	0'155
Wheat Bran ...	2	0'195	0'052	0'872
Oil Cake ...	2	0'550	0'225	0'333
TOTAL SEERS ...		1'257	0'456	4'749

The above table thus prescribes 1·257 *seers* or 2·51 lbs. of Proteids and $0·456 \times 2·3 + 4·749 = 5·79$ *seers* or 11·58 lbs. of Carbohydrate equivalents.

According to Kellner's mean figures, the cow should get :—

	<i>D. Prot.</i>	<i>D. Carbohy.</i>
For maintenance	0·49 lbs.	6·10 lbs.
and for 16 lbs. milk	0·97 „	4·00 „
That is the cow should get in all.....	1·46 lbs.	10·10 lbs.
But the ration worked out above allows.....	2·51 lbs.	11·58 lbs.

If one *seer* of Maize be substituted for the two *seers* of *Til* Cake the ration would contain 0·776 *seers* or 1·552 lbs. of proteids and 5·723 *seers* or 11·44 lbs. of Carbohydrate equivalents. The slight difference from the standard calculated by Kellner's figures may be neglected in practice.

In the absence of digestibility figures calculated separately for Indian foods and Indian cattle, Kellner's figures may be used in working out rations. For practical purposes, however, cows or buffaloes may have for maintenance : 8 to 12 *seers* of dry fodder or its equivalent of green fodder according to the body weight, or, for 100 lbs. body weight 4-5 lbs. green fodder or 2-3 lbs. dry fodder, and as a special ration for milk, the concentrated food should be nearly two thirds the quantity of milk. Nearly half of the concentrated food should be made up of highly concentrated foods like Oil Cakes, *Chuni* etc. taken together and the other half of comparatively less concentrated foods like *bhusi* of *Tur*, gram, *urd* etc. It should be noted that the feeding value of a ration is changed by substitution of one stuff for another or by changing their relative quantities in the mixture.

37. Concentrated Foods :—

Concentrated foods contain a far greater quantity of nourishing matter bulk for bulk than the bulky fodders, and are at the same time dearer. These foods should therefore be used with the utmost economy. If too much concentrated food is given it may either be wasted or may produce some stomach complaint. The quantity of food, as seen before, should vary according to the milk yield of the cows or the work done by the bullocks, and their body weights. The concentrated food should be given in the proper form. Care should be taken that no injurious substances like pins, nails or pieces of glass get into the food. All seeds and grains etc. should be crushed, soaked in water and then given to the cattle, or they may be boiled first. All concentrated foods should be mixed with *bhusa* or *jowar* cuttings before being given to the cattle. Concentrated food should not be bought and stored in large quantities specially oil cakes, *chunies* and *bhusies*, because such substances are spoiled by storing, becoming mouldy or being eaten by insects. Monthly requirements only may be bought at a time. Market values of concentrated foods vary from time to time ; the market rate and the richness of the stuff should determine what should be bought for cattle feeding. Bulls and bullocks should be given grain, oil cake, and bran ; milking cows should be given oil cakes, *chunies*, *bhusies*, bran, flour of barley or gram, and milking buffaloes cotton seed in addition.

38. Jowar :—

Jowar is a very important fodder crop. It is given in the green as well as in the dry condition. *Jowar* crop sown for grain yields coarse fodder as the stalks are, in such cases, very thick and woody, but when it is sown for fodder

generally a high seed rate is given and hence it gives fodder of good quality as the stalks are comparatively thin and soft. When it is cut while in flower it gives the maximum nutriment. In feeding green *jowar* one point has to be specially noted and that is, that it sometimes becomes fatal to the animal under certain conditions. The very young *jowar* plant that is sown in early summer should not be given to cattle, particularly after long intervals of dry and cloudy days, because in such cases it contains a comparatively high proportion of glucocides which ferment in the stomach of the animal and give rise to hydrocyanic acid gas which proves fatal when the *jowar* is eaten in excess. (Four or five grains of this acid are enough to kill a bullock.) So in the case of *jowar* sown early in summer it is safe to feed it after two or three showers of monsoon rains. *Jowar* crops are sometimes affected by the stem borer and this lowers its feeding value, the soft pith of the stem being all eaten away by the insect. In some places *Jowar* stalks are left standing in the field after the removal of ears for protecting the mixture crop of *Arhar*, but their feeding value is decreased in this manner. Good *Jowar Karbi* has thin stalks with many pale yellowish coloured leaves without any red spots and it is not damaged by insects. *Jowar* seed is sometimes given also to cattle as food but large quantities of it are said to produce mange.

39. Maize :—

Maize is sometimes grown for supplying green fodder and when it is cut in the milk stage, it makes good nutritious fodder. But maize *karbi* after the ripening and removal of cobs makes very inferior fodder. Maize gives as heavy a fodder yield as *jowar* and it has two important points in its favour when compared with *jowar*, viz. (1) that it can be grown any time in the year and (2) that it can be fed

safely at any stage of its growth while such is not the case with *jowar*. Good silage of maize can also be made. Maize grain is a good nutritive food and is given in either a crushed or ground condition. It is very useful for widening the albuminoid ratio of a ration without increasing its bulk proportionately and thus saving the proteids of the ration for their special use in animal economy. Maize grain is specially suitable for working cattle.

40. **Bajra :—**

Bajra karbi is an inferior fodder when compared with wheat and barley *bhusa* or *jowar karbi* and hence it is given to cattle only in times of scarcity. But the hot mash prepared by boiling the crushed grain, to which some *gur* and other condiments are added, is very beneficial to milch cattle after calving. *Bajra* grain mash is specially suitable for buffalo in the winter season.

41. **Rice Straw :—**

Rice straw has a low feeding value when compared with other cereal fodders and hence only in times of scarcity is it used as fodder. The poor quality of cattle on rice growing tracts is a sufficient proof of the low feeding value. Rice straw is said to decrease the yield of milk. In Bangalore feeding experiments, the physiological effect produced by rice straw was Diuresis. The excessive urination was reduced to normal when the rice straw eating animals were given hay rations. It was also noted that the diuresis was due to the high potash content of the straw.

42. **Guinea Grass :—**

Guinea grass is useful for supplementing the green fodder supply and in feeding value it resembles cereal green fodders. There is one point in its favour i. e. it can be planted in shady places and along water channels and

when once planted it does well in the same plot for several years provided it gets proper treatment.

43. Oat and Barley Green Fodders :—

Oat and barley are important *rabi* green fodders. In feeding value these are nearly equal to green *jowar* fodder and their feeding value is much increased when these crops are grown mixed with peas. These crops can be put into silo and a good silage obtained. On good tillering property we get heavy out-turns per acre. Sometimes rape and mustard are also mixed with the crop at the time of sowing. Sometimes wheat fodder is also given to cattle but this crop is more important for the grain and hence when there is much vegetative growth when young, the crop is partially topped and given to cattle.

44. Bhusa of oats, wheat and barley :—

Bhusa of wheat and barley is largely used as bulky fodder for cattle, while oat *bhusa* cannot be had everywhere as this crop is not grown generally by cultivators. Wheat and barley crops are staple food crops and often these are grown mixed with pulse crops, gram and peas, and hence the mixed *bhusa* thus obtained is more nutritive than the *bhusa* of the single crop of wheat and barley. *Bhusa* of good quality is fine, with well-crushed small pieces of straw and with only a negligible quantity of dust. The inferior quality has big pieces of stalks and an appreciable amount of dust. When *bhusa* is damaged by water it is dirty yellowish in colour. The quality of *bhusa* depends partly upon the care taken in its storing and preservation. If stored in a damp place or where it can be damaged by white ants its quality is lowered. *Bhusa* as sole bulky fodder is suitable for working and draught cattle but milking cattle should

get green fleshy fodder in addition to *bhusa* for maintaining the full milk yield.

45. Grass Hay :—

The quality of grass hay depends upon the quality of grass from which it is made, the stage of growth at which it is cut for hay-making and the care taken in its preservation and storage. Hay prepared from coarse grass is inferior to that prepared from good grass. Hay prepared from grass that is just flowering is of better quality. In hay-making care should be taken not to expose it to showers of rain and also not to lose any leaves as their loss lowers its feeding value. After drying, the stuff should be stored properly so that it cannot be damaged by rain. Coarse grass hay should be cut into chaff before feeding so that it may not be wasted. This is not necessary in the case of fine hay. Grass hay is preferably given to horses than to cattle.

46. Lucerne and Clovers :—

Lucerne is most nutritive among bulky green fodders and hence it is to be used economically. It should not be given in large quantities at a time; five *seers* per head per day is a good allowance. Fresh lucerne should not be given to milking animals as it tends to impart a peculiar flavour to milk. The best method is to feed the lot cut in the evening with the morning ration and that cut in the morning with the evening ration. In preparing hay of lucerne, care should be taken not to lose any leaves. The best plan is to store it when partially dried because the leaves are very easily dropped in handling it when it is fully dried. We should always have some area under lucerne for supplementing the green fodder supply all the year round and to add to the nutritive value of bulky fodders.

Large quantities of lucerne should not be given as this is likely to produce stomach complaints. The proper stage for cutting the crop for feeding is the flowering stage, as at this stage we get the most nutrition and the greatest out-turn. In general properties clovers resemble lucerne, the only difference being that these crops are required to be sown afresh every *rabi* season while lucerne crops can be kept in the same field for several years provided proper cultivation and treatment is given.

47. Carrots :—

Carrots are very useful for supplementing the green fodder of the *rabi* season. These are fleshy and rich in carbohydrates and hence they have a tendency to maintain the milk yield of milch cattle. They are also very useful in making the ration more palatable. Out-turn per acre is also very heavy and hence it is a profitable crop. Five *seers* of carrots is a good allowance per head per day. Before feeding these should be properly chopped so that they can mix well with other ingredients of the ration.

48. Pulse Crop Fodders :—

Under this group come the green fodders of *kulthi*, *urd*, *mung*, *wal*, *chavali*, pea etc. All these fodders are very nutritive and hence they should be given to cattle along with other bulky fodders. Roughly speaking green pulse fodders should not exceed one third of the total bulky fodder in a ration and if large quantities are given they are likely to produce stomach troubles. It is a good plan to grow pulse crops with cereal fodders as a mixture and the mixed crop then cut and fed to the cattle. Such a mixture is more nutritive than the sole fodder of a cereal as the pulse crops are rich in proteids. *Bhusa* of pulse crops is very palatable and very nutritive when compared to *bhusas*

or stalks of cereal crops. It is more costly and cannot be had in large quantities. When mixed with the chaff or *bhusa* of cereals it makes a good nutritive mixture. When fed alone it is likely to produce stomach derangement.

49. Pulse seeds and their Bye-Products :—

Pulses are very rich in food nutritions but being more valuable as human food they are very costly for cattle feeding, and hence these must be used with the utmost economy. They should be given after crushing and steeping or boiling in water to avoid waste in feeding. In preparing *dal* from pulses, *chuni* and *bhusi* or *phol* are got as bye-products and these are usually given to cattle as food. Of these the tough covering of pulse-seed is *bhusi* or *phol*, and *chuni* contains small broken pieces of *dal* together with the broken embryo and some portion of the husk ; this is why *chuni* is more nutritive and nearly equal to the pulse seed in feeding value. If these bye-products can be had in a pure condition they will be useful in supplementing concentrated foods, but the quality of bazar *chuni* and *bhusi* is very low sometimes on account of the dust and insect life found in them. Sometimes the quantity of dust is as much as to prohibit the use of the article as cattle food. It is not impossible that injurious substances like nails, pieces of stone or other sharp-edged substances may get mixed with the *chuni* and *bhusi* if they are stored carelessly. A careful scrutiny should, therefore, be made when purchasing these articles from the bazar, since in shops no particular care seems to be taken in the storage of such articles. Pulse seeds or *chunies* are very useful in narrowing the albuminoid ratio of the ration and thus making it more rich. *Chunies* and *bhusies* have a tendency to maintain the flow of milk and

these are preferably given to milch cattle. *Bhusi* is useful in increasing the bulk of concentrated food.

50. Cotton Seed :—

Cotton seed is given to cattle after either crushing, or soaking, or boiling in water, but it should have as little fibre as possible. Cotton seed cakes in the market can be had in two qualities, undecorticated and decorticated. Decorticated cake is more nutritive as the hard covering (hulls) of the seed is removed before pressing for oil. Cotton seed hulls also have some feeding value and these may therefore be given to cattle. Cotton seed and its by-products have the property of increasing the hardness of butter fat, which is why the milk of cattle on cotton growing tracts like Khandesh and Dharwar is of superior quality so far as the quantity and quality of *Ghee* is concerned. Cotton seed and its by-products can be fed to any cattle, but these are specially suitable for buffaloes whose milk is generally used for butter and *Ghee* making.

51. Linseed :—

Linseed is one of the concentrated feeding stuffs. It is given after crushing and steeping, or boiling in water, or it is given as cake after the extraction of its oil. Linseed preparations have laxative properties which are used to keep the bowels free. Linseed preparations are especially given to young and pregnant stock. Linseed cake in milch cattle produces a tendency to put on fat and affects, to some extent, the quality of butter fat.

52. Rape and Mustard :—

Green fodder of rape and mustard can be given to cattle along with other fodders, but it should not be given in large quantities as it is likely to taint the milk. These crops are grown in the *rabi* season and as, in that season, there

is generally a deficiency of green fodder, rape and mustard fodders may be used as supplementary to other green fodders like oats, peas, etc. Rape and mustard cakes are very pungent due to the essential oil they contain and so they should be given after soaking in water and mixing with other foods. The slight fermentation gives them a peculiar flavour which is liked by the cattle. Rape and mustard cakes should not be given in large quantities to milch cattle, as the milk is likely to be affected. These cakes are suitable for buffaloes, especially in the winter season, but as they are rather heating they should not be given to pregnant and recently served cattle. The cakes keep well.

53. Other Oil-Cakes :—

Other important oil-cakes are ground-nut cake, *til*-cake, niger seed cake, safflower cake, and poppy cake. Of these ground-nut cake is most nourishing of all on account of its high proteid and oil content but its keeping quality is low. *Til* and niger seed cakes are nearly equal in feeding value but *til*-cake is more suitable in the winter season especially for buffaloes. The value of safflower cake depends upon the proportion of hard coverings and on the mixture of other oil seeds with it. Sometimes a mixture of ground-nut and safflower is pressed for oil; the mixed cake thus obtained possesses a greater feeding value. Poppy cake sometimes acts adversely on milk yield.

54. Condiments and Food Adjuncts :—

Among food adjuncts common salt is most important. It makes the food more palatable, it helps the secretion of digestive juices thus aiding digestion, it keeps the blood pure, prevents the growth of worms in the intestines

and helps to create greater thirst for water ; which qualities jointly help in maintaining the proper flow of milk. One *chhatak* of salt per head per day is quite sufficient. Next to salt comes *Gur*. *Gur* is useful in making the ration palatable and in widening the albuminoid ratio without appreciably increasing the bulk of the food ; it also helps in saving proteids from oxidation. Four *chhataks* per head may be given occasionally. Breeding bulls should not get it continuously or in large quantities, as it produces a tendency to put on fat. Edible oils or *ghee* should be given to cattle occasionally. This helps in keeping the bowels free, and for working cattle is very useful in maintaining their energy and strength. Four to six *chhataks* per head are quite sufficient. *Haldi* is sometimes given as a condiment as it helps in purifying blood. Ginger and pepper help digestion and improve appetite. Garlic as a tonic is sometimes given to breeding bulls or to sick cattle. It should not be given to milch cattle as it taints the milk. Condiments like *ajwain*, *sira*, *sonf* and *soya* help digestion, improve appetite, improve the flavour of rations and help in releasing the full flow of milk. These condiments should be given only at intervals, lest the cattle should get accustomed to them, in which case the salutary effect of these condiments may not be visible.

55. Silage :—

Most of the green fodders can be made into silage by preserving them in a silo. A silo is a structure in which the fodder is preserved. It may be a pit dug in the ground—usually a *kachcha* pit—or it can be made *pucca* with masonry work, or it may be constructed from bamboos, wooden planks or iron sheets. In times of necessity even a room in the fodder house can be used as a silo. Green fodder can also be stacked into a heap on high level ground, thus preparing



[By Courtesy]

[Imp. Dept. of Agri.

PLATE 2. Silage making—Spraying water.. *Imp. Inst. of A. H. and Dairying, Bangalors.*

"stack silo". Ordinary pit silos are wholly underground; but masonry silos may be underground or partly above-ground. Round silos are preferable to rectangular ones, as fodder can be well pressed and kept air-tight better in the former. Ordinary *kachcha* silos dug in the ground should have their sides and bottom plastered with clay or tank mud and then beaten with wooden sticks. This makes them impervious to water. In brick silos the inside should be plastered with portland cement. Arrangements should be made in the construction of brick silos above ground for putting in and taking out the fodder. Before putting green fodder into the silo, it should be cut with a chaff-cutter. First of all a layer of some coarse grass, about 5 or 6 inches in thickness, should be placed on the bottom, then fodder cuttings should be spread on it uniformly and, when the layer is one foot in thickness, common salt should be sprinkled on it uniformly at the rate of 1 lb. for every 100 cu. ft. and finally the layer should be properly pressed by making the labourers tread it down. The pressure should be uniform all over and special care should be taken to press the fodder at the sides and corners of the silo. When the first layer is properly pressed, another layer of cuttings should be added and the process repeated till the silo is filled up. If the cuttings get dry by exposure to sun and air, a little sprinkling of water will keep them moist. The object of adding salt is to make the silage palatable and to check excessive fermentation. Fodder cuttings generally settle and sink down to some extent during the night; and when therefore, the filling is continued next morning, the fodder should be again pressed before the addition of a fresh layer. According to convenience, either labourers, rollers or bullocks should be used to press the fodder. Weighing down

the fodder with logs of wood or slabs of stone is also in some cases preferable. When the silo is full, a layer of coarse grass should be spread on the top and in the case of above-ground silos the fodder should be weighted down with logs of wood, stones or bricks. In the case of *kachcha* pit silos a layer of earth, about 1 to 2 ft. in thickness, should be spread over the coarse grass. This layer should be slightly conical or pyramidal in shape so as to keep off rain-water and to keep pace with the sinking of the fodder in the pit. If cracks occur after some days, they should be filled up so as to prevent the entrance of air into the pit. The silo is then left undisturbed until the silage is required for use.

When green fodder is preserved in this way, it undergoes many physical and chemical changes. The colour, taste and smell change, and the water content is lowered. Fermentation sets in and the temperature of the mass is raised. The oxygen necessary for fermentation is supplied by the air present in the mass of fodder cuttings, and if too much air is left in the mass, or if air is allowed free access to the mass, then excessive fermentation will take place, thus spoiling the silage. This is why the fodder should be properly pressed at the time of filling, the process being designed to drive off as much air as possible. Properly fermented silage has a cooked appearance and is yellow or greenish yellow in colour and smells of acetic acid. Over-fermented and spoiled silage has a dark brown and rotten appearance, smells bad and is often mouldy. Generally the silage of the top and bottom layers and on the sides is more or less mouldy and spoiled, hence this should not be given to cattle. Silage from the mid-mass should be used for the cattle. Chemical changes in fermentation affect the carbohydrates favourably and the proteids adversely.

During fermentation the fodder in fact becomes partially cooked, and is thus soft and easily chewed by the cattle.

Silage-making may be a precautionary measure against fodder famine; but in dairy farming the maintenance of a succulent fodder supply all the year round is a necessity. Dairy cattle like silage and once used to it, they eat it relishingly. It is always better to use silage in the winter season for feeding as then the weather conditions are most favourable for its use. When the silo is once opened, the feeding with it should be continued till it is finished in order to avoid much wastage. Generally, in ensilage, we get back 65 to 75 per cent. of the green fodder put in in good condition; and 25 to 35 per cent. is the loss due to wastage and loss of moisture. Roughly 1 cu. ft. of silage in the original pressed condition weighs about 15 *seers* on an average and according to the fodder requirements the dimensions of the silo should be determined. Per head we may give 10 to 15 *seers* of silage per day. The standard size of a silo recommended for the Military dairies is 20' diameter and 30' depth.

56. Nagpur Silage Experiments* :—

These experiments were carried out in the year 1924-25. The silos were divided into three groups : (1) Telinkheri silos (2) Nagpur Agricultural College farm silos and (3) College tower silos. Telinkheri silos were pits dug out in solid trap rock, the College farm silos were dug in the black soil and the tower silo was of brick work with an inside plaster of cement. The fodder used for ensilage was green *Jowar*. When the silos were being filled, bags were filled with the fodder cuttings and placed in the mass, records of the weights of the bags and the fodder, and the position of the bags in the pits with respect to the bottom and the sides being kept

* Agri. Memoir, Chemi, Series. Vol. VIII, No. 10.

for necessary calculations. A thermometer was also placed in each bag to note the temperature. The silos were filled in October 1924 and opened in the summer of 1925. At the time of filling the silos, representative samples of the fodder cuttings were taken and analysed immediately. When the silos were opened the contents of the various bags were weighed and analysed. For experimental purposes, in one case the fodder was withered in the sun for 12 hours and water was sprinkled on it at the time of filling the silo, and in the other case no water was added to the fodder; while in all other cases a small quantity of water was sprinkled in at the time of filling. The analytical results of the experiments are given in the following tables:—

Showing loss of moisture and dry matter.

	Telinkheri Pit No. 1.		College Farm Pit No. 3.		Coll. Tower	
No. of bag ...	1	2	5	6	8	9
Position ...	Top	Bottom	Top	Bottom	Top	Bottom
Max. Temp. C. ...	41.7	39.6	41.4	36.6	62.0	39.4
Wt. of fodder lb. ...	51.00	51.25	45.62	41.37	49.93	42.00
Wt. of silage ,, ...	52.00	53.40	47.10	43.00	48.00	45.31
Dry matter ensd. ...	13.05	13.02	14.26	12.13	15.63	15.24
Per cent. loss dry mat.	11.90	6.00	14.40	7.50	7.20	8.20
	Pit No. 2 withered water added.		Pit No. 4 without water and withering.			
Bag No. ...	3	4	7			
Position ...	Top	Bottom				
Max. temp. C. ...	44.1	37.0	38.8			
Wt. of fodder lb. ...	52.56	40.62	47.87			
Wt. of silage lb. ...	51.50	40.25	46.37			
Dry Matt. ensld. ...	16.69	13.09	16.62			
Per cent. loss dry. matt.	8.80	14.60	12.00			

In the following table the analytical results of silage from only one pit are given simply to show the chemical changes taking place in ensilage :—

Comparison of silage and fodder.

	Bag No. 1 top.		Bag No. 2 bottom.	
	Jowar.	Silage.	Jowar.	Silage.
Crude protein ... %	4.76	4.80	4.02	4.57
Ether extract ... %	1.22	2.10	1.27	2.66
N. free extract ... %	59.15	58.46	59.55	55.01
Crude fibre ... %	27.42	25.28	26.55	27.33
Ash ... %	7.43	9.36	8.71	10.43
True protein ... %	3.40	3.67	2.95	3.00
"Amides" %	1.36	1.13	1.07	1.57
Dry matter ... oz.	208.8	184.0	208.3	195.8
Org. matter ... oz.	193.3	166.7	190.1	175.4
Crude protein ... oz.	9.9	8.5	8.4	8.5
Ether extract ... oz.	2.5	10.0	2.6	15.8
N. free extract ... oz.	123.5	104.1	124.1	102.2
Crude fibre ... oz.	57.3	44.9	55.3	50.8
Ash ... oz.	15.5	16.6	18.1	19.4
True protein ... oz.	7.1	6.5	6.1	5.6
"Amides" oz.	2.8	2.0	2.2	2.9

SUMMARY OF THE EXPERIMENT.

1. "Good samples of silage were produced which were readily eaten by cattle. There seems to be no advantage derived from sprinkling the crop with water or from withering in the sun previous to ensilage.

2. No differences in the composition of the silage or in the losses occurring could be observed between the silage produced in pits dug in the black cotton soil and in trap-rock respectively. There is some indication that the fermentation ceases more quickly in the black soil pits than in the rock pits.

3. The total change in weight after ensilage was very small in all cases, usually amounting to 2 or 3 per cent. either way except in the case of the bottom bag (No. 9) in the tower silo. This gained 7.9 per cent. in weight which must have been due to the drainage of juice from the great weight of silage above it. There was, however, a loss of dry matter varying from 6 to 14.4 per cent. This appeared to be the least in the Tower silo but otherwise, the differences observed do not seem to be in any way related to the various conditions under which the silage was made.

4. Indeed, in one case in which the green crop was wilted in the sun for 12 hours before ensiling, the proportion of pure to crude protein diminished to a great extent, yet in the resulting silage the proportion of pure to crude protein actually increased largely. This would actually indicate a re-synthesis of protein from the "Amide" fraction during ensilage. This is admittedly contrary to expectation.

5. Our silage contained much more volatile organic acid and distinctly less non-volatile acid than the Cambridge samples. Butyric acid appeared to be absent from all our samples."

CHAPTER VI

GENERAL MANAGEMENT OF CATTLE.

57. Tying of Cattle :—

If there be a mixed herd of cows, buffaloes, bulls and bullocks, the animals should not be tied in a mixed manner. The cows, buffaloes etc. should be separated and they should be tied quite separately. If there be a large number of cows, buffaloes etc., there should be separate sheds for them. In this way many troubles are avoided, *e.g.*, if calves are tied with the cows, they are sure to drink the milk or they are likely to receive injuries from the big animals. If the cows are separated from the buffaloes, food and fodder can be distributed much more easily and without any confusion. There should be a fixed place for each individual in the shed. The cattle should be tied by their necks and not by the horns. The latest method of tying cattle is to tie the cows by means of frames. This method is adopted to save floor space but it is not convenient to cattle because they cannot then bend their necks far back enough to reach the hinder parts of their bodies when flies and mosquitos trouble them.

58. Feeding, Watering and Grazing :—

The feeding should always be done at fixed hours, since irregularity in feeding affects the general health and milk yield adversely. The ration should be properly balanced according to the milk yield and the condition of the cattle. There should be occasional changes in the feeding stuff to avoid monotony and an attempt should be made to make the

ration palatable and easily digestible. Common salt should be used as a constant constituent of the ration. Condiments like *sonf*, *ajwain*, turmeric, *gur*, etc. should also be occasionally given to stimulate digestion. Laxative feeding stuffs and purgatives are given occasionally to keep the bowels in proper condition. Water also should be given at fixed hours 2 to 4 times a day according to the season and care should be taken to keep it pure. Good grazing is very economic and also keeps the cattle in good health as they naturally get exercise and fresh air. If there are good grazing facilities, much of the fodder is saved. Grazing has one more advantage as it helps in keeping cleaner both the animals themselves and also the cowshed floor, thus indirectly assisting in the production of clean milk. Cattle should be taken out for grazing every day regularly if weather conditions allow, and should get at least two or three hours for grazing. The morning is the best time for this purpose.

59. Grooming and Exercise :—

The animals should be groomed at least once a day. Their bodies should be rubbed and cleaned by means of brushes and towels. Rubbing of the body encourages the proper circulation of blood, and by rubbing and brushing the loose hair and dirt are removed from the body (this helps in the production of clean milk, as loose hair and dirt are sources of contamination). Grooming is also helpful in disclosing any injuries etc. on the body of the animal and applying immediate remedies for them. Hoofs should be thoroughly examined and cleaned while grooming the animal. The animal should be given regular exercise daily either by taking it out to pasture for grazing, or, failing this, by giving it a thorough grooming. Exercise, though regular, should be moderate, especially in the case of pregnant

animals when they are approaching their delivery time. The stud bull should be given regular and sufficient exercise daily, for if this is neglected he will become fat, and so useless for stud purposes. Exercise is quite essential for the young stock.

60. Bathing :—

Cattle should be washed at such intervals as may suit the particular season and locality, for the climatic conditions are so very widely different in different districts of the same province in India. In southern India a buffalo may have a bath almost daily without any bad effects, but this practice is sure to produce bad effects in more temperate tracts of Northern India. The buffalo requires more frequent baths than the cow, as the former feels pleasure in rolling in pools of muddy water and does not mind soiling her body, while the latter is not naturally inclined to this. The main object of a bath is to keep the body clean in order to decrease the chances of skin diseases and contamination of milk.

61. Care of Pregnant Animals :—

Pregnant animals should not be treated roughly in any way and proper care should be taken about their feeding and general management. Pregnant animals should not be allowed to walk long distances, nor should they be allowed to run fast, or fight with each other. Especially when delivery time approaches, they should be kept in a calm and quiet place, and tied separately. At least 15 days before delivery they should be given soft and laxative foods. In order to avoid contagion, pregnant animals should not be tied in a place where a case of abortion has occurred. When the delivery time is approaching, pregnant animals should not be taken out for grazing.

The various causes of abortion viz. sickness, contagious disease, poison, too much excitement or fright, rotten mouldy food, shock through fall, re-service by the bull and exposure to extremes of climatic conditions and the like, should always be avoided.

62. Care at Delivery Time :—

Some days before the delivery, the udder begins to enlarge and the mammary glands become active, while in heavy milkers milking is sometimes required to be done even before actual delivery in order to avoid the inflammation of the udder. The milk-vein also becomes distended and prominent. As the delivery time approaches, the skin of the vulva becomes loose. A slight depression in the lumbar region is seen, the animal likes to go away to a calm and quiet place; or, if tied, frequently sits down, and gets up, and tries to deliver. During actual delivery the foetal covering protrudes, then bursts and under normal conditions the front two legs of the calf come out, then the head follows and the cow gives birth to the calf. If any thing abnormal is seen, that is, if the cow is seen to labour very hard for delivery without success, veterinary help or an experienced milkman should be called at once to help the animal to a safe delivery. Abnormal presentation of the calf is very harmful and sometimes in such cases either the calf or the cow dies. After delivery the body of the cow should be cleaned by means of moist cloth frequently dipped in warm water and then the cow should be taken to a dry clean place. The cow generally cleanses the body of her newly born by licking it but we should see that its eyes, ears, nostrils are cleaned and freely working; if any sticky matter is left adhering, it should be removed. If the hoofs are abnormally long, they should be slightly chipped

off from the lower side. If there is too much bleeding from the navel cord, it should be stopped by ligature. Sometimes the navel cord is touched with Blue-stone (Copper Sulphate) to cause it to shrivel and drop early. Under normal conditions the calf after its birth tries to stand and suckle but has to be helped in its attempt. The calf should be allowed to drink just sufficient quantity of the colostrum as this has laxative properties and helps in keeping the intestines freely working. A very large quantity of colostrum should be avoided, as it is likely to cause diarrhoea. The after-birth is generally dropped within a few hours after delivery but if retained for a longer period it should be taken out carefully with the help of an experienced man as otherwise it will rot in the womb and cause blood poisoning. Within one or two hours after delivery, the cow should be given a warm refreshing mash prepared by boiling in water either crushed wheat, barley, *bajra* or bran of wheat to which a little *gur*, ginger, pepper and salt is added. This acts as a stimulant and refreshes the animal and helps in getting rid of the after-birth in a short time. Such a warm refreshing mash should be given twice a day for two or three days at least, but afterwards condiments may not be added. The warm mash should be continued for twelve days and afterwards an ordinary concentrated food ration may be given. After delivery the cow and the calf should be protected from extremes of climatic conditions. The cow should not be roughly treated or excited in any way and outsiders should not be allowed to go to the calf if it be tied within her view; these precautions are necessary as otherwise the animal is likely to become vicious and may not allow anybody to approach and milk her.

63. Weaning :

Excepting Military Dairies, calf weaning is not practised here as it is thought to be a sin to deprive the young one wholly of the food provided by nature, and secondly the practice is not acceptable here from the utility point of view as the bullocks are the sole motive power in agricultural operations and weaned calves do not grow into bullocks of good working capacity. Suckling has one more advantage as it helps indirectly in raising the keeping quality of milk, because the calf drinks the fore portion of milk which has usually the highest bacterial content. According to Walton four ounces of the fore milk of a cow yielding 10 lbs. of milk when mixed with the rest would raise the content of the mixed milk by 800 bacteria per c. c. In Western countries the milk yield of cows is many times greater and also other conditions may be quite different, so the practice may have some utility in it. In weaning, the calf is separated from its mother just after its birth and hand-fed for some days with its mother's milk or whole milk. Afterwards, the whole milk is gradually replaced by separated milk and when the calf begins to eat other food, milk-feeding is stopped. In such hand-feeding, special care is required to be taken otherwise the calf becomes a weakling and its growth is checked. If weaning is to be practised it should be begun from the very first delivery and not later.

64. Care of Calves :—

Calves need to be specially cared for, if they are to grow into good animals. Rough and careless handling of them should be avoided as far as possible. Proper feeding, grazing, and sufficient exercise in the open where they can run about and play at will are essential

to keep them healthy. While very young, they should be given sufficient milk, but when they begin taking other foods, the easily digestible and nutritious foods should be given preferably. Defective or insufficient nutrition during their period of growth will tend to render them weak and stunted and ultimately unprofitable animals. Cleanliness has also much to do with the proper growth of animals, since if their bodies are allowed to remain uncleaned for any length of time, they are liable to be affected by skin diseases and may thus shelter parasites which may hamper nutrition and thus affect growth. Calves should be particularly protected from climatic extremes.

65. Dehorning :

In Western Countries cattle are sometimes dehorned with the idea of preventing injury when cattle should fight with each other. This is brought about by using caustic soda to stop the growth of horns. Dehorning is done in the case of very young calves. As soon as the growing points of horns are visible, the hair round about is clipped, the spots are moistened with water, and after being scratched with a pointed knife the places are rubbed with a caustic soda stick. The caustic eats away the growing tissues of the bud of the horns and thus stops further growth. Care is required to be taken in applying the caustic to prevent the caustic liquid from flowing to the eyes and thus causing injury to them. After touching with caustic the calves should not be let out in rain or washed with water. Further care should be taken not to touch the skin with caustic round about the horn bud. The wound caused by touching with caustic should be kept clean and allowed to heal. In India,

dehorning is not practised except in some cases in military dairies and that too, perhaps, with the object of giving the dehorned cattle the appearance of the Short-horn breed of Western countries.

66. Care of Sick-Animals :—

When cattle get sick they do not eat their usual quantity of food and if the sickness is severe they do not eat or drink at all. They appear uneasy, frequently sit down and get up or lie down. They examine the place of pain or strike it with their tails. The solid and liquid excreta is not normal or it gets stopped. Tears from the eyes or saliva from the mouth begin to flow. There may be a rise of body temperature which can be felt by touching the ears. The pulse, which is felt near the root of the tail on the lower side, may be abnormal. The stomach may be distended. There may be swellings or inflammations. They may not chew their cud as usual. The hair may be erect. When patted on the back they may not shake their skins as in normal health. They may be grinding their teeth or may not open their mouths. There may be a discharge from the nose. They may not respond as usual when called by their names. These and similar signs are clear symptoms of sickness and the first step to be taken is to separate the sick animal from the healthy ones and then proceed to determine the nature of the sickness and treat it according to a veterinary doctor's advice. Previous history as to the feeding and grazing of the animal should be noted so that the doctor can determine the nature of the sickness and prescribe the right medicine. Doctor's instructions regarding the feeding, administration of doses etc. should be properly followed. A proper record of all the symptoms observed

and the remedies applied should be maintained so that in case of a similar sickness in future, they may stand in good stead. If the sickness proves to be contagious, all the bedding under that animal should be burnt and the place should be thoroughly disinfected. People attending on such cattle should not be allowed to handle good animals and all measures required to prevent the spread of the disease should be taken. When the animal is sick, it should be gently handled and kind words spoken to encourage it. No one should be allowed to tease the animal. When it begins to recover, over-feeding should be particularly avoided. Only soft and easily digestible food should be given at *fixed* hours and never in large quantities at any one time. Good green grass will serve as a good change in the food and a change in diet will certainly be beneficial to the animal.

CHAPTER VII

FEEDING EXPERIMENTS

67. Feeding Experiments:—

In the first edition of this book, it was stated regarding the co-efficients of digestibility that "unfortunately these have not been worked out for Indian foods and for Indian cattle in India as yet. Figures from foreign countries are available but these cannot be wholly applied to Indian foods and Indian cattle." But since the publication of the first edition (1923), some literature regarding the feeding experiments carried out by our Departments of Agriculture has been published. The Imperial Institute of Animal Husbandry and Dairying at Bangalore is dealing with the nutrition problem, and every year we hope for useful information which will, we hope, in course of time, cover all the necessary data for our cattle and foodstuffs. The experiments being the first of their kind, we may give here, without apology, the summaries of these in the experimenters' own words as far as possible, so that they may help the dairy student, and the dairy farmer in studying animal nutrition properly.

68. Lyallpur digestibility trials* :—

The credit of first undertaking the digestibility experiments goes to the Punjab Agricultural Department. The digestibility trials were started in 1921 and the main object in view was to determine the quantitative feeding values and the digestibility of *Shisham* leaves as a reserve fodder. As is necessary in digestibility experiments with cattle, to determine the digestion co-efficient of a basal ration the first step in these experiments was to determine the digestibility of wheat *bhusa*. The bullocks obtained for the experiment were rather old and feeble. The animals were prepared for the experiments by giving them only wheat *bhusa* to remove all traces of previous food; during this preparatory period (29th November to 7th December 1921) the amounts of *bhusa* eaten and the dung voided were noted, and the animals were weighed daily. The actual feeding experiment was started on the 7th and concluded on the 23rd December and during this period the food given and the dung voided was analysed daily, in addition to the daily weighing of the animals, food and dung. During this period, 16 lbs. of *bhusa* was finely sieved and was served in troughs in lots morning, noon and evening. On the following morning the uneaten portions were carefully collected and weighed. The animals were watered twice daily, once after the daily weighing and once after the evening meal. During the experimental period, the animals had no other work to do than to walk up to the weighing bridge 200 yards away and back to the stall. The sequence of the feeding trials was (1) *Bhusa*, (2) *Bhusa* and gram, (3) *Bhusa* and Maize and (4) *Bhusa* and *shisham* leaves. The results of the experiments with *bhusa* alone are tabulated overleaf for convenience and easy reference.

* Agri. Memoir, Chem. Series, Vol. VII, No. 4.

ANIMAL.				SAWA.			GORA.		
Particular.		Per cent. comp.	Food eaten lbs.	Dung voided lbs.	Digesti. coefficient.	Food eaten lbs.	Dung voided lbs.	Digesti. coefficient.	
Amount	...	...	166	381	...	148	308'50	...
Dry matter	...	94'29	156'50	83'06	46'93	139'60	77'12	44'76	
Ash	...	7'58	12'58	17'14	-36'25	11'22	15'46	-37'79	
Ether extract	...	0'72	1'20	1'22	-1'67	1'07	1'11	-3'74	
Crude fibre	...	39'87	66'18	25'45	61'53	59'00	24'10	59'13	
Protein	...	1'72	2'86	4'08	-42'65	2'55	3'70	-45'09	
N. free extract	...	44'40	73'70	35'17	52'26	65'71	32'76	50'13	

From the above table it will be noticed that the amount of Ash, ether extract and the proteid in the dung are greater than originally supplied in the food and hence the negative digestibility co-efficients. Regarding these negative results the experimenters state: "This is intelligible when dealing with *bhusa* such as that used, which contains but a small percentage of those substances, when it is remembered that certain excretory products from the animals are also voided in the fœces which have been ignored in the experiment but which are obviously included in the indigestible fraction of the food." They further add: "An interpretation of these figures indicates that the crude fibre and carbohydrates are between 50 and 60 per cent. digestible, the digestibility of the very small percentages of fats and proteins being overmasked by the presence of the excretory products contaminating the fœces."

69. Experiment with *bhusa* and gram :—

In this experiment the animals were given 4 lbs. of ground gram in addition to 16 lbs. of *bhusa*. The gram was coarsely crushed and was fed in the morning with some *bhusa* so that the whole of the mixture was eaten up, and during the rest of the day additional *bhusa* was given to make a total of 16 lbs. The particulars of the experiment and the analytical results are given below.

NAME OF ANIMAL.	SAVA.	
<i>Bhusa</i> given ...	224 lbs.	...
<i>Bhusa</i> residue...	42 "	...
<i>Bhusa</i> eaten ...	182 "	...
Gram eaten ...	56 "	...
Dung voided ...	471.5 "	...

} Period 14 days
(16th to 29th
January 1922.)

	Dry matter. %	Ash %	Ether extract %	Crude fibre %	Protein %	N. free extract. %
Per cent. Com. of <i>Bhusa</i>	94.29	7.58	0.72	39.87	1.72	44.40
" " " Gram	91.58	3.29	2.62	6.90	18.88	59.89
" " " Dung	19.16	3.68	0.42	5.35	1.45	8.26
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
In <i>Bhusa</i> given	171.60	13.80	1.31	72.56	3.13	80.81
In gram given	51.30	1.84	1.47	3.86	10.57	33.54
In total food given	222.90	15.64	2.78	76.42	13.70	114.35
In dung voided	90.34	17.36	1.98	25.23	6.84	38.95
Total digested	132.56	-1.72	0.80	51.19	6.86	75.40
Total digested from <i>Bhusa</i>	80.54	-5.00	-0.02	44.62	-1.34	42.24
" " " gram	52.02	3.28	0.82	6.57	8.20	33.16
Digestion co-efficient of combined food... ..	59.46	-11.00	28.78	66.98	50.07	65.92
Digestion co-efficient of gram	101.40	178.30	55.78	170.20	77.58	98.85
Digestion co-efficient of gram similarly worked out with the animal Gora	82.30	85.30	48.30	162.40	65.95	79.72
Average digestibility of Gram	91.85	131.80	52.04	166.30	71.76	89.28

The computation of the digestibility co-efficients of gram, as will be seen from the above table, was based on the digestibility figures of *bhusa* obtained in the first experiment given before.

The new feature of this experiment is in the more than cent. per cent. co-efficients of digestibility of dry matter, ash and crude fibre of gram in the case of the animal Sawa and of crude fibre alone with the animal Gora. Regarding these excessive digestibilities the experimenters state: "In view of the negative values given for the *bhusa* figures, it seems perhaps invidious to work out the co-efficients of gram alone. If, however, we assume that the digestibility of *bhusa* was unaltered by the addition of the gram, an assumption which is not strictly justified, it is possible to compute how much of each kind of digestible matter, protein, crude fibre, nitrogen free extract &c. in the total ration, was derived from the *bhusa*; the remainder must therefore have come from the gram." Regarding the very high digestion co-efficients, they add: "The interpretation is that the influence of the gram on the *bhusa* is to render some of the ingredients of the latter still more digestible in the combined diet than alone, this added digestibility thus being added on to that of the gram." Regarding the animal Gora, they state that the animal was in a better physical condition and somewhat younger than Sawa and therefore the figures in his case approximate more nearly to what one would expect.

70. Experiment with *Bhusa-Maize* and *Bhusa-Shisham* :—

The results of these experiments are tabulated overleaf.

			Dry matter.	Ash.	Ether extract.	Crude fibre.	Protein.	N. free extract.
<i>Bhusa Maisa—(combined.)</i>								
Animal Sawa	...	...	63'40	—22'24	51'22	67'00	31'45	71'41
" Gora	...	...	57'28	7'31	55'62	63'03	29'21	61'85
<i>Maisa Computed—</i>								
Animal Sawa	...	...	100'65	286'20	74'60	326'20	61'40	96'34
" Gora	...	...	85'29	387'10	81'70	246'60	58'91	76'98
AVERAGE			92'97	336'65	78'15	286'40	60'15	86'66
<i>Bhusa and Shisham combined—</i>								
Animal Sawa	...	...	59'20	28'38	52'83	64'16	35'25	62'71
" Gora	...	...	57'59	35'56	52'85	60'68	42'45	60'23
<i>Shisham leaves computed—</i>								
Animal Sawa	...	...	136'25	343'40	118'10	99'71	85'01	127'00
" Gora	...	...	143'35	415'80	126'00	83'14	101'70	126'50
AVERAGE			139'80	379'60	122'05	91'42	93'35	126'75

Regarding the abnormal figures obtained in the *bhusa* and maize trial, the experimenters state that the continued effect of feeding the animals on partly cereal diet is having a considerable influence on the digestibility of the *bhusa* fed. Regarding the *bhusa* and *shisham* leaves figures, they comment: "Had the figures for the *Shisham* shown a negative value, we would have interpreted it as meaning that the leaves could not be utilized by the animals, but being so highly positive, although the figures offer no criterion as to the true digestibility co-efficient for the *Shisham*, they yet indicate that the very low negative values obtained when *bhusa* is fed alone are being ameliorated and converted into positive products, or, in other words, that an admixture of *Shisham* with *bhusa* considerably augments not only the digestibility of the combined feed but also renders the *bhusa* itself more digestible."

On the completion of these abovementioned experiments, the digestibility experiments of *bhusa* alone were again started in 1923 with a new and better pair of bullocks, Nila and Mina, because in the previous *bhusa* experiments abnormal negative co-efficients were obtained which affected all subsequent experiments with *bhusa* and gram, *bhusa* and maize and *bhusa* with *Shisham* leaves.

The result of this second experiment is given overleaf which shows normal digestibility co-efficients for wheat *bhusa*.

71. Second Series of Lyallpur digestibility trials* :—

In the first series of the trials the object was to determine the feeding values of *Shisham* leaves while in the second series the object was to find the feeding value of

*Agri. Memoir, Chem. Series, Vol. IX, No. 3.

	Dry matter.	Ash.	Ether extract.	Crude fibre.	Protein	N. free extract.
Animal Nila	55.78	11.50	43.87	65.65	35.84	56.31
„ Mina	61.10	17.38	52.32	72.26	42.36	59.51
Average comes to	58.44	14.44	48.09	68.95	39.10	57.91
Percentage comp. of <i>Bhusa</i>	91.46	7.08	0.740	41.36	3.70	37.85

The normal result is evidently due to the better pair of bullocks and better *bhusa*.

Shisham leaves silage both alone and in combination with other food stuffs. In this series the rations were tried as under :—

- (1) *Bhusa* and green *Sarson*.
- (2) *Bhusa* alone.
- (3) *Bhusa* and Siloed *Shisham* leaves.
- (4) Siloed *Shisham* leaves alone.

In this series four Montgomery bullocks with ages varying between 4 and 5 years, were chosen for the experiment and these were under trial from 1st December 1923 to 3rd April 1924.

During this period the four animals were weighed daily and their daily urine was analysed in addition to the analysing of the food and dung, in order to obtain all necessary details. A summary of these experiments is given overleaf. The experimenters' comments are as follows :—

(1) *Bhusa and sarson trial* :—“Taking into consideration the fact that during this whole period the weight of the animals remained constant, we may perhaps assume that this diet represents a close approximation to a maintenance diet for the bullocks at rest. There are certain facts brought out when we refer to the table showing the nitrogen balance of the animals on this diet. The total nitrogen given in the food has been computed, as also the total nitrogen excreted in the urine and in the dung. The balance throughout these periods is slightly on the negative side indicating that this diet is just under what may be considered a maintenance ration. Armsby gives the digestible protein required per day for a bullock weighing 1000 lbs. as 0.5 lbs. for American animals which is considerably higher than the figure obtained in these trials.

Particulars.	<i>Bhusa</i> and <i>Sarson</i> combined.	<i>Bhusa</i> alone.	<i>Bhusa</i> and <i>Shisham</i> silage combined.	<i>Shisham</i> silage alone.
<i>Digestibility Co-efficients—</i>				
Dry matter	49·60	48·86	42·78	36·22
Ash	16·01	—20·07	14·33	...
Fat	61·44	32·53	36·38	28·06
Crude fibre	58·97	65·40	50·95	33·99
Protein	28·51	—35·87	42·29	51·79
N. Free extract	51·85	51·18	46·86	50·03
Starch equivalents per day	3·32	2·15	2·79	1·62
Protein digested per day lbs.	0·13	—0·057	0·47	0·46
Mean daily Nitrogen balance in grammes	—8·6	—18·7	—9·2	—37·3
Quantities in terms of grammes of Nitrogen in daily urine.	Av. 10 days.	Av. 13 days.	Av. 12 days.	Av. 10 days.
(1) Ammonia and Amino acid	0·94	1·06	8·41	14·36
(2) Urea... ..	3·30	2·82	19·36	37·85
(3) Uric Acid	0·53	0·37	0·60	0·35
(4) Creatinine	2·95	3·04	2·59	2·85

(II) *Bhusa alone trial* :—“The percentage of crude protein in the *bhusa* was low being only 1·67 per cent. and this is reflected in the digestibility co-efficients of the same as found which were negative for all the animals and consequently the figure for the daily digestible protein required is negative, an obviously absurd result indicating that the *bhusa* does not constitute a maintenance ration even when the animals are fed as much as they can eat.

(III) *Bhusa and Shisham silage* :—“The *shisham* is comparatively rich in protein which is apparently easily digested, although taking into consideration the fact that the animals were fed as much *shisham* as they cared to eat and also the fact that the nitrogen balance is on the negative side, it would not appear that the animal is fully able to utilize in the tissues all the protein which has actually been digested. This is an important factor to be kept in sight when computing the efficacy of any particular diet, for even digested protein may not be entirely available for the general use of the animal because, as in this case, although the food was fed ‘*ad lib*’ the nitrogen balance is still on the wrong side.

(IV) *Siloed shisham leaves alone* :—“The total protein digested per day is still in the region of 0·5 lbs., but the negative nitrogen balance has very considerably increased. The explanation of this would appear to be that although considerable quantities of protein are daily digested, certain essential ‘elements’ are lacking which are required by the animal, and in its effort to secure these it has recourse to the breaking down of its own tissues.” Regarding the condition of the animals during this trial they observe : “All the animals decreased considerably in weight.....they lost ‘condition’. They licked earth

from the walls and mangers and tried to eat the wooden partitions. Their eyes became lachrymose, they showed a reluctance to rise when sitting and the urines showed a considerable deposit of broken cellular material "

From these digestibility trials we should note the following points :—

(1) Neither *shisham* leaves, fresh or siloed, nor wheat *bhusa* of poor quality alone form a maintenance diet.

(2) A mixture of either grains or pulse seeds, or pulse fodder with cereal straw, like wheat *bhusa*, form a maintenance diet.

(3) Mixtures of grains, pulse seeds or fodders with wheat *bhusa* affects the digestibility of the latter favourably.

(4) For reliable digestibility data the animal chosen for experiment should not be old or in poor condition.

(5) The amount of protein, as revealed by chemical analysis, in the feeding stuffs, does not give the right idea as to its favourable effect in the animal metabolism, the kind of protein being as important, or even more important, than the amount.

72. Bangalore Maintenance experiment* :—

The maintenance experiments were undertaken with the object of carrying out a systematic study of the chief Indian roughages. In the first series of these, three well matched pairs of mature bullocks were selected, and one animal from each pair was fed on rice straw and the other on baled hay, the concentrated ration being identical for each pair. The live weight of each animal in the first pair was approximately 1000, in the second 750, and in the third 500 lbs. respectively. These digestion experiments were carried out in three stages of feeding with the object of determining (a) digestion of rice straw, (b) digestion

*Agri. Memoir, Chem. Series, Vol. IX, No. 2.

of baled hay, (c) the net energy values and (d) the physiological effects. The results of these are given in the tables overleaf in average figures.

The remarks regarding the digestion of rice straw and hay are as under :—

RICE STRAW. "In Pusa and Bangalore 100 lbs. dry straw yielded 48·8 and 49·9 lbs. of digestible dry matter respectively. In America only 42·1 lbs. were obtained..... There are two possible reasons for the higher digestion found at Bangalore. Either our animals have a better digestion capacity for such roughage or the American straw is less digestible. Judging by chemical composition, there is no reason why the American straw should be less digestible. Indeed its higher protein content might lead one to believe that it would be more easily digested."

BALED HAY. "In this case, when comparing similar material, it appears that digestibility is largely dependent upon a low fibre content..... The digestibility of the hay used at Bangalore is somewhat higher than American prairie hay, but it is much inferior to the better class of American hays. The net energy value of our hay will therefore be much lower than that of average American hays. It is worth recollecting at this point that our bullocks on rice straw attained a superior digestion to that found in America."

73. Estimation of net energy values :—

These experiments were carried out in two tests. In the first test the animals were given regular exercise and this was taken into account in working out the data. In the second test the animals were kept practically at rest and possible sources of error were avoided to ensure reliability of the results. The results of the second test are given on page 99.

Digestion of rice straw and baled hay.

			Dry. matter.	Org. matter.	Protein.	Ether extra.	Fibre.	N. free extra.	Carbo- hydr.
<i>Rice straw—</i>									
Av. Composition	...	...	100'0	82'41	2'79	0'86	30'91	47'88	78'79
„ Amt. Digested	...	...	53'54	49'97	0'313	0'380	21'67	27'60	49'27
„ Digestion co-efficient...	...	...	53'54	60'61	11'17	43'41	70'43	57'71	62'53
<i>Baled hay—</i>									
Av. Composition	...	...	100'0	89'91	2'42	1'20	35'51	51'41	86'92
„ Amt. Digested	...	...	50'32	48'24	0'047	0'468	21'97	25'99	47'89
„ Digestion co-efficient...	...	...	50'32	53'72	1'88	39'12	62'72	50'42	55'13

Data relating to quantitative feeding.

Second Test	1000 lb. Animal		750 lb. Animal		500 lb. Animal	
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
	Straw	Hay	Straw	Hay	Straw	Hay
Average live wt. lbs.	993	944	767	749	607	535
Average live wt. increase lbs.	0'31	0'31	0'24	0'19	0'20	0'10
Daily conc. consumption lbs.	1'58	1'58	1'32	1'32	1'10	1'10
Daily roughage .. lbs.	14'45	14'54	11'57	12'08	9'28	9'83

FEEDING EXPERIMENTS

To reduce the data to a common workable basis the net energy values, required theoretically to produce the observed growth, were estimated by using Armsby's figures, namely 6 therms energy for maintenance for 1000 lbs. body weight and 3 therms for 1 lb of growth. The energy values thus calculated were as below:—

Estimation of net energy value of rice straw and hay.

100

Second Test.	Rice-straw eaters			Hay eaters		
	1	3	5	2	4	6
Therms net energy required for maintenance.	6'00	5'02	4'26	5'89	4'92	3'92
Therms net energy required for live wt. increase.	0'93	0'72	0'66	0'93	0'60	0'30
Therms total net energy obtained from ration.	6'93	5'74	4'92	6'73	5'52	4'22
Therms net energy of concentrates ...	1'47	1'22	1'02	1'47	1'02	1'02
Therms net energy from roughage ...	5'46	4'52	3'90	5'26	4'50	3'20
Lbs. roughage consumed ...	14'45	11'57	9'28	14'54	12'08	9'33
Net energy value of roughage per 100 lbs....	37'70	39'00	42'00	36'20	35'80	34'30*

MANGAL OF DAIRY FARMING

*Health of the animal was abnormal. This result was excluded in calculating the net energy value of hay.

Regarding these net energy values they remark :—

“As far as the second test can be relied upon, it shows that the net energy values of rice-straw and hay are 40 therms and 36 therms per 100 lbs. respectively (or 44 therms and 39·6 therms per 100 lbs. dry matter). It may be stated at once that these figures differ entirely from Armsby's values. For rice-straw the Bangalore feeding test figure is 17 therms higher, for hay it is 12 therms lower than Armsby's values. The largest item on which the Bangalore calculation is based is the net energy required for maintenance. For this purpose Armsby's average of 6 therms per 1000 lbs. live weight was used. This requirement is not absolutely constant and may vary considerably in certain cases. Values ranging from 5 to 7 therms are quoted in the literature. It is important to note what effect such variation would have on the calculated net energy. In the next table the net energy of the roughages has been calculated exactly as above, but making different allowances for the maintenance requirement.

Assumed energy for maintenance.	Estimated energy rice-straw.			Estimated energy Hay.		
	No. 1.	No. 3.	No. 5.	No. 2.	No. 4.	No. 6.
5 Therms	30·8	31·8	34·4	29·5	28·8	27·3
6 "	37·7	39·0	42·0	36·2	35·8	34·3
7 "	54·9	56·9	60·6	53·0	52·6	52·2

These figures make one point quite clear. It is certain that there were no marked differences in the maintenance requirements of our six bullocks. The figures of one line cannot be mixed up with any of the figures on another line.

There is no such variation for maintenance requirement amongst these six bullocks as 5 to 6 or 6 to 7 therms. This is a very definite result which shows that the net energy values in one of the lines of the table above must roughly represent the actual net energy values of the two food stuffs..... It is seen now that an allowance of 5 therms still leaves the value for rice-straw too high, whilst it brings down the hay value to an incredibly low level. It has to be concluded therefore that the closest agreement cannot be attained by using any other than Armsby's average maintenance allowance of 6 therms."

74. Physiological Effects :—

The most important physiological effect observed in these maintenance experiments was diuresis in the case of all the rice-straw eaters, and the excessive excretion of urine which was persistent throughout the experiment. The analysis of urine and the roughages eaten regarding the potash content showed clearly a close relation, the higher potash content in the roughage the greater the quantity of urine excreted. This will be seen from the data tabulated on the opposite page.

"This table shows that when the amount of potash ingested is high, as in the case of the straw eaters, almost all of it is excreted in the urine. When the amount ingested is low, a high proportion of it is still excreted in the urine, but an appreciable fraction remains to be excreted in the fæces. It may be noted here, too, that while the amount of urine is mainly dependent upon the potash, there is another subsidiary factor at work. Its nature has not been established as yet."

When the straw eating animals Nos. 1, 3 and 5 were brought to the hay ration of the remaining three, gradually

Comparison of potash ingested and urine excreted.

	Animal No.	Test No.	Potash consumed grains.	Potash in Urine grains.	Volume of urine liters.
Rice-straw eaters ...	1	1	108·2	92·5	7·87
		2	107·1	100·3	6·83
		3	138·5	130·6	7·57
...	3	1	87·1	83·8	7·80
		2	84·2	92·2	5·88
		3	117·9	119·5	7·22
...	5	1	63·4	61·4	6·30
		2	65·6	67·1	4·97
		3	92·5	90·1	5·75
Hay eaters ...	2	1	50·8	33·1	3·95
		2	40·2	31·5	2·84
		3	46·8	33·5	3·33
...	4	1	42·3	27·1	3·67
		2	33·2	26·3	3·02
		3	38·8	31·3	3·34
...	6	1	31·2	20·1	3·22
		2	25·6	21·5	3·14
		3	30·2	22·5	2·56

Live weight lbs.	1000		750		500	
Animal No.	1	2	3	4	5	6
Average roughage eaten Kilos, per day.	6'804	6'790	5'359	5'301	4'520	3'994
	<i>December 4th.</i>					
	4'175	3'465	4'078	3'815	2'633	3'145
	<i>December 5th.</i>					
Daily Urine in Kilos. a fortnight after the change of ration.	4'135	3'350	2'610	3'053	2'425	3'795
	<i>December 6th.</i>					
	3'905	2'935	3'843	2'420	2'742	2'520
Average ...	4'072	3'250	3'510	3'096	2'600	3'153

the quantity of urine was practically reduced to normal as will be seen from the table on the opposite page (104).

Regarding this potash diuresis, they further remark: "It is impossible to say at present what the effect of this diuresis will be. Up to a point the elimination of urine is a healthy symptom. It may be expected to clear the system. On the other hand, the excretion of very large amounts of urine or of urine of abnormal reaction is a strain on the kidneys and must inevitably lead to serious results. It is possible that a subject of fundamental importance to animal nutrition in India has been met with here."

It may be noted here that during these experiments the colour of the coat of rice straw eating animals was affected. The original black colour was faded. This perhaps may be an indication of the fall in vitality of the whole system due to deranged circulation. The change in coat colour is evidently due to derangement in the functioning of the hair glands, and this may be due to either defective nerve vitality or defective circulation, at least in that part of the body. If we take the potash diuresis into account, the deranged circulation may perhaps be the cause. Diuresis means excessive supply of blood to the kidneys and this means deficient blood supply to other glands of the body. When the ration was changed for hay instead of straw, the animals got their original black colour.

75. Growth Production Experiment* :—

The object of the experiment was to determine the requirements for growth, and to compare the results with the standards of other countries. For this experiment 12 cross-bred heifers were chosen, half of which were under one year and the remaining half were under two years of age so that there were two groups, the younger and the older, the average age being 255 and 439 days respectively.

* Agri. Memoir, Chem. Series, Vol. VIII, No. 11.

The results were obtained for each individual heifer as well as for each group separately. During the experimental period of 116 days the food consumption of all the animals was measured and the increase in live weight was noted by weighing the animals on three consecutive days at regular intervals. During the experimental period the following feed was given per head per day.

Food.	Younger Group. lbs.	Older Group. lbs.
(1) Mixture		
7 parts Bran ...	} 2	3
3 „ Cotton seed meal ...		
5 „ Gram Husk ...		
(2) Ground nut cake ...	1	1
(3) Silage ...	5	10
(4) Hay ...	As much as they could eat.	

The summary of the result is given in the following tables.

	Younger Group.	Older Group.
<i>Digestibility of the ration.</i>		
Av. Dig. Coeff. of Dry matter ...	49'82	53'04
„ „ „ „ Org. „ ...	52'82	56'21
„ „ „ „ Protein ...	61'51	60'84
„ „ „ „ Ether extract ...	73'43	73'77
„ „ „ „ Fibre ...	56'75	61'03
„ „ „ „ N. free extr. ...	45'98	49'42
„ „ „ „ T. Carbohydr. ...	50'51	54'39
<i>Live weight increases in lbs.</i>		
Av. Live wt. on 8th July 1924 ...	218'8	382'2
„ „ „ „ entire period... ..	255'0	439'0
„ „ „ „ increase per day whole period	1'011	1'036
„ „ „ „ increase per day 1 week period	0'943	0'947

			YOUNGER GROUP.		OLDER GROUP.	
			Actual.	Computed.	Actual.	Computed.
<i>Digestion of nutrients.</i>						
Protein total lbs.	...	...	69'17	97'68	85'00	120'04
.. per day ..	...	...	0'596	0'842	0'738	1'035
Total dig. nutri. total	...	...	489'8	550'8	710'7	777'7
.. .. per day	...	...	4'223	4'748	6'385	6'704
<i>Net energy Therms.</i>						
(a) Total	...	...	443'4	496'4	660'0	687'9
(b) Per day	...	...	5'823	4'270	5'809	5'930
<i>Requirements per lb. Growth.</i>						
(a) entire period protein lb.	...	...	0'282	0'525	0'313	0'602
Energy Therm	...	...	1'323	1'777	2'232	2'465
(b) 14-week period Protein lb.	...	...	0'304	0'565	0'348	0'660
Energy Therm	...	...	1'420	1'907	2'435	2'696

The experimenters remark on this growth production experiments as under :—

- (1) "Digestion attained by individual animals of the two groups of heifers varied somewhat widely, but the digestion capacity of the older group was on the average distinctly higher than that of the younger group.
- (2) "The use of American digestion co-efficients for computing the digestibility of our rations gives misleading results.
- (3) "By comparing actual digestion with the digestion attained by mature bullocks on the same food at Bangalore it is found that the carbohydrate digestion is 10% below normal in the younger group and 3.4% below normal in the older group.
- (4) "The Armsby standard of requirements, though based on data for the energy content of the gain which does not hold for our animals, can be used for computing rations for our animals because the overestimates of the values of the gains compensate almost exactly for losses due to lower digestion etc. On the whole our requirements for growing animals are higher than Armsby's figures.
- (5) "Compared with the Wolff-Lehmann feeding standard our heifers utilised the standard amount of protein and less than the standard amount of total nutrients."

Regarding this growth production experiment we should note that the heifers chosen for the experiments were cross-bred and it is quite likely that the figures attained with these cross-breeds may not be applicable to our indigenous cattle breeds. As crossing with foreign breed bulls affects the milk-yielding capacity of the cross-breeds

it is quite likely that it might affect the digestion and assimilation capacities as well. A parallel experiment with indigenous pure-bred heifers would give us data that would, perhaps, be more applicable to our breeds. The experimenters' remark No. 3 quoted above is worth noting in this connection.

76. Bangalore Milk production Experiments* :—

The object of this experiment was to see whether foreign feeding standards could be applied to our milch cattle without any change or whether any modification of these would be necessary. For this experiment 8 newly calved cross-bred cows, differing in age and milk yield, were selected, and the experiment was concluded in 154 days. During the experiment the rations of the cows were worked out from the feeding standards of Savage because these allowed a liberal standard in nutrients and more protein. The ration was altered periodically to correspond with the yield and the quality of the milk. The cows were weighed every day, their milk yield was recorded daily, and weekly composite samples of the milk of each cow was analysed for fat and protein content. During the experiment two digestion tests were also made. The summary of the experimental results is given in the following tables.

(A) Food, Body weights and Milk yield.

Average composition of the foods.

Food.	Crude protein %	Ash %	Ether extract %	Crude fibre %	N. free extract %
Hay	2.31	7.63	1.50	41.06	47.50
Silage	5.79	8.28	1.87	39.85	44.21
Lucerne	21.75	11.03	2.80	29.90	34.52
Ground nut cake	57.31	4.75	8.07	4.86	25.01
Brewery grain	18.00	3.46	4.85	13.25	60.44
Grain mixture	16.00	7.50	4.53	23.36	58.61

*Agri. Memoir, Chem. Series, Vol. VIII, No. 9.

Cow No.	1	2	3	4	5	6	7	8
<i>Food in lbs.—</i>								
Hay ...	1189'8	1094'6	859'3	783'0	796'7	810'1	950'9	875'8
Silage ...	1007'1	1322'9	1072'5	1268'3	1280'1	1270'3	1385'5	1337'9
Lucerne ...	166'2	72'7	162'1	166'1	165'6	166'1	166'1	166'0
Grain mixture ...	1803'2	662'2	551'0	763'9	762'0	431'7	1008'4	756'3
Ground nut cake ...	363'9	345'6	301'4	324'3	324'5	256'8	352'7	342'2
Brew. grn. ...	405'0	405'0	405'0	405'0	405'0	405'0	405'0	405'0
<i>Bdy. weights—</i>								
Av. live weight lb.	912	955'9	897	708	801	828	915	853
Gain lb.	37'1	30'3	42'7	32'4	60'8	77'5	43'5	57'0
<i>Milk yield—</i>								
Total lb.	5461'2	3264'5	2887'3	3331'8	3463'8	2452'0	4059'8	3745'3
Av. Fat %	4'49	3'95	4'11	5'28	4'25	3'89	4'29	3'71
<i>Daily averages—</i>								
Food lb.	31'41	23'94	20'33	22'97	23'61	20'42	26'23	23'68
„ per 1000 lbs. wt.	34'26	25'28	22'71	32'36	29'59	24'48	28'67	27'69
Digested Org. Mat.	57'60	54'30	60'50	55'10	53'80	56'60	57'00	57'10

(B) Nutrients and net energy for milk production.
(Total amount digested actually and the amounts computed.)

Cow No.	Digested cr. protein		Digested org. matter		Digested nutrients		Net Energy		
	lbs.	as % of compu.	lbs.	as % of compu.	lbs.	as % of compu.	Therms	as % of compu.	
1	Computed	...	549.1		2760.5		2967.9		2625.7
	Actual	...	420.7	76.62	2630.0	95.27	2803.0	94.44	2502.0
2	Computed	...	406.9		2202.6		2355.5		2090.0
	Actual	...	295.8	72.70	1970.3	89.45	2084.1	88.48	1870.0
3	Computed	...	368.5		1900.6		2035.1		1805.9
	Actual	...	279.6	75.88	1867.7	98.27	1971.5	96.88	1775.0
4	Computed	...	405.3		2107.8		2259.5		2002.2
	Actual	...	300.1	74.04	1892.5	89.78	2010.1	88.96	1797.0
5	Computed	...	405.5		2119.3		2271.2		2011.8
	Actual	...	294.1	72.53	1862.2	87.87	1975.2	86.97	1768.0
6	Computed	...	337.6		1888.7		2017.1		1774.2
	Actual	...	240.1	71.12	1752.5	92.79	1845.2	91.69	1646.0
7	Computed	...	456.6		2411.8		2584.2		2286.3
	Actual	...	354.2	77.67	2253.8	93.45	2390.5	92.51	2137.0
8	Computed	...	418.8		2202.8		2359.1		2090.8
	Actual	...	314.8	75.17	2056.0	93.12	2177.8	92.31	1951.0
Average		...		74.5		92.5		91.5	

(Nutrients for Milk Production.)

				Crude Protein		Total Nutrients		Net Energy	
				Total lbs.	Per lb. of milk lbs.	Total lbs.	Per lb. of milk lbs.	Total Therms	Per lb. of milk Therms
Cow No. 1 Milk 5461·2 Fat % 4·49	Computed	...	...	450·8		1820·2		1756·7	
	Actual	...	...	322·4	0·059	1655·3	0·303	1633·0	0·299
Cow No. 2 Milk 3264·5 Fat % 3·95	Computed	...	...	303·8		1170·8		1193·3	
	Actual	...	...	192·7	0·059	899·4	0·276	973·3	0·298
Cow No. 3 Milk 2887·3 Fat % 4·11	Computed	...	...	271·8		900·0		946·5	
	Actual	...	...	182·9	0·063	836·4	0·290	916·6	0·318
Cow No. 4 Milk 3331·8 Fat % 5·28	Computed	...	...	329·0		1290·0		1268·0	
	Actual	...	...	223·8	0·067	1040·6	0·312	1062·8	0·319
Cow No. 5 Milk 3463·8 Fat % 4·25	Computed	...	...	319·1		1218·9		1214·9	
	Actual	...	...	207·7	0·060	922·9	0·266	971·1	0·280
Cow No. 6 Milk 2452·0 Fat % 3·89	Computed	...	...	248·3		941·0		959·5	
	Actual	...	...	150·8	0·062	769·1	0·314	831·3	0·280

				Crude Protein		Total Nutrients		Net Energy	
				Total lbs.	Per lb. of milk lbs.	Total lbs.	Per lb. of milk lbs.	Total Therms	Per lb. of milk Therms
Cow No. 7 Milk 4059'8 Fat % 4'20	Computed	...	...	357'4		1434'2		1415'6	
	Actual	...	...	255'6	0'063	1240'5	0'306	1286'3	0'312
Cow No. 8 Milk 3745'3 Fat % 3'71	Computed	...	...	326'8		1361'4		1259'7	
	Actual	...	...	222'8	0'060	1080'1	0'288	1119'9	0'299
Average					0'061		0'294		0'300
Haecker Standard					0'055		0'356	Eckles	
Bavage					0'067		0'363	average	0'323

These figures show that better milkers use the nutrients more economically by yielding more milk when compared to the poor milkers. The following table shows that the urinary nitrogen is a direct measure of the amount of protein supplied in excess of that converted into milk proteid and this excess of urinary nitrogen is more marked in the case of cows giving less milk.

(Ratio of Milk nitrogen to Urinary nitrogen.)

Cow No.	Order of milk yield	Test No.	Av. daily milk lbs.	Av. daily Nitrogen in milk in grm.	Av. daily Nitrogen in urine in grm.	Ratio of milk N: to Urinary N.
1	1	1st	38'4	78'87	135'84	1 : 1'723
		2nd	30'3	69'63	117'50	1 : 1'688
2	6	1st	23'9	49'33	118'30	1 : 2'398
		2nd	15'3	35'05	94'54	1 : 2'698
3	7	1st	18'7	42'02	97'36	1 : 2'317
		2nd	15'0	37'29	103'90	1 : 2'716
4	5	1st	24'1	55'85	107'20	1 : 1'821
		2nd	17'7	46'02	82'30	1 : 1'788
5	4	1st	25'2	58'66	98'31	1 : 1'676
		2nd	17'7	43'17	74'05	1 : 1'715
6	8	1st	17'3	39'32	88'10	1 : 2'241
		2nd	12'1	29'45	63'26	1 : 2'148
7	2	1st	29'1	64'73	106'95	1 : 1'652
		2nd	24'0	56'92	100'40	1 : 1'764
8	3	1st	27'0	59'55	103'96	1 : 1'746
		2nd	20'2	48'35	79'00	1 : 1'634

(Energy cost of milk production.)

Cow No.	Fat % in milk	Total fat	Total energy of digested ration Therms.	Total energy per lb. fat.	Available energy Therms.	
					(maintenance deducted.)	per lb. fat
4	5'28	175'35	1797'0	10'25	1062'8	6'06
1	4'49	245'83	2502'0	10'18	1633'0	6'63
7	4'29	165'73	2137'0	12'89	1266'3	7'64
5	4'25	145'61	1768'0	12'13	971'1	6'67
3	4'11	118'95	1775'0	14'92	916'6	7'71
2	3'95	125'72	1870'0	14'87	973'3	7'74
6	3'89	95'74	1646'0	17'19	831'3	8'68
8	3'71	138'95	1951'0	14'04	1119'9	8'06

This table shows that the production of one pound of fat in milk of poor quality requires more food energy than in milk of good quality. It will thus be noted that the cows yielding milk of poor quality are more expensive than those giving rich milk.

77. Summary of Milk Production experiment :—

- (1) "The actual digestion of organic matter was very nearly uniform for each cow throughout the feeding trial.
- (2) "The actual digestion of protein was decidedly less, of the fibre and fat distinctly more and of the organic matter slightly less than the computed amounts.
- (3) "Our protein digestion was more depressed while our organic matter digestion was less depressed (when compared to the American results). The latter is a favourable result which can be only partly accounted for by the high protein content of our ration. We are led to the conclusion that our cows possess better digestive capacity for organic matter and the difference is mainly due to higher digestion of fibre.
- (4) "Our average computed requirement of digestible protein is 0.092 lbs. per lb. of milk. Savage's average is 0.067. Our computed figure however is not strictly comparable with Savage's because (A) our roughages contain less than the average amount of digestible protein, and (B) our cows digest slightly less protein even when allowance is made for the low digestibility of our roughage. Therefore the excess of protein actually digested and utilized per lb. of milk is less than the difference between these two figures. That we fed a considerable excess of protein is shown by the urinary N. to milk N. ratios. Our average requirement of computed total nutrients is found to be equal to Haecker's figure. From

evidence adduced, this is seen to be a very economical use of total computed nutrients. The efficiency attained by our cows is attributed partly to the large proportion of protein in our total nutrients and partly to the better digestion attained by our cows.

- (5) "The actual requirements for milk production are in every case much lower than the computed figures. There is at present no procedure for making computations which agree closely with actual results.
 - (6) "In applying existing digestion co-efficients to the computation of rations in India, we find that the results obtained are not strictly comparable with American data. For rations similar to those used by us (and these rations imply an abundance of protein foods), the American digestion co-efficients are applicable if an excess of protein is fed and total nutrients are provided according to Haecker's standard. At present it is impossible to say what the result would be with less protein than the amount used by us.
 - (7) "The conception of net energy with respect to milk production requires further investigation. The data obtained by Eckles showed that the net energy required for the production of milk is less than the energy content of the milk produced. Our figures corroborate and amplify Eckles' data.
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PART III

MILK AND ITS PRODUCTS

CHAPTER VIII

MILK

78. Udder :—

Milk is secreted in the mammary glands which are collectively known, in the case of cattle, as the udder. The udder is divided into two compartments by a partition wall of strong fibrous tissue, each compartment containing one milk gland. The milk gland is sub-divided into several smaller compartments of which each is called a "lobule". The lobule in its turn is divided into small cavities called "Alveoli" where milk is actually secreted. The milk gland is supplied with pure blood by the Pudic artery and its capillaries; and impure blood from the milk gland is taken away by the Pudic vein which is commonly known as the "abdominal vein" or "milk vein". The gland is supplied with lymphatics and nerves. The lobules are separated from each other by partition walls and each has a duct. The alveoli are also separated from each other by thin membranes and are lined internally with a thin layer of active cells called "epithelial cells". Each alveolus has a duct through which its secretion flows. The ducts of several alveoli join with each other to form a bigger duct and several such join with each other to form a common duct of the lobule. The ducts of several lobules join with each other and ultimately the common ducts open into the milk

cavity. This cavity in its turn opens into the teat and communicates with the hole through which the milk comes out. There are several sphincter muscles in the gland situated round the milk ducts at their openings into the cavity and by means of these the cow can stop the flow of milk when excited.

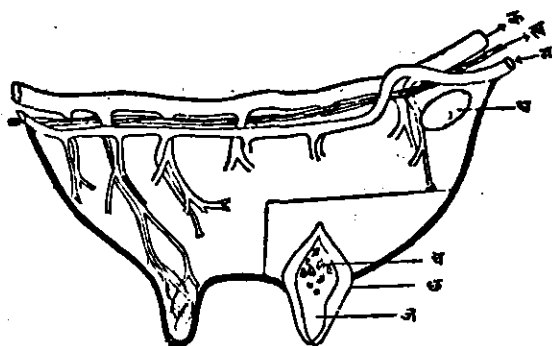


Fig. 1:—Internal Structure of Udder.

क:—Pudic Vein; ख:—Branch of Iliac nerve; ग:—Pudic Artery; घ:—Lymphatic gland; ङ:—Openings of milk ducts in Milk cavity; च:—Skin of the Udder; ज:—Cavity in the teat.

79. Formation of Milk:—

Until the year 1840 it was the common belief in Western countries that milk was simply a filtrate from the blood; but later, this supposition was shown to be erroneous as a result of the chemical analysis of milk and of the blood, the normal organic constituents of milk not being found in the blood. Examined under the microscope the milk gland revealed some connection between the formation of fat in milk, and the degeneration of the epithelial cells. It was also seen that the nuclei of the gland cells were constantly increasing and degenerating and they were exuded from the cells and collected in the open space of

the alveoli. Later on it was noticed that with the birth of the young one, the flow of blood towards the uterus was checked and diverted towards the gland, and hence it was thought that the material used up in nourishing the foetus was afterwards utilized in the formation of the milk. Thus, at present, there are several theories about the formation of milk, but what actually happens is not clearly understood; this much, however, appears to be certain: that in the formation of milk, the activity of the epithelial cells, the blood supply to the gland, and the circulating lymph take part. The fact that whenever a strong smelling substance such as garlic is given to a cow, the smell is perceived to some extent in the milk, shows that at least strong smelling substances of the food go into the blood and through it find their way into the milk. The close relation between blood and milk is also proved by the fact that some medicines and poisonous substances administered to milch cattle appear in their milk.

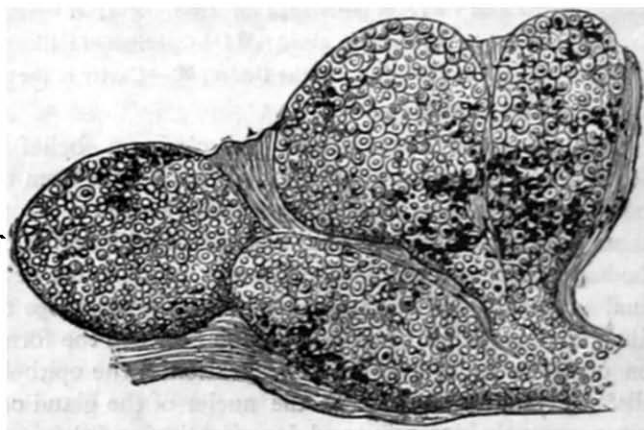


Fig. 2:—Alveoli (Magnified) in which milk is secreted.

80. Constituents of Milk :—

Milk contains water, butter fat, albuminoids, milk sugar and mineral matter. The *butter fat* is made up of different fats of varying compositions and properties. The fats are Stearin, Palmitin, Olein, Myristin, Butyrin, Caproin, Caprylin, Caprin, and Laurin (the first four of these are of non-volatile fatty acids and the rest of volatile fatty acids). These fats are present in the form of minute globules of various sizes. The fats have a tendency to decrease the specific gravity of milk. Milk containing large fat globules is better for cream and butter, because large fat globules are easily separated in preparing cream, and coalesce easily in butter making. The *albuminoids* of milk consist of two different proteids having different properties :—(1) Casein and (2) Albumin. Casein exists in a colloidal form and albumin in a dissolved condition. Casein is combined with salts of lime and hence on its precipitation some of these salts are also precipitated with it. Casein coagulates in the presence of organic and mineral acids while albumin alone coagulates on heating to about 160° F. The proportion of albumin in normal milk is comparatively very small. *Milk sugar* is a product found nowhere in nature, except in milk. It is soluble in water but comparatively less sweet and less soluble than cane sugar. It is insoluble in alcohol. On fermentation it is decomposed and Lactic Acid is formed. The *mineral matter* of milk contains Potash, Soda, Lime, Magnesia, Iron Oxide, Phosphoric Acid, Chlorine and traces of Sulphuric Acid, all present in the form of salts; probably Potash, Lime, Magnesia and Iron are present as Phosphates. The following table gives the complete analysis* of cow's milk

*McConnell—Agri. Note Book.

and will also give a good idea of the complexity of its composition. Milk also contains, according to Blyth, some air made up of 19·13% Oxygen, 3·27% Carbon dioxide and 77·60% Nitrogen. Leucocytes and Lactic bacteria are also present. The percentage composition of milk of animals belonging to different species is given in Article 83.

Complete Analysis of Cow's Milk.

Water	87·750 Water.
Casein	...	3·000	3·500 Proteids.
Nuclein	...	Trace	
Lact. Albumin	...	0·500	
Globulin	...	Trace	
Olein	...	1·430	3·400 Fats.
Stearin	...	1·680	
Palmitin	...		
Butyrin	...	0·143	
Caproin	...	0·085	
Caprylin	...	0·061	
Caprin (Rutin)	...		
Myristin	...	Trace	
Butin	...		
Laurin	...		
Lecithin	...		
Milk Sugar	...	4·450	4·600 Carbohydrates.
Galactose	...	0·170	
Calcium Citrate	...	0·1650	0·700 Min. Matter.
Mon. Pot. Phosp.	...	0·0900	
Sod. Chloride	...	0·0750	
Di. Pot. Phosp.	...	0·0610	
Pot. Chloride	...	0·0645	
Tri. Cal. Phosp.	...	0·0626	
Di. Cal. Phosp.	...	0·0523	
Pot. Citrate	...	0·0385	
Cal. Oxide (in Casein)	...	0·0365	
Mg. Citrate	...	0·0286	
Di. Mg. Phosphate	...	0·0260	
Cal. Carbonate	...	Traces.	
Cal. Fluoride	...		
Ferric Oxide	...		
Iodine	...		
Silica	...		

Urea	0'0070
Fibrin	0'0002
Sulphates	} Traces.
Sulphocyanates	
Hypoxanthin	
Cholestrin	
Lactochrome	
Odorous matter	
Galactase (Enzyme)	Traces.
Bitter Principle (Tannin Precipitate)	0'1000
Total	99'9672

31. Properties of Milk:—

Milk is a mixture of butter fat, milk sugar, albuminoids, mineral matter and water. The butter fat, some of the albuminoids and some of the mineral matter are suspended in a very fine state of division, while the milk sugar, a portion of mineral matter and a portion of albuminoids are in solution. Milk is heavier than water; the specific gravity of the milk of one cow at one milking varies from 1'028 to 1'034; but of the mixed milk of many cows, the specific gravity varies from 1'029 to 1'033. On an average, in England, the Specific Gravity of milk is taken to be 1'032, while in India the average specific gravity of cow and buffalo milk averages to 1'030 at 60° F. The Specific Gravity of the total solids (T. S.) of milk varies from 1'3 to 1'4 while the specific gravity of solids-not-fat (S. N. F.) is constant viz. 1'6. The reaction of milk on litmus is amphoteric (acid and alkaline). This double reaction is due to the presence of acid and alkaline salts. On keeping, the acid reaction increases. This is due to the formation of Lactic acid from milk sugar through the action of lactic bacteria. On standing milk in a cool room a layer of cream is formed at the top, because

the fat globules, being lighter, rise and collect at the top. When the milk is heated to 140° F. a tough layer is formed on the upper surface. This layer is formed by the oxidation of the albuminoids. If the first layer is removed, a second layer is formed and the same thing happens on further removals. If the layer is not removed it increases in thickness. The layer contains much of the milk fat. On prolonged heating the colour of the milk is changed; it becomes slightly pinkish, which is probably due to the partial charring of the milk sugar. The smell also is changed on prolonged heating and some of the fat globules unite with each other and form small drops of butter fat. Milk boils at about 214° F. and freezes at 33° F. and has the maximum density at about 37° F. Its latent heat is 0.847, water being 1.000. Colostrum is yellowish in colour and thick in consistency, it is also heavier than normal milk and its specific gravity varies from 1.046 to 1.079. The relative proportions of water, butter fat, albuminoids, mineral matter and milk sugar are different. It contains a far greater amount of albumin and hence on heating it coagulates easily.

Milk is an ideal article of diet that is provided by nature for the young one. It contains fat, which can be readily assimilated by the system and utilized for the supply of heat and energy. It contains albuminoids in an easily digestible form; these are used up in the building up of the muscles. The milk sugar supplies heat and energy and makes the milk palatable. The mineral compounds supply material for the bone-formation of the body. Milk is an admirable diet for weak constitutions, especially for those having a poor digestion. It should be quite pure and taken only in small quantities at a time, otherwise bad results might

follow. For persons of weak digestion milk requires to be specially treated *before being administered*: e. g. (i) dilution with water followed by boiling; (ii) removal of the skin formed on milk by heating; (iii) addition of lime water or soda to the milk before being given to sick people. All these steps are intended to help its digestion. Milk possesses the special property of absorbing odours; hence, it should be kept in a properly ventilated and clean place.

3a. Variation in the quantity and quality of milk:—

The constituents of milk mentioned before are not found to be in the same proportion in all milks but their relative proportions seem to be dependent upon various contributing factors. Of all these constituents butter fat and water are most variable, the mineral matter and albuminoids are the least variable. The solids of milk, excepting the butter fat, tend to make the milk heavier than water, while butter fat makes it lighter. Milk, rich in butter fat, is also rich in albuminoids, milk sugar and mineral matter; while, milk, poor in fat, is also poor in these "solids-not-fat", and hence the specific gravity of poor and rich milk does not vary very much. Timpe's formula for calculating proteids from fat percentage is: $\text{proteids} = 2 + 0.35 \text{ fat \%}$. According to Sherman the excess of proteids above normal averages about $\frac{1}{3}$ of the excess of fat. The factors which cause variation in milk constituents are:—

- (1) Species of the animal, (2) Breed of the animal,
- (3) Food and Fodder given to the animal, (4) Individuality,
- (5) Lactation period, (6) Time of milking, (7) Age, (8) Portion of milk, (9) Condition of the animal, (10) Season and Climate, (11) Part of udder from which milk is drawn.

83. Species :—

The quality of milk varies with the species of the animal. This will be clear from the following table which gives analyses of the milk of animals of different species.

Species.	Water %	Fat. %	Proteid. %	Lactose. %	Inorganic Salts. %
Human ...	86.7	4.1	1.2	6.9	0.2
Cow Indian ...	85.3	5.8	3.5	4.5	0.7
Buff.	81.2	8.7	4.3	4.9	0.8
Goat ...	87.6	4.2	3.6	4.0	0.5
Sheep ...	1.3	5.3	7.1	4.2	1.0

84. Breed :—

The proportion of milk constituents varies according to the breed of animal. Some breeds are heavy milkers and others are poor, while some yield milk of superior quality. This is simply due to the inherent qualities of different breeds developed under favourable conditions. The variations in the quality of milk of different breeds will be seen from the following table :—

Breed.	Fat %	
	Maximum.	Minimum.
Gir Cow ...	9.0	3.4
Sindi Cow ...	8.8	2.9
Montgomery Cow ...	5.5	3.3
Surti Buffalo ...	12.6	2.5

85. Food and Fodder:—

The quantity of milk as well as its quality is affected by the kind of food that is given to the cattle. If the cows are kept only on dry fodder their milk yield is reduced and the quality is also affected. If the cows are kept only on fleshy green fodders the amount of milk is increased but the milk becomes more watery and comparatively deficient in butter fat. If the cows are fed with only bulky fodders the yield as well as the quality is affected. Cows getting concentrated food like, oil cakes, *chuni*, *bhusi* etc. give a greater quantity of better milk than cows getting only bulky fodders. Some foods also affect the quality of milk. Cows getting cotton seed or cotton seed cake give milk that is very useful for butter making, as cotton seed has the property of hardening the butter fat. According to Porter, foods and fodders grown on lime soils improve the curdling and keeping qualities of milk and make it sweeter. Fodders from marshy lands deteriorate the quality of milk. Foods rich in proteids increase the percentage of butter fat in milk to some extent. According to Kellner, crushed oats and maize, wheat bran and *til* and rape cakes tend to soften the butter. Some condiments like ginger, *sira*, *sonf* etc. tend to increase the flow of milk temporarily. Strong smelling substances like garlic impart to some extent their characteristic smell to milk.

86. Individuality:—

Taking into account the animals of any one breed it is usual to find some individuals giving decidedly a greater quantity of milk than the average milk yield of the breed. Thus, out of the same breed, some cows are poor milkers, some are average milkers and some decidedly

superior milkers; this varying behaviour in the matter of producing a greater or smaller quantity of milk than the average is naturally developed in some individuals only, and this is known as "individuality". In the following table the difference in the percentages of fat in the milk of cows of the same breed is given,

Breed and Cow.	Morning.		Evening.		Authority.
	Max.	Min.	Max.	Min.	
Sindi Cow No. 12 ...	7.3	2.9	Mann and Meggitt.
" " " 7 ...	...	...	7.7	3.2
Gir " " 2 ...	...	...	9.6	4.8
" " " 8 ...	7.4	3.6	...	...
Surti Buff. " 10 ...	8.8	2.5	...	...
" " " 13 ...	...	...	10.7	5.2

87. Lactation:—

During the first part of the lactation period the amount of milk given by a cow is more than in the latter part. The maximum limit is reached during the first two or three months, after which the quantity gradually decreases, till the animal runs dry. The average rate of increase or decrease varies from 2.4 to 4.4 and 1.8 to 3.7 oz. daily in the case of Montgomery cows and Delhi buffaloes respectively. The quality of milk also varies with the advance in the lactation period. Colostrum is very thick, highly coloured and rich in albuminoids. As the period advances the proportion of albuminoids is gradually decreased and the proportion of water is gradually increased. Generally in

the second month the milk becomes more watery and the amount of butter fat is then at its lowest. From the third month the amount of water is gradually decreased and the amount of albuminoids and butter fat is gradually increased i.e. during the latter part of the lactation period the milk becomes richer but its quantity is gradually decreased. During the last portion of the lactation period, when the cow is generally pregnant, the amount of saline matter is increased, so much so that the milk becomes distinctly saltish in taste. : The following table shows the difference in the quantity of milk according to the advance in lactation period.

Part of Lactation.		Gir Cow.	Sindi Cow.	Surti Buff.
1st	Tenth	... 299	415	374
2nd	..	... 337	440	491
3rd	..	... 369	454	483
4th	..	... 353	434	438
5th	..	... 318	388	393
6th	..	... 276	333	351
7th	..	... 238	299	311
8th	..	... 203	257	270
9th	..	... 146	205	227
10th	..	... 79	137	143

The variation in quality of milk as the period advances will be seen from the following :—

Part of Lactation.		Surti Buff. No. 17 Fat %	
1st	Tenth	... ..	7.4
2nd	..	... ..	6.8
3rd	..	... ..	7.6
4th	..	... ..	7.4
5th	..	... ..	8.0
6th	..	... ..	7.9
7th	..	... ..	7.7
8th	..	... ..	8.5
9th	..	... ..	8.5
10th	..	... ..	8.4

The following table clearly shows the difference between milk and colostrum. The mineral matter of colostrum contains a very high percentage of calcium oxide and phosphoric acid. These two constituents in large quantities are essential for the building up of bones. The high proportion of proteid matter is necessary for the development of the muscles of the growing calf.

	Colostrum.	Milk.
Water ...	71.69	85.30
Butter fat ...	3.37	5.55
Casein ...	4.83	3.67
Albumin ...	15.85	
Milk Sugar ...	2.40	4.66
Mineral Matter ...	1.78	0.76

88. Time of milking :—

Generally, cows are milked twice a day ; but the amount of milk given at each milking varies with the period that passes between two successive milkings. Generally when the days are shorter the quantity of milk obtained from the evening milking is comparatively less than that obtained from the morning milking. When cows are milked at equal intervals their milk yield is nearly the same at both milkings. The quality of milk also varies with the time of milking. Under ordinary conditions evening milk is always richer than morning milk in butter fat. According to the Mann and Meggitt analysis of 141 samples, the milk of a herd of Gir and Sindhi cows showed an excess of 0.9% in the evening milk on an average, but if an equal interval is allowed morning milk is richer as is seen in Pusa experiments. If cows are milked thrice a day at equal intervals about 20% more milk per day is thus obtained than when milked only twice a day but the quantity at each milking is necessarily less.

89. Age:—

The age of the animal influences the quality of milk. From the first lactation period the amount of milk gradually increases at each calving, because the udder of the cow develops in size and capacity every year till the eighth year. Supposing the first calving takes place in the 4th year, the udder of the cow will be fully developed and will have the maximum milk producing capacity at the 4th calving. Cows live for about 20 years and they produce on an average 10 to 12 calves, and by the 4th or 5th calving the maximum daily milk yield is noted after which the milk yield gradually falls as the cow becomes older and older. It will thus be seen that it is always profitable to buy young cows and not fully grown ones. Eckles gives the difference in the quantity and quality of milk as the age advances for a herd of 10 cows and for 6 successive lactation periods as under:—

Lactation Period.	1	2	3	4	5	6
Average Milk Yield in lbs.	4754	5060	5648	6575	6341	6339
Average Fat %	4.85	5.10	5.09	4.82	4.68	4.69

90. Portions of a milking:—

The proportion of milk constituents is not found to be the same if the milk is examined part by part as it is drawn at one milking. The first portion of milk is always more watery and contains the least percentage of butter fat. As the milking is continued the proportion of water is decreased and that of butter fat is gradually increased, and the last portions of the milk drawn, called strippings, contain comparatively the least percentage of water and the greatest percentage of butter fat.

This will be evident from the following :—

	Fat %	Water %	Total Solids %
First Portion	... 1'20	89'42	10'58
Last Portion	... 7'88	83'37	16'65
Strippings	... 10'00	84'60	19'40

(Mc Connell Agri. Note Book.)

Portion of Milk at one Milking	Morning.	Evening.
	Fat %	Fat %
First Portion	... 0'4	0'8
Middle Portion	... 2'0	3'2
Strippings	... 12'2	8'0

(J. Golding.)

Regarding the bacterial content, the fore milk is the worst as it contains the highest number of bacteria. When the cows are not suckled or when the fore milk is mixed with the rest, the bacterial content is raised and that affects the keeping quality of milk.

91. Season :—

As the climatic conditions change the composition of milk also changes. This is due to the difference in the quality of fodder and variations in temperature and other climatic conditions. From the table given below it will be quite clear. It will also be noted that milk in winter is of the best quality while in the rainy season its quality is poor.

Season.	Morning.	Evening.
	Fat %	Fat %
Cold Season (Nov.—Feb.)	... 7'16	8'22
Summer „ (March—May)	... 6'94	7'81
Rains „ (June—Oct.)	... 6'86	7'66

(Mann and Meggitt.)

The bacteriological investigations carried out at Pusa show that the bacterial content of milk varies according to the season, the summer milk showing lower content than the rainy season milk. The bacterial contents were as under in the two seasons.

In both cases fresh after-noon milk was taken for examination.

SUMMER SEASON

Out of 37 samples :

5	samples	gave	from	2000	to	3000	counts	per	c. c.
9	"	"	"	3000	"	5000	"	"	"
7	"	"	"	5000	"	8000	"	"	"
7	"	"	"	8000	"	10000	"	"	"
5	"	"	"	10000	"	15000	"	"	"
2	"	"	"	15000	"	20000	"	"	"
2	"	"	"	over	20000	"	"	"	"

In 10 samples bacillus coli reaction was negative in 1/10 c. c. and in 10 samples it was positive in 1/100 c. c.

RAINY SEASON.

Out of 35 samples :

5	gave	below	15000	counts	per	c. c.
6	"	between	15000	and	20000	"
13	"	"	20000	"	30000	"
5	"	"	30000	"	50000	"
4	"	"	50000	"	75000	"
1	"	"	75000	"	100000	"
1	"	above	100000	"	"	"

In only 12 samples bacillus coli reaction was negative in 1/100 c. c.

According to Willoughby the seasonal variations take place as under :—

November to January...	Rich in Fat and S. N. F.
February to April ...	Fat decreases, S. N. F. remain the same.
May to June ...	Fat and S. N. F. decrease.
July to August ...	Milk is poorest.
September to October	Fat and S. N. F. increase.

92. Part of Udder :—

The experiments carried on at Pusa by Leather and Dobbs show that the milk taken from the right and left mammary glands separately shows variation in the quantity and quality as well. Some cows yielded more milk from the right gland than from the left while in others opposite results were seen. The following table shows this :—

Cows.	Left Side.		Right side.			Period days.	
	Yield lb.	Fat %		Yield lb.	Fat %		
		Morn-ing.	Even-ing.		Morn-ing.		Even-ing.
Khaki ...	7'17	4'63	4'12	6'29	4'62	3'74	29
Sabhagi ...	5'08	4'96	4'00	6'07	4'79	4'10	29
Kamali ...	5'05	4'73	3'52	6'07	5'30	3'62	31
Moghi ...	4'62	4'94	3'72	6'30	5'36	3'83	31
Budhi ...	6'10	4'46	3'16	6'62	4'60	3'50	31

These differences are not so very important from a practical standpoint but they are worth noting in scientific

study. These experimenters have also found that the milk from fore and hind quarters of both sides show difference in the quality.

93. Other Factors :—

Variation in the milk yield is caused by extremes of climatic conditions e.g. cows exposed to cold and heat reduce their milk yield. The yield is also affected when the cows have to move from one place to another. This is partly due to the change of their attendants and surroundings and partly due to change of food and climate. When the Punjab cows are taken to other provinces with a different climate they reduce their milk yield, though proper precautions are taken in their feeding. The milk yield is affected when the cows are on heat and when they become pregnant. If the cows are taken walking a long distance their milk yield is decreased temporarily. This change is due to too much exertion. If the cows are frightened their milk yield is affected. Milk is also reduced by sickness.

94. Limits of Variation of Milk Constituents :—

According to Bennister and Richmond the maximum and minimum limits of variation of milk constituents are as under :—

Limit.	Fat %	S. N. F. %	T. Solids.	Ash.
Maximum	... 12.52	10.51	20.97	0.85
Minimum	... 1.04	8.23	11.55	0.73

In the case of Indian cow and buffalo milks the variations observed are as under :—

	Fat %	S. N. F. %
Cow's Milk	... 2.9—9.0	8.0—11.1
Buff. Milk	... 2.5—12.6	8.2—12.2

CHAPTER IX

MILK PRODUCTS

95. Milking of Cattle:—

The purity of milk partly depends upon the care taken during milking because there are many chances of getting the milk contaminated as it is drawn or while it remains in the cattle-shed yard. In order to avoid this, special precautions are required to be taken. The cow-shed should be cleaned before milking but if this is not possible, the cows should be taken out and tied in a clean courtyard in open air and milked. The cleaning of the courtyard should not be done just before or during the milking operation because by doing so the air becomes full of dust particles which are likely to get mixed with the milk. The body of the cow should be properly cleaned especially the lower portion of the abdomen, and the udder. Just before milking the udder and teats should be wiped clean with a moist towel. The tail of the cow should be tied to one of the hind legs in order to prevent its movement and so to prevent the falling of the dirt into the milk when the tail is moved. The milking pots should be clean and dry. Pusa experiments show that cover-top milking pots help in reducing the bacterial contamination and these are therefore preferable. In this respect the time honoured narrow mouthed *lotas* are far better than the new corner buckets. The milkman should wash his hands quite clean before the milking. The milkman's finger nails should be closely cut in order to

prevent chances of injury to the teats of the cow. Before proceeding to milk the milkman should call the cow by her name and should pat her gently. At the same time the calf should be allowed to suckle and it should be separated very carefully, when it has taken the usual quantity of milk. If the calf is drawn all of a sudden while sucking it is likely to injure the teats of the cow as the calf is likely to bite the teat in attempting to resist and to drink more milk. Milking should be done firmly and swiftly by both the hands. If the fore teat of the left side is taken in the left hand the hind teat of the right side should be taken in the right hand and the cow should be milked. At the time of milking the teat should not be drawn down in order to get the milk out but the teat should be held between the fingers and it should be pressed between the thumb and the fingers in order to get the milk flow; at the same time the hands should be pressed gently on the udder. Some times gentle knocking on the udder with the fist is required in order to accelerate the flow of milk. When milking is over the calf should be let loose to suckle. The cows should not be given any thing to eat at the time of milking because they soon acquire this habit and do not allow milking unless they get something to eat. The feeding and watering of cows should be done one hour previous to milking. At the time of milking the cows should not be frightened or excited in any way. The cows should be milked thoroughly. If some milk is allowed to remain in the udder the milk yield decreases specially in the case of cows without a calf. As far as possible the cows should be milked at equal intervals. If the periods are unequal the quantity of milk given by the cow varies. Beginners or bad milkers should not be allowed to milk good cows because they are likely to spoil them. If the cows are heavy milkers they should be milked thrice

or even four times a day; because, if this is not done, they some times acquire the habit of sucking their own milk and are thus spoiled. Some times in the case of very heavy milkers the milk flows out by itself from the teats or some times the udder becomes inflamed. The milk yield of each and every cow should be weighed and noted in the milk yield register at each milking. A herd recorder* is very useful for this purpose.

96. Care after milking:—

The milk should not be kept in the cowshed for any length of time after milking; but, it should at once be removed to a well ventilated and clean room. If it is left in there it absorbs the bad vapours of the cowshed. When the milk is taken to the proper room it should be strained with a piece of clean cloth and it should be weighed and the weight should be noted down in the account book at once. The milk should not be kept open in any case but it should always be covered with a piece of clean cloth. If we have to use metal ware or pots for covering the milk vessels we should, in the first place, see that they are clean. This is specially the case to be attended to in covering vessels containing warm milk. If the bottom of the vessel is not clean the water vapour from the warm milk is condensed on the bottom and it falls back into milk in the form of drops taking with it the dirt and the milk is spoiled. In summer, milk should not be kept for a long time in warm or hot rooms because it is spoiled in a very short time. In such cases it should be always kept in cool and well ventilated places.

*A *herd recorder* is simply a spring balance for weighing the milk of a dairy herd. It consists of a tripod stand spring balance and a bucket. When the empty bucket is put on the hook the pointer indicates the zero mark on the balance dial. On the dial of the balance pounds and gallons are marked separately.



Plate 3 :—1, Herd recorder ; 2, Milk cans ; 3, Measure ; 4, Seal pincers.

97. Purification of milk by means of Cream Separator:—

Milk is sometimes purified after ordinary straining, by means of the Cream Separator. In Alfa Laval machines, a tin ring specially prepared for the purpose is fitted and the cream screw is screwed out till it comes in level with the bowl surface and then the milk is centrifuged in the separator. In doing so all dust particles and a quantity of bacteria that escape through ordinary straining are separated and collected in the sticky layer adhering to the inside of the bowl cover, and pure milk comes out of the machine. This process is better than mere cloth straining.

98. Refrigeration of milk:—

Milk is warm when it leaves the udder and hence if it is kept in that condition the development of bacteria takes place, their number gradually increasing. These bacteria may be derived from the air of the cowshed or the room in which the milk is kept, or from such other sources as flies, churns, milking pots, the body of the cow, the milker, the strainer, &c. In order to check bacterial growth and to improve its keeping quality milk is given a cooling treatment. This is done by means of a "refrigerator" or "cooler". Its construction is quite simple; on the outside there is a spiral threadlike projection for increasing the surface area and for maintaining the current of milk in a thin layer, and just underneath this there is a coil of tubing for the flow of cold water. On the top there is an arrangement for receiving the milk and at the bottom one for collecting it. Milk flows on the outside from top to bottom while the cold water current underneath it flows in exactly the opposite direction.

It is worked by opening first the current of cold water and then the milk. The temperature of milk is lowered as it descends, and as it leaves the refrigerator it has nearly the same temperature as that of the cold water. Generally the temperature is lowered to 50° to 60° F. If milk is given this cooling treatment its keeping properties are improved and it can be safely sent to customers residing at a distance. The use of an ordinary refrigerator requires a liberal supply of ice-cold water. In large dairy concerns carbon dioxide or ammonia refrigerators are used. Refrigeration of milk should be completed within 15 to 20 minutes after milking.

99. Pasteurization of milk :—

When milk has to be carried to distant places by means of carts or railway trains it is usually pasteurized. This operation is a combination of heating and cooling in the order mentioned. The apparatus in which milk is heated is called the "pasteurizer" and that in which milk is cooled a "refrigerator". The pasteurizer is a cylindrical metallic vessel with a steam jacket all round, a lid, a fan, and, there is an inlet for steam at the rim, and an outlet at the bottom, and these communicate only with the steam jacket. The inlet for the milk in the vessel is at the bottom and the outlet is at the rim. This arrangement is exactly opposite to that of the refrigerator. The fan is worked by means of either a steam or water turbine. There is also an arrangement for noting the temperature of milk as it leaves the machine. When the machine has to be worked the fan and lid are fitted up, steam opened into the jacket, the fan is set in motion and when it attains its full speed milk is admitted into the machine. —By the rapid circular motion of the fan a

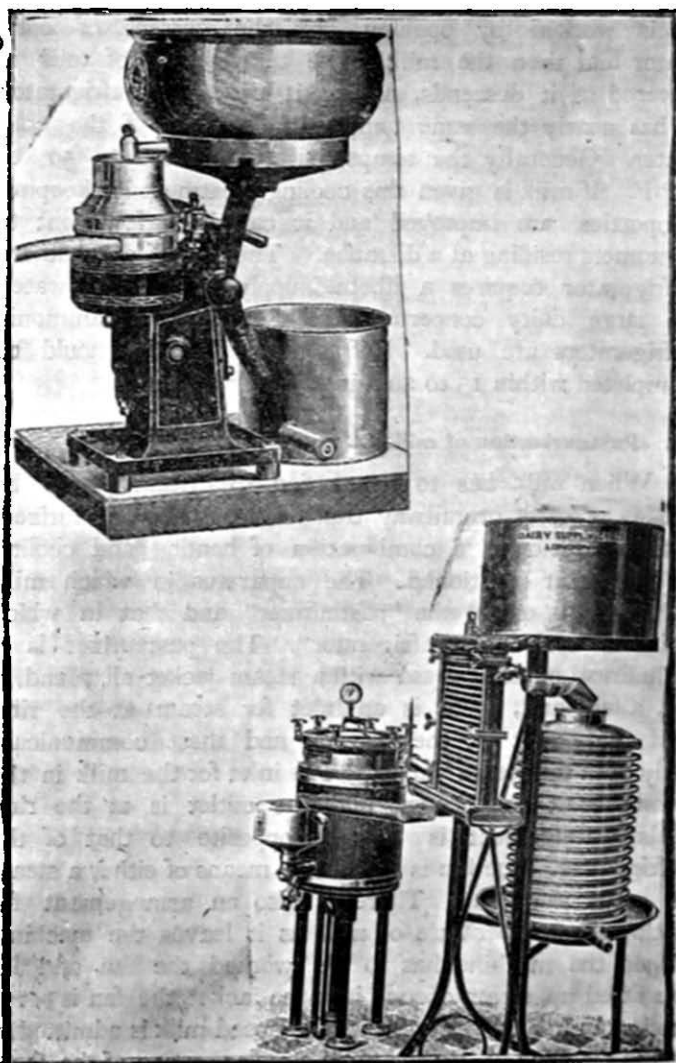


Plate 4:—1, Cream separator ; 2, Pasteurizer ; 3 Refrigerator.

sort of whirlpool of milk is formed and milk rises from bottom to top in a thin layer along the sides of the vessel and as it rises its temperature is raised as there is only the metal of the vessel between milk layer and steam. In this way the uppermost portion of milk attains the highest temperature as it leaves the machine. Generally the temperature of milk is raised to 140° to 176°F . and by regulating the current of steam and milk the temperature of milk can be raised to any desired degree. Milk as it flows out of the pasteurizer is admitted into the refrigerator where its temperature is lowered to 55° to 60°F . After cooling, the milk is canned and then despatched. The chief object in pasteurizing the milk is to kill all living bacteria and thus to improve its keeping property. The pasteurizing temperature is not sufficient to kill the spores of bacteria that may be present in the milk. On pasteurization milk acquires a characteristic flavour. The flavour of cream and butter made from pasteurized milk is also slightly different from that made from fresh milk.

400. Sterilization of Milk:—

Sterilization of milk is done in two ways:—

(1) The "intermittent" method, that is, pasteurizing milk at intervals three or four times and (2) the "direct" method, that is, subjecting the milk to sterilizing heat, by means of steam, so as to kill all bacteria and their spores. For the second method a special apparatus is required. Fresh milk is taken and put into special sterilizing bottles. These are provided with spring stoppers lined with rubber washers, the whole being subjected to steam. The bottles are previously cleaned and sterilized, when milk is put in leaving nearly $\frac{1}{2}$ of the bottle

empty. Then the stoppers are loosely put on and the closing caps are put in position after drawing out the closing rods. The bottles are then put into the sterilizer, the lid is fixed and steam is gradually admitted. The temperature is raised to 230° to 260°F. and maintained for about half an hour. The lid of the sterilizer is opened after the steam is shut off and immediately the closing rods are pressed to fix the stoppers of the bottles. Hot water is then admitted into the apparatus and after a time some slightly warm water so as to lower the temperature gradually in order to avoid cracking the bottles. When the bottles are cooled down to air temperature they are taken out and placed horizontally on a stand and occasionally shaken in order to avoid the formation of a firm cream layer. To ensure success in sterilization the milk must be quite fresh to start with and with as low bacterial content as possible.

101. Distribution of milk :—

Vessels in which milk is to be taken for distribution must be quite clean and properly tinned. The vessels should be provided with a well fitting cover so that dust may not fall in the milk during transit. The vessels should be locked or sealed after putting in the quantity of milk to be distributed. This precaution is necessary in order to prevent adulteration. When the milk is to be distributed by means of measures care should be taken to keep the measures quite clean. The measures must never be kept on the ground. Before putting in the milk we should see whether the customer's pots in which the milk is to be given are clean or not and in no case should the milk be touched by hand. Before distributing milk it should be well stirred in order to mix the upper layer

and the lower portion of the milk properly, otherwise the upper portion will be distributed to some customers and the lower portion to others, which will naturally contain comparatively less fat, and hence all the customers may not get milk of the same quality. The total loss in pasteurizing and distributing should not exceed 3 per cent.

102. Cream:—

Cream may be defined as milk containing a very high percentage of butter fat. When ordinary milk is kept standing several hours in a cool place the greater portion of its butter fat collects in its upper layer. This layer is the cream. It is comparatively lighter than milk. It also differs in colour being slightly pinkish or yellowish. It contains from 25 to 65 per cent. butter fat, the rest being casein, albumin, milk sugar, mineral matter and water. Thus, the constituents of cream and milk are the same but their proportions vary.

The following table shows the relation between milk and cream.

Sample.	Av. of.	B. Fat%	T. S. %	S. N. F. %.	
Original Milk	...	71	4.38	13.42	9.03
10 to 15% F. Cream	...	6	14.44	21.87	7.60
20 .. 30%	7	25.09	31.30	6.22
30 .. 40%	14	36.98	42.28	5.39
40 .. 50%	15	44.73	50.05	5.39
50 .. 60%	11	54.08	58.55	4.38
60 .. 70%	2	62.45	66.69	3.24

Compared with milk, cream has a thicker consistency, is more easily digested and also very easily fermented. When fermentation sets in, cream becomes thicker and frothy, acquires a sour smell and shows a rise of temperature. When it is intended for butter making it should be put in wide mouthed enamelled vessels or chinaware and should be covered with a thin cloth and kept in a fairly cool and airy place for ripening. If it is kept in a warm place it is fermented in a very short time. If fermentation is allowed to proceed too far the butter fat is decomposed and butyric acid is formed : and then it smells bad. In winter, cream takes rather longer to ripen while in summer the ripening takes place more rapidly. If the quantity of cream is too small for butter making cream of 2 or 3 days may be added till the quantity becomes sufficient for butter making, but care should be taken to mix the fresh cream with the stale cream quite uniformly. If it is not uniformly mixed the unmixed portion of stale cream is fermented more, and when butter has to be made from such a sample it separates from the old cream first, while the butter from the fresh cream separates after a long time and when the butter from the old cream has become over-churned. There are two methods of preparing cream from milk :—(1) the process of Setting, (2) by means of a Cream Separator.

103. Setting Process :—

In the process of setting, the milk is kept in a clean pot in a cool place and is allowed to remain undisturbed for about 24 hours. During this period the cream collects in the upper portion of the milk in a thick layer. Then it is separated from the milk by means of special spoons. That portion of the milk which is left behind after removal of cream is called "skimmed milk". For this process the temperature of the room in which the milk is

kept should not exceed 55° F. If the temperature is higher the milk is spoiled very easily and in that state the cream does not properly separate.

104. Cream Separator:—

Various kinds of cream separating machines are available in the market but all of them are constructed on one and the same principle, that of centrifugal force. Milk is a mechanical mixture of water and several solids. Some of these solids are in a suspended condition and some are dissolved in water and at the same time some of them are lighter and others heavier than water. Butter fats are suspended in the form of very minute globules and hence when milk is subjected to the action of centrifugal force these butter fat globules are separated from heavier constituents of milk and are collected towards the central portion of the moving mass. Advantage of this is taken in separating the cream and machines for this purpose are constructed accordingly.

105. Preparation of Cream by means of Cream Separator:—

The most important precautions to be observed in working Alfa Laval machines are (1) Proper temperature of milk, (2) Uniform motion of machine, avoiding jerks, (3) Proper speed of the handle, (4) Proper height of the "cream screw" above the rim of the cream cover, (5) Proper distance of the cream screw from the centre of the bowl, (6) Straining of the milk, (7) Proper lubrication of the machine. In actual working the machine should be well lubricated, that is with its oil reservoir full. All the moveable parts of the cream separator should then be adjusted in their proper order. Milk which is previously strained and brought to proper temperature (in winter 95°F. and in summer 85°F.) should then be put into the milk reservoir and the

machine started very slowly at first, and the speed gradually increased till at last the handle turns about 60 times per minute. When this speed is attained the milk should be let in and the machine worked with the same speed and evenly till the reservoir is emptied. About one pound of separated milk should then be added to the reservoir and the handle let go; the cream tube should be watched and as soon as milk is seen to flow from it the flow of milk into the machine should be stopped. Then the quantity of the separated milk and cream should be entered in a register. In winter it is always better to keep the bowl in warm water for some time before adjusting it in the machine as this precaution prevents the choking of the small spaces between discs. The sticky substance adhering to the inner surface of the cover of the bowl contains all the dirt and a large number of bacteria present in milk and hence this layer should not be mistaken for cream but should be thrown away. When cream separation is over all separable tinned parts should be removed for washing and the stand and enamelled portion should be wiped clean with moist cloth. Water is not to be used as it sets in rusting. The quantity and quality of cream thus obtained varies according to the quality of the milk, the speed of the bowl and the position of the cream screw. From buffalo milk we get naturally more cream. If the speed of the bowl is increased or the cream screw is screwed in, the quality of cream is improved but the quantity is decreased and opposite results are obtained if the speed is decreased and the cream screw is screwed out. A separator record should be kept to check the working of the machine. The following formulæ and table are useful in cream calculations.

$$(1) \text{ Minimum cream removed} = 100 - \frac{F}{3} \times 100$$

where F = Fat % in separated milk.

$$(2) R = \frac{100(F - F')}{X - F'}$$

$$(3) X = \frac{100(F - F')}{R} + F'$$

where R = % of cream to milk: F = % Fat in milk:
F' = % fat in separated milk: X = % Fat in cream.

(4) Cream raising co-efficient

$$= \frac{\text{lb. of fat in cream got} \times 100}{\text{lb. of fat in the milk separated}}$$

(5) Cream lbs.

$$= \frac{\text{lb. of milk} \times \text{fat \% in milk}}{\text{Fat \% in cream.}}$$

Table showing ratio of Fat to T. Solids in cream.

(RICHMOND)

T. Solids	Fat %	T. Solids	Fat %
60	55.8	44	38.2
59	54.7	43	37.1
58	53.6	42	36.0
57	52.5	41	34.9
56	51.4	40	33.8
55	50.3	39	32.7
54	49.2	38	31.6
53	48.1	37	30.4
52	47.0	36	29.3
51	45.9	35	28.2
50	44.8	34	27.1
49	43.7	33	26.0
48	42.6	32	24.9
47	41.5	31	23.8
46	40.4	30	22.7
45	39.3	...	...

106. Standardizing Cream:—

When cream is required to be of some standard quality with respect to fat contents, the difference between the fat percentage of the ordinary cream and that of the required standard is adjusted by diluting with separated or whole milk or mixing in with cream containing a higher or lower fat percentage as the case may be, thus bringing the fat percentage to the standard. For this purpose the fat percentage in the samples of cream and milk has to be determined first and the proportions in which these have to be mixed may be determined according to Pearson's Formula given below. The same method is applied to standardize milk* if the original milk differs from the standard required.

107. Pearson's Formula:—

The difference between the standard fat % required in cream and the fat % in the milk represents the parts of *cream sample* to be mixed, and the difference between the standard fat % and the fat % in the cream sample represents the parts of *milk sample* to be mixed. This mixture would be the standardized cream. The formula is expressed diagrammatically in the following example.

Example:—

In what proportion should cream containing 50 % butter fat and milk containing 3.5 % butter fat be added to make a cream containing 20 % butter fat ?

Cream	F. %	50	}	stand	{	16.5 lbs. cream
				—20—		to be added to
Milk	F. %	3.5	}	crm. F. %	{	30 lbs. milk.

*Strictly speaking this is adulteration, as "standardized milk" is not "whole milk". Standardized milk must, therefore, be labelled as such.

Or the following formula may be used :—

Sep. Milk to be added lbs. roughly

$$\frac{\text{cream lbs.} \times \text{fat \% in cream}}{\text{Fat \% in standardized cream}} = \text{cream lb.}$$

108. Separated Milk :—

Separated milk is the milk from which cream has been removed. It contains about 0.2% butter fat. The percentage of other constituents of separated milk is comparatively greater than in milk. It is more nutritive because it contains a greater portion of albuminoids which are necessary for the formation of flesh; the only deficiency is of butter fat. It is also purer than the whole milk because such impurities like dust particles and bacteria that escape through the straining cloth are collected and retained by the sticky layer that is formed on the inner surface of the bowl of the separator.

109. Butter :—

Butter is usually prepared from ripened cream; but it can be prepared from fresh cream as well. In ripening cream all points given in Art. 102 should be noted. If the ripening of cream is to be hastened a little fresh butter milk should be added and well mixed with it. In summer, cream intended for butter making should be thicker and richer in butter fat while in winter it should be thinner and less rich in fat. This precaution makes the cream ripen in reasonable time. Butter churns of various patterns are available but barrel churns are preferable for all the ordinary purposes, as they are simpler and easier to work with. The lid of the churn is fitted with a glass window pane for watching the formation of butter grains, and a spring ventilator for the escape of gases disengaged by agitation of cream.

during the churning. The barrel is provided with a hole for the removal of butter milk and water used in washing the butter grains. Butter-making requires plenty of cold water and hence plenty of ice is required. Ice-making machines are, therefore, kept in large dairy concerns. In butter-making only wooden appliances and enamelled vessels are to be used as the butter fat does not stick to the former when they are previously well soaked in water and the acid of butter-milk does not act on the latter.

The first part of the morning, when conditions of atmospheric temperature are favourable, is the most suitable time for butter-making. First of all wooden appliances that are to be used in connection with butter-making should be thoroughly soaked in water and scrubbed with salt and kept wet by covering them with a wet cloth ready for use. This precaution prevents the sticking of butter. Then the ripened cream should be thinned sufficiently by adding cold water the quantity varying according to the thickness of cream. Then butter colour* of ordinary concentration should be added at the rate of 5 to 8 drops per lb. of cream and well mixed. After adding colour the mixture should be strained and its temperature should be brought to 50° to 55° F. in summer and 55° to 60° F. in winter. Afterwards the cream should be put into the churn leaving a little more than half of it empty. Then the lid should be fixed and the handle should be turned at the rate of 30 to 40 revolutions per minute. If the churn is turned more rapidly the butter takes longer to make. After a few turns the churn

**Colour of Butter :—*

Annatto seed colour is used for colouring butter artificially. The seed is steeped in milk, squeezed and strained and then the coloured milk is added to cream at the time of churning. Or the colour is extracted in olive oil and the extract is kept ready for use. Such colour extract can be had ready made.



Plate 5 :—1, Sterilizer ; 2, Barrel butter churn ; 3, Circular butter worker.

should be ventilated for the escape of gases by pressing the spring provided for the purpose and then the turning of the handles should be continued and the glass pane watched. If formation of butter grains is seen to be delayed a little warm or cold water as required should be sprinkled (i.e. when the temperature of cream is too low warm water and when it is too high cold water should be used). This treatment hastens the formation of butter grains because it creates a favourable temperature for the union of fat globules with one another.

When fine butter grains are formed the glass pane appears less cloudy and as the separation of grains become more and more complete the glass gets clearer and clearer. At this stage the motion of the churn should be reduced and when butter grains of the size of a *jowar* grain are formed the churning should be stopped, little ice cold water added, and a few more turns given. After allowing the churn to stand at rest a few minutes, butter milk should be removed by opening the plug of the hole. The butter milk should be passed through a horse hair sieve or muslin cloth so that the butter grains that escape can be collected and put back into the churn. As soon as butter grains are seen to flow out, the hole should be corked and cold water added and a few revolutions again given to the churn, the latter being then allowed to stand still for a while and water removed as before. This is the process of washing the butter grains. Two or three washings are sufficient to remove all butter milk from the butter. More washings than this might diminish the flavour of the butter while butter-milk left in the butter might reduce its keeping quality. After the butter has been washed in the churn, a little ice cold salt water should be added and the mixture churned gently for a short while. After standing, the

butter grains will have become sufficiently hard for being removed with a scoop and put on a butter worker. It should then be properly worked on the butter worker* with the addition of a little finely powdered common salt if it is intended to be preserved for some time. Care should, however, be taken not to destroy the grain in attempting to press out more water lest the market value of the commodity be affected. Properly worked butter presents a granular appearance, when the butter block is half cut with scotch hands and then broken into two pieces. The appearance of the article influences its price. When a butter block is pressed with scotch hands from sides the formation of small drops of water on the upper surface indicates usual water content. After working, the butter should be weighed and made into blocks of definite weights, wrapped in butter cloth or paper and then stored in a butter box in ice. The following table and formulæ will be useful in butter calculations.

Table showing the amount of milk, of known fat content, required to prepare one lb. butter.

Milk lbs.	Fat % in Milk.	Milk lbs.	Fat % in Milk.	Milk lbs.	Fat % in Milk.	Milk lbs.	Fat % in Milk.
10	10'00	17	5'88	24	4'35	31	3'17
11	9'09	18	5'55	25	4'00	32	3'12
12	8'33	19	5'26	26	3'85	33	3'03
13	7'69	20	5'00	27	3'70	34	2'94
14	7'14	21	4'76	28	3'57		
15	6'66	22	4'70	29	3'45		
16	6'25	23	4'54	30	3'33		

*Various patterns are available in the market but the circular and table form butter workers are most popular. The butter worker is used to take out water from the butter grain mass by pressure from a roller, and for mixing salt uniformly with butter. They are made of wood.

Useful formulæ in connection with Butter Calculations are:—

(1) Fat % in ripened cream multiplied by 1.085 = Butter % in cream.

$$(2) \text{ Butter Ratio} = \frac{\text{lbs. of Milk in 24 hours}}{\text{lbs. of Butter in 24 hours}}$$

$$(3) \text{ Churn yield} = \frac{\text{lbs. of butter}}{\text{lbs. of milk}} \times 100$$

Butter contains water, butter fat, proteids, lactose, ash contents and common salt, if it is salted. The percentage of water in the market commodity varies from 7 to 16%, albuminoids, sugar etc. vary from 0.8 to 2.0 % and butter fat varies from 80 to 91 %. Butter should not contain on any account more than 3 % salt or 15 % water. Water contents should be between 10 and 15 %. Specific Gravity of butter is 0.943 at 60°F. and at 100°F. it varies from 0.91 to 0.95. The melting point of butter varies from 85° to 95°F. and the solidifying point varies from 60° to 86°F. Butter fat contains:—

Butyric ... 3.8 %	Caproic ... 3.6 %
Caprylic ... 0.5 %	Capric ... 1.9 %
Lauric ... 7.4 %	Myristic ... 20.2 %
Palmitic ... 25.7 %	Stearic ... 1.8 %
Oleic etc. ... 35.0 %	

The flavour of butter from ripened cream is superior to that of the sweet cream butter; but the sweet cream butter keeps longer than that made from ripened cream.

110. Butter Milk:—

The liquid from the ripened cream which remains behind after separation of the butter is called butter-milk.

This contains all the constituents of milk in different proportions. There is also a small quantity of Lactic Acid in addition to the usual milk constituents. It contains on an average 91% water; 0.3 to 0.5 % butter fat; 3.50 % of albuminoids; 4% milk sugar and lactic acid and 0.7 % ash constituents. Butter milk from *Dahi* (Curds) is very nutritious because it contains comparatively large proportions of albuminoids and butter fat. Butter milk from *Dahi* is an article of food while that obtained from cream is more watery and hence it is given to cows and calves. The butter milk that has to be added to the cream in order to hasten the ripening operation should be quite fresh and should not contain too much lactic acid. If stale butter milk is added to the cream it becomes too sour and at the same time some of the butter fat is likely to be decomposed and impart a disagreeable odour due to formation of Butyric Acid.

III. Cheese:—

Cheese is a product of milk. In its preparation stale milk is used; annatto seed colour is added and then it is treated with rennet to bring about its coagulation. The coagulated mass is cut into pieces and the whey containing milk sugar and ash constituent, is separated by draining and by pressure. Then the curd is milled into fine pieces, salt is added, whey is further separated by pressure and the mass is made into block by pressing it into moulds, wrapped and stored for curing. In India, cheese making can not be taken up by any caste or creed that owns any form of faith having its origin in the Vedic religion. Rennet is the most objectionable item, as it is prepared from the extract of the stomach of calves, and it is the principal material required for the coagulation of milk in cheese making. The substitution of some *vegetable rennet* in place of calf stomach rennet would remove this difficulty. According to Mollison,

cheese can be prepared by using "vegetable rennet", prepared by steeping powdered berries of *Withania coagulans* (Kaknaj or Panirband) 6 oz. in 2 lbs. of water to which 3 ozs. of salt have been added and then straining. One ounce of this solution is said to be sufficient to coagulate 1 lb. of milk. According to Mukerji, Mr. Subba Rao of the Madras Agricultural Department has been successful in making cheese without the addition of rennet, by adding to the milk the juice of *Epicarpurus orientalis*. The milky juice of the petiole stalks of 32 leaves of this tree was used for 4 lbs of milk. Further experiments are required on this subject.

112. Casein:—

Casein is prepared from separated milk by treating it with some acid for precipitation. For this purpose separated milk is taken, and to it dilute sulphuric, hydrochloric or acetic acid is added and it is then warmed. On warming casein is precipitated and then it is separated from whey containing excess of the acid, milk sugar etc. and washed several times with water to remove the acid that may remain in the mass. Then it is dried, powdered and stored. Fresh casein is white in colour but on drying it becomes flinty in appearance and very hard. When pure casein has to be prepared, casein prepared by the above method is dissolved in some alkalis solution, like Ammonium Hydrate and it is then re-precipitated and the same process repeated further if necessary. Casein is used in industries in various ways, e. g. calico printing, colouring, glazing, preparing chemical foods and also in preparing sticking pastes, buttons etc. For these purposes casein should be free from fat and moisture as far as possible.

113. Preparation of Dahi and Butter:—

Dahi is made out of milk which has been previously heated. The heating of this milk is never sudden and excessive, but is always gradual and slow being continued over a long period. Excessive heat is likely to cause the charring of some of the constituents of milk, especially of milk sugar and altering the colour of milk to pinkish. If the milk is heated too much it froths over and some of the butter fat is lost. Milk should, after being heated, be cooled down to a temperature of about 100° F. and then fresh butter milk should be added in small quantities and well stirred, the pot being kept covered in a warm place. In summer *Dahi* is made within 12 hours, but in winter when the atmospheric temperature is generally low *Dahi* formation sometimes takes 2 or 3 days. Some times the *Dahi* pots have to be wrapped up in blankets in order to maintain warmth. Shallow earthen pots are better for *Dahi* making than metal vessels. Good *Dahi* is made from whole milk. *Dahi* made from separated milk is inferior in flavour and deficient in butter fat. If *Dahi* has to be made for making butter the upper portion of the heated milk with the creamy layer is curdled separately and then churned for butter. The butter milk, which is added to the milk for curdling, contains Lactic Bacteria which bring about the usual changes. If the fermentation is continued further the usual lactic fermentation may stop and Butyric fermentation set in. The peculiar bad smell which is noticed in old *Dahi* is due to this latter viz. Butyric Fermentation.

The Churning is done by means of a wooden "Mathani or Ravi" in a spacious vessel with the addition

of warm or cold water, according to the temperature of the day, since this helps to hasten the separation of butter. When butter separates, it is collected and washed with cold water many times and then it is kept in a pot containing cold water. In this process the butter becomes rather soft and in summer its grain is spoiled. Butter prepared in this way tastes slightly sour and contains comparatively more casein.

114. Preparation of Ghee :—

Ghee is made by heating butter to a gentle heat until it is freed of all water. This stage is known by the total stoppage of the sound of boiling water when the *Ghee* pot should be removed from the fire and allowed to cool. Strong heat may cause a partial charring and consequent bad smell in the *Ghee*. While the *Ghee* is still liquid and warm it should be strained through a piece of moist clean linen and then kept covered in tinned pots or earthen ware in a cool place. *Ghee* made from fresh butter keeps well for a long time while that made from spoiled butter is spoiled in a very short time and smells bad. Market *Ghee* always contains a small amount of water or butter milk. If water or butter milk is left in the *Ghee* some fats are readily decomposed and it is turned rancid.

115. *Khova*, *Khoya* or *Mava* :—

Khova or *Mava* is the vernacular name applied to milk thickened to semi-solid consistency by the evaporation of its water. For making *Khova*, milk is heated very slowly in a shallow thick boiling pan and as it is being heated it is stirred constantly in order to prevent the formation of skin and also to accelerate the evaporation of water. As the water is evaporated the milk becomes thicker in consistency

and the heating is stopped when it becomes semi-solid. *Khoya* properly prepared is white in colour and has good flavour. *Khoya* contains all the constituents of milk but their proportions are different. *Khoya* is used for preparing many kinds of sweets. *Khoya* prepared from the milk of newly delivered cows keeps in good condition for a very long time. The flavour of the *Khoya* depends upon the richness of the milk and the care taken in preparing it. Market *Khoya* is some times adulterated with starchy substances like arrow root, rice flour, wheat flour etc.

116. Dairy room :—

The dairy room in which milk is to be kept and milk products like cream, butter etc. are to be prepared should be situated at a convenient distance from the cattle shed. The place should be airy and dry. In building the room good material should be used and care should be taken in making it sanitary and at the same time convenient for work. There should be a verandah all round and the height of the room should not be less than 15', in order to have a low temperature in the room. The plinth of the building should not be less than one foot and a half high. There should be a sufficient number of rooms, the number and dimensions, of course, varying according to the needs. In small concerns only two rooms are sufficient but in large dairies 5 or 6 rooms are required. It is better to have one room for milk distribution, one for cream and butter, one for pasteurization, one for washing and one for stores. The boiler-shed should be at a distance from the dairy rooms. There should be some open space for keeping the washed utensils, cloth etc. in the sun for drying after washing. The floor of the rooms should be made water-tight by using stone slabs or cement. There

should be a drain and the floor should slope towards it so as to carry away all water that is used for washing purposes. The walls should be made water proof at least to a height of 5 feet from the floor by cement plaster and there should be sufficient number of windows and sky lights in order to have good ventilation. There should be double shutters for windows and doors, one ordinary and the other of wiregauze so as to keep off dirt, insects etc. as far as possible. The ceiling should be dirt proof. The drain from the dairy room should open into the manure pit and water should not be allowed to soak into the ground near the rooms. There should be proper arrangements for the supply of pure water which is required in large quantities for daily use. The dairy rooms should be well furnished with all the necessary equipment so that daily routine work may be carried on without any hindrance.

The dairy rooms should be white washed at least twice a year and their floor and drains should be periodically washed with disinfecting fluids. For this purpose strong smelling disinfectants, like phenol, should not be used as the milk and its products are sure to absorb the bad smell. Lime and potash-permanganate are better for the purpose. The floors and gutters should be washed twice a day using a good brush for the scrubbing of all traces of milk that drop to the floor. The keeping quality of milk and its products partly depends upon cleanliness and hence all possible care should be taken in maintaining it. The dairy surroundings also should be kept clean and sanitary.

CHAPTER X

TESTS FOR MILK, CREAM & BUTTER.

117. Standard for Milk:—

In order to determine the standard for the quality of milk a large number of pure milk samples must be examined and the average figures regarding the % of the constituents etc. must be worked out; then only can the standard be fixed. Such experimental work is just begun here in India and hence there are comparatively very few available figures. In the following tables the averages worked out from some available figures are given and these would be sufficient for the time being to give a rough idea of the quality of Indian milk.

	Fat %	S.N.F.	T.S.	Samples.	Authority.
Cows Milk ...	5·88	9·17	15·05	1288	Dr. Mann & Meggitt
	4·5	8·75	13·25	400	.. Joshi
Average ...	5·19	8·96	14·5		
Buff. Milk ...	7·5	10·2	17·7	1252	Dr. Mann & Meggitt
	7·25	9·5	16·7	400	.. Joshi
Average ...	7·37	9·8	17·2		

Cows Milk.			Buffalo Milk.		
Sp. Gr.	No. of samples.	Authority.	Sp. Gr.	No. of samples.	Authority.
1·029	50	Dr. Joshi ...	1·029	476	Dr. Joshi.
1·031	134	Dr. Mann and Meggitt.	1·030	(?)	Dr. Mann and Meggitt.
1·030	(?)	Manager, Mili. Dairy, Peshawar.	1·032	(?)	Dr. Leather.
1·030	Average		1·030	Average.	

Thus the averages for Indian cows milk and buffalo milk come to :—

	Fat %	S. N. F. %	T. S. %	Sp. Gr.
Cow...	... 5.19	8.96	14.5	1.030
Buffalo	... 7.37	9.8	17.2	1.030

For comparison in testing, the averages may be taken in round figures, as :—

	Fat %	S. N. F. %	T. S. %	Sp. Gr.
Cow...	... 5.0	8.5	13.5	1.030
Buffalo	... 7.0	9.5	16.5	1.030

For mixed milk no such standard can be proposed as the mixed milk may contain cow and buffalo milks in any proportion and therefore the percentage figure of butter fat &c. may be anywhere between the average percentages.

118. Sampling of Milk for Analysis :—

Great care should be taken in sampling the milk for analytical purposes. Milk is a mechanical mixture of water, fat globules, proteids, lactose and inorganic salts. Of these, fat globules are the lightest and as they are in a suspended condition they tend to rise to the surface of milk if kept still for some time. If the sample were taken from the upper portion of such milk it would show a far greater than the real percentage of fat. Similarly if the sample were taken from the lowest portion it would show the least fat percentage. In order to avoid such discrepancies, samples of milk should be taken after it has been thoroughly stirred to ensure a uniform mixture. For this purpose pouring out milk from one pot into another three or four times is quite sufficient. Simply stirring

the milk mass round in the pot does not ensure uniform mixture. For taking out the sample a dipper with a long handle should be used so that a portion of the middle mass of the milk can be taken. Such a sample will represent the whole mass of milk as regards the percentage composition. When weekly tests are to be made "composite sampling" should be done as above and in doing so the same quantity of the sample should be taken every time, otherwise the results will not be accurate. For taking samples of milk the dipper should be of one or two ounces capacity. In composite sampling or when the sample can not be analysed the very day, some preservative is required to be used for keeping the milk in good condition. Such a preservative should not affect the fat percentage materially.

119. Specific Gravity of Milk :—

The specific gravity of milk can be easily determined by means of the hydrostatic balance or a hydrometer. Hydrometers specially constructed for determining the specific gravity of milk are sometimes called "Lactometers". Some patterns are also fitted with a thermometer. The hydrometer should be dipped into the milk slowly right up to the 0° mark and then allowed to become stable by itself and then the reading should be taken. Specific gravity varies with temperature; hence the temperature of the sample should be noted along with the hydrometer reading and a correction in the reading for its difference from 60° F should be made. It is better to use hydrometers fitted with a thermometer so that both the readings can be taken simultaneously and more accurate results obtained. The correction for temperature should be made by means of Richmond's slide rule, or, if the observed temperature is more than 60°, 0.1 may be added to the observed reading

for every degree difference in temperature; but, if the observed temperature be less than 60°, 0.1 should be deducted for every temperature degree difference. The result will represent the corrected hydrometer reading for 60° F. In composite sampling the specific gravity of each sample should be taken daily before putting the sample in the sample bottle, because the composite sample is required to be preserved with some preservative like pot. bichromate or some other preservative salt and this adds to the solids of milk and the specific gravity is thus affected.

120. Total Solids in Milk:—

All constituents of milk except water form the "total solids". Total solids contain butter fat which is lighter than water and hence has the tendency of lowering the sp. gr.; while milk sugar, proteids and ash constituents have the tendency of raising the specific gravity. Hence the sp. gr. of milk varies with the relative proportion of fat and "solids-not-fat". Thus if the fat % in milk is known and its sp. gr. is determined, the percentage of total solids can be calculated with the help of the following formulæ.

$$(a) T \text{ (total solids)} = \frac{S}{4} + \frac{6F}{5} + 0.14$$

where S = Hydrometer reading at 60° F and
F = Fat %

$$(b) \text{ S. N. F. } = \frac{\text{Fat \%} + \text{Hydrometer reading at 60°}}{4}$$

roughly.

121. Richmond's "Milk Scale":—

Richmond has constructed a slide rule for reckoning the % of total solids (T) of milk when fat % and the specific

gravity are known. The construction of the scale for the determination of the percentage of total solids is based on the formula (a) given above. The slide rule is used in the following way :—

(1) For correction of Specific Gravity—

Find the observed hydrometer reading in the central slide and bring it to 60° mark in the temperature scale. Find out observed temperature in the "Temperature" scale, then the degree in the "Lactometer reading" coinciding with the observed temperature denotes the reading corrected to 60°F.

(2) For finding out the percentage of total solids—

Bring the arrow head mark (†) of the central slide to the observed fat percentage in the "Fat" scale. Then the figure in the "Total Solids" scale, coinciding with the corrected "specific gravity" figure in the central slide, denotes the percentage of total solids.

122. Fat percentage in milk :—

For all practical purposes the most easy, rapid and accurate method for determining the fat percentage is Gerber's Butyrometric method. Gerber has designed special graduated test tubes for giving direct percentage readings. In this method measured quantities of sulphuric acid, milk and amyl alcohol are put in the test tubes, a uniform mixture is formed, and then they are centrifuged for the separation of the fat column. The object in using sulphuric acid is to char the proteids and sugar and thus do away with the colloidal condition in order to facilitate the free movement of fat globules. Sulphuric acid also causes difference in the specific gravity of the mixture which ensures the ready

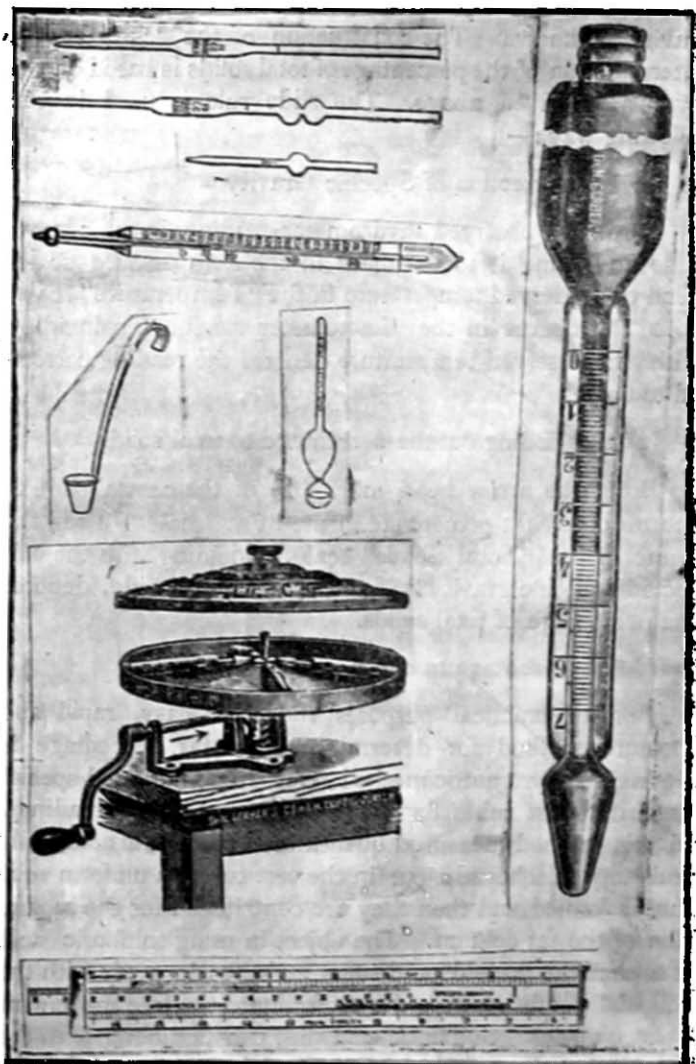


Plate 6:—Apparatus for Gerber's Fat Test.

separation of the fat column on centrifuging. The following instructions should be followed in this method.

1. Take a clear dry butyrometer test tube and measure accurately with an "acid" pipette 10 c. c. sulphuric acid of 1.825 sp. gr. and put it carefully in the test tube without touching the mouth.

2. Pour the sample of milk to be tested from one vessel into another 3 or 4 times, then suck milk in the "milk" pipette, let the milk run from it and then take from the mid portion 11 c. c. milk exactly and put it into the test tube drop by drop, the tip of the pipette resting on the side of the tube and not touching the acid.

3. Put 1 c. c. amyl alcohol in the tube.

4. Close the tube with a rubber stopper, hold it in a towel and shake it vigorously, the thumb resting on the stopper all the time. Invert the test tube 3 or 4 times during the operation in order to remove the sulphuric acid from the narrow neck and bulb of the tube to form uniform mixture.

5. Then put the test tube in the brass case the stopper downwards. Fix it in the clamps the graduated stem of the test tube being towards the centre. Fix the cover and rotate the machine vigorously for 2 or 3 minutes.

6. When the machine stops of itself, take out the test tubes, the rubber stopper being always downwards, and put them in the hot water bath (about 160°F.). Then adjust the stopper and take the reading holding the tube quite vertical so that the fat column meniscus is level with the eye.

7. Mean of duplicate samples should be taken as the fat % in the milk.

123. Adulteration of Milk :—

In determining the percentage of adulterated water in milk, a proper sample should be taken and then its sp. gr. at 60° F. and fat percentage should be found out. After determining the percentage of either "Total Solids" or "Solids-not-fat", the percentage of added water should be calculated according to the following formula :—

$$(1) \text{ Water added \%} = 100 - \frac{100 \times \text{S. N. F \% of sample}}{8.5 \text{ or } 9.5}$$

Where 9.5 is used for Buff. milk and 8.5 for Cow milk.

Dr. Leather gives the following formula for finding out the percentage of added water, based on the freezing point of the suspected milk.

(2) Added water % = $-174(-0.542 - t)$ where (t) is the freezing point in degrees centigrade.

"Percentage lactometers" are not reliable and hence are quite worthless for detecting adulteration. For instance, if water is added to partially skimmed milk such lactometers are quite useless for detecting the fraud. These are constructed on a sp. gr. basis, and the sp. gr. of milk varies according to the relative percentage of the constituents and the temperature. If milk is adulterated and the sp. gr. is brought to normal by some means, these lactometers will show the milk as pure "whole milk". Hence such instruments should not be used.

The nature of adulterations may be determined from the following :—

No.	Nature of fraud.	Fat %	S. N. F. %	Sp. Gr.
1	Addition of water alone	Decrease	Decrease	Decrease.
2	Partial skimming ...	Decrease	Increase	Increase.
3	Partial skimming and adding water.	Decrease	May be normal	May be normal.
4	Partial skimming and adding water, sugar or starch.	Decrease	May be normal	May be normal.
5	Adding skim milk ...	Decrease	Increase	Increase.
6	Adding skim milk and water.	Decrease	May be normal	May be normal.
7	Adding water to Buffalo Milk and selling as Cows Milk.	May be normal	May be normal	Decrease.

224. Determination of Fat Percentage in cream:—

Fat percentage in cream can be determined rapidly by Gerber's method. For this purpose ordinary butyrometer milk test tubes may be used. A measured quantity of cream should be taken and diluted with ten times as much water to form a uniform mixture. Then the same method as is followed in finding out the percentage of butter fat in milk should be employed and the result multiplied by 11. The product will be the percentage of fat in the original cream.

If Gerber's cream tubes are to be used for finding out the fat percentage in cream the instructions mentioned below should be followed. The use of these cream tubes requires the help of a special beam balance. This is a balance specially constructed for using with Gerber's dairy test apparatus for taking direct readings with the help of several riders.

1. Weigh accurately 5 grams of a well mixed cream in the small glass cup used with the cream test tubes.
2. Insert the cup with the rubber stopper in the test tube and put in 10 c. c. water, 10 c. c. sulphuric acid and

1 c. c. amyl alcohol. Then close the other end of the test tube with the rubber stopper and proceed further in the same way as in finding out the fat percentage in the milk.

If the fat percentage in milk and the percentage of cream removed be known, the fat percentage in cream removed should be calculated according to the following formula—

$$\text{Fat \% in cream} = \frac{100 (\text{Fat \% in milk} - 0.1)}{\% \text{ cream removed}}$$

125. Determination of Water Percentage in Butter :—

To find out the percentage of water in butter, a weighed quantity of butter sample should be slowly heated so that all moisture is evaporated. It should be noted that genuine butter boils with plenty of foam and is likely to froth over. Then again it should be weighed. The difference between the weights will be the basis for calculating the percentage of water. Gerber's method is quite rapid and efficient. The following instructions should be followed in finding the percentage of water in butter with the help of the special balance.

(1) Put the cup on the balance pan and set up the equilibrium by means of the adjusting screw. (2) Put the large rider on the pin at the other end of the beam and the small rider on the "O" mark. (3) Then put butter in the cup till it is exactly balanced. (4) Heat the cup on the spirit lamp flame till all water is evaporated. Avoid spitting of butter fat while heating. (5) Then put the cup on the pan and set up the equilibrium by the change in position of the smaller rider. Then the figure coinciding with the smaller rider shows the percentage of water in the butter sample.

26. Amyl Alcohol:—

Amyl alcohol is used in fat determination and for this purpose it must be quite free from petroleum and other fatty substances and therefore should be tested for fat contents before use. Pure amyl alcohol has a sp. gr. of 0.814 at 60° F. Its purity may be tested in the following way:—

Put 10 c. c. water in the Gerber's milk test tube, add 10 c. c. sulphuric acid (sp. gr. 1.825) and 2 c. c. of amyl alcohol to be tested. Mix well and then centrifuge. Pure fat-free alcohol does not show a layer of fat. If a fatty layer is seen, its reading should be taken and that should be deducted from the fat percentage got by using that amyl alcohol.

CHAPTER XI

DAIRY BACTERIOLOGY.

27. Bacteria:—

Bacteria play a very important part in dairying and therefore the dairy farmer should have some knowledge of the ways in which they serve either useful purposes or otherwise. In the living kingdom they occupy an intermediate position between animal life and plant life, but they are more like plants and as such they are classed under the fungus group of lower plants. They are one-celled and of such a minute size that they can only be seen with the help of a microscope of high magnification. Bacteria have different shapes. They may be round, oval, rod-like, spiral, filamentous &c., and they may occur singly, in duals, in

masses or in chains. Their shape may change with their growth, but each type has its own characteristic shape with the help of which they may be classed and named e. g. those with round shape as *micrococci*, those that are round but occur in chains as *streptococci*, rodlike as *bacillus*, filamentous as *leptothrix*, spiral as *spirillum* &c. Bacteria do not possess green colouring matter, chlorophyll, like higher plants. Some types do not show any signs of movement while others move quite freely by means of threadlike growths from their bodies. Like all other living things bacteria require the usual conditions for the support of their life, the necessities being suitable temperature, sufficient moisture, a medium for living, and food. When these conditions are fulfilled they multiply in vast numbers in a short period. Their mode of multiplication is by "division" or "fission" and by spore formation. In the former case each microbe divides into two and each half grows into a separate individual, which again in its turn divides into two, and so on. While in the latter case the bacteria form round structures with better protective covering and each structure giving rise to a new individual on germination just like the seeds of higher plants. These structures are called *spores*. These spores withstand unfavourable conditions to a great extent and germinate when favourable conditions arise. Particularly through this mode of multiplication bacteria give trouble to the dairy farmer because the spores cannot be killed very easily.

128. Effect of temperature on bacteria :—

Roughly speaking the temperature between 80° and 100°F. is most suitable for bacterial growth. Below 70°F. their growth is retarded and below the freezing point it is stopped. The temperature of 212°F., the boiling point

of water, kills all grown bacteria. Some types of bacteria cross these temperature limits. Lower temperature than the freezing point does not kill the growing bacteria but they are rendered simply inactive. The spores of some bacteria resist a higher temperature than the boiling point and some types withstand even as high a temperature as 320° to 356° F. before being killed and that too for a period of at least half an hour. This is the reason why milk is required to be heated under pressure in sterilization. Most of the full grown bacteria without spores are killed between 140° - 160° F. and this is why milk has to be heated to that extent in pasteurization. Steaming is more effective in killing bacteria and their spores because they are more resistant to dry heat than moist heat; and for this reason the steaming of the milk vessels is essential to ensure low bacterial content of milk. When the milk is heated to 180° or higher, some of its constituents are affected and therefore for raising its keeping quality without changing its properties it is heated to 140° to 160° F., cooled and allowed to stand to help the growth of bacteria from the spores and again heated to 140° to 160° F. and this is done several times. When the milk has to be transported to a long distance it is packed in ice in order to check the fresh growth of bacteria and retard their activity during the period of the journey. Thus the effect of temperature on bacteria will show clearly why particular operations have to be done at particular temperatures and why the thermometer is a necessity in dairying.

129. Moisture and bacteria :—

Bacteria require moisture for their growth like other living things, but they resist dryness to some extent. The spores remain alive for a much longer period than the full

grown bacteria, but as soon as they get sufficient moisture, other conditions being favourable, they will germinate just like ordinary seeds, and give rise to bacteria. The bacteria that cause cholera cannot do without moisture, and are killed as soon as they are dried up. In the rainy season and in damp localities sickness is more marked than in summer and in dry localities, and this very fact shows that moisture in sufficient quantities is a necessary condition for their growth. Many diseases that are caused by bacteria are spread very easily through water and drinks like milk. The air in the dairy room and cowshed is comparatively damper and therefore in these places bacterial growth takes place very vigorously. This explains the necessity of cleanliness by way of daily washings and periodical disinfections. Low lying and damp places are to be avoided for dairy buildings because these are more favourable for bacterial activity.

130. Food material for bacteria :—

Although bacteria, like other plants, require carbon, oxygen, nitrogen &c., for their growth, the way in which they derive their food material differs from that of ordinary plants. As bacteria are devoid of chlorophyll and therefore unable to assimilate carbon from the carbon-dioxide in the air, they get carbon from organic compounds. The organic compounds of carbon and nitrogen form their chief food material. Some bacteria live on dead organic matter while some types live on living plants or animals just like the parasitic plants that grow on trees. The bacteria of the former type are useful as they do the work of cleaning by reducing higher organic compounds to simpler ones, while those of the latter type cause disease except such types as the nitrogen-absorbing bacteria found in the

nodular growths on the roots of pulse crops and directly or indirectly bringing about the ultimate death of the host. Some types of bacteria derive their oxygen directly from the air, while other types as free oxygen in the air checks their growth, have to derive their oxygen supply from organic matter. Bacteria of the first type are called *aerobic* and those of the latter type are called *anaerobic*. The bacteria that bring about nitrification in the soil are of the aerobic type. This will explain why proper aeration of the soil by way of drainage and tillage is necessary for increasing the quantity of available plant food, specially the nitrates, in the soil. Bacteria of the other type (anaerobic) thrive when free air is cut off from the medium and therefore their region of activity is restricted to marshy places, water-logged soils, deeper portions of manure pits &c. Bacteria derive their inorganic food supply also from organic matter. Milk is the ideal medium for bacteria because it supplies all their requirements. Milk contains plenty of water, carbonaceous and nitrogenous organic matter in the form of butter fat, lactose, proteids; inorganic food in the form of salts of lime, soda, potash &c. with carbon dioxide, chlorine, sulphuric and phosphoric acids; and all these exist in such a fine state of sub-division that these can be used quite readily by bacteria. The temperature of milk as it leaves the udder is also most favourable for bacterial growth. This explains why milk is spoiled so very readily and why we have to be very particular regarding cleanliness to ensure as low a bacterial content as possible.

131. Occurrence of Bacteria :—

Bacteria occur in large numbers on the surface of our bodies, on our clothes, on the surface of the articles in

our rooms, on the surface of all plants and animals. They are present in the soil in vast numbers. They are in plenty in the waters of rivers, tanks, canals and wells. They are present in countless numbers wherever organic matter is decaying. The atmospheric air also contains bacteria. In short we may say that there is no place and no substance, on the surface of our earth, that is exposed to the air and dust and at the same time bacteria free. The air of thickly populated areas contains comparatively more bacteria than the open country air and therefore the dairies should be situated at a suitable distance from towns and cities. The river water in the vicinity of towns and cities is much contaminated with bacteria because the city refuse finds its way into the river. The down stream river bank should particularly be avoided for dairy purposes. The air in the dairy rooms contains plenty of bacteria, specially lactic, and therefore the bacteria content of milk, cream &c. is raised if these are not kept at a sufficiently low temperature. The cattle shed, yard and the manure pits are the strongholds of bacteria, because in spite of our washings and cleanings, there is always some decaying organic matter where the activity of the bacteria is going on. The peculiar smell, characteristic of a cattleshed, is an indication of this. It may be noted that the smell, characteristic of the milk and butter rooms, differs from that of the cattle shed and that shows that here the bacterial activity is different in nature. The milk pots are not to be kept in the cattle shed any longer than necessary, simply because of the cattle shed air, dust and flies which are sources of bacterial contamination. For this very reason separate milking sheds are constructed away from the cattle shed and manure pits to lessen the chances of contamination.

132. Bacteria and their work :—

Through bacterial activity organic matter is decomposed and new products with different properties are formed. Among these new products carbon dioxide, marsh gas, ammonia, sulphuretted and phosphoretted hydrogen, organic acids, peptone and like substances, toxins and ferments are important. The chemical changes that are brought about by bacteria are due either to oxidation or reduction processes, depending on the nature of the bacteria. Aerobic bacteria bring about oxidation and the anaerobic type bring about reduction. The ferments that are produced through their activity help in bringing about complex chemical changes. Some of the products of their activity are useful while others are harmful and accordingly we have either to maintain or accelerate their work or to check and stop their activity. We have to see therefore what types are our friends and what are our foes. Among our friends may be mentioned the soil bacteria that reduce the organic matter to humus, those that bring about nitrification, those that "fix" nitrogen from the air, the bacteria that are useful in making silage from green fodders and those that help us in making *Dahi* from milk and in ripening cream and cheese. Among our foes may be mentioned the denitrifying bacteria, those that spoil the milk and its products and those that cause diseases in man and animals.

133. Bacteria and the soil :—

The dairy farmer should have some information of the bacterial activity in the soil, (though this has no direct bearing on the milk and its products), because he has to grow fodder for his cattle, and bacterial activity has much to do with the successful growing of crops. Crops require available nitrogen in the form of nitrates and this is

supplied through the bacterial activity in the soil. The dead organic matter, that gets mixed with soil or that has been added to it in the form of manure, is attacked by bacteria and the amount of available nitrogen fed to the crop is increased. Some of the important changes brought about by bacteria in this connection have been mentioned in Art. 7 under nitrification. The humus of the soil to which the organic matter is reduced through bacterial activity is a very important constituent of the soil, as its percentage affects the physical properties of the soil and thus its fertility as well (see Art. 3 & 8). Denitrifying bacteria cause loss of available nitrogen through denitrification. The changes taking place in this case are exactly the opposite of those in the process of nitrification, the nitrates being reduced ultimately to ammonia and nitrogen which are lost. These types also render the soil acid. The conditions favourable for denitrification and acidity, are bad drainage, water logging, absence of air in the soil and presence of organic matter in plenty—the conditions to be avoided in maintaining soil fertility. This does not mean that anaerobic types of bacteria are not useful at all. These are quite essential because they prepare the ground for nitrifying bacteria to begin their activity by reducing the proteid nitrogen of organic matter to ammonia form. Besides these the soil contains bacteria that have the power of making use of the free atmospheric nitrogen and retaining it in the soil, and owing to this quality they are termed "nitrogen fixing bacteria". The familiar example of this type is the bacteria found in the nodules growing on the roots of leguminous crops. This shows why such crops are important in the rotation or mixture of crops for maintaining the soil fertility.

134. Cattle food and bacteria :—

In preparing silage from green fodders we have to depend on bacterial activity for its quality. In this process the carbohydrates of the fodder are chiefly affected and carbon dioxide and lactic and acetic acids are chiefly produced, and the fermentation is dependent on the amount of air that is retained in the fodder mass or that gets into the mass through cracks in the silo. The greater the amount of oxygen the greater the activity of the bacteria and therefore the greater the acidity produced. Thus the sweetness of the silage depends upon the degree of the fermentation. The fermentation of the fodder is so vigorous and so much heat is generated through oxidation that we cannot insert our hand comfortably in the fodder mass the very second day of filling the silo. If too much air gets into the fodder mass the silage becomes so very acidic that cattle refuse to eat it. This is the reason why we have to be very particular when filling the silo to take all proper precautions (see Art. 55). When we steep cattle food like oil cake, *chuni* &c., fermentation sets in through bacterial action and when it is slight it adds to the flavour of the food and cattle relish it. It may be noted here that some of the bacteria that enter the animal system with the food and that inhabit the intestines are ejected with the dung and thus the dust of the cattle shed contaminates the milk.

135. Bacteria and the body of the cow and the milker :—

The coat of the cow always contains some dust in spite of precautions taken to keep it clean by way of brushing, washing &c. This dust gets into the milk at milking time in a number of ways e. g. the milker may rub his head against the coat and thus brush the dust into the milk, the

cow may shake her skin or move her tail to drive away a fly or mosquito, the wind which may carry dust, the movements caused in the udder during milking &c. It is to minimise the dust falling into the milk from these sources that cover-top milking pots or narrow mouthed *lotas* are preferable. If the body of the cow is soiled with dung, urine and dust, an enormous number of bacteria are added to the milk during milking. This explains why we have to be very particular in keeping the cow shed floor and the body of the cow as clean as possible and why the udder has to be washed and cleaned before milking. The milk of the first few sprints has always high bacterial content simply because the teats always contain some milk and bacteria from the floor of the shed find their way through the hole in the teat and multiply in it. Therefore this milk should not be mixed with the rest, when the calf is either dead or is not allowed to suck. When the cow is affected with some contagious disease, the bacteria causing it appear in the milk. Similarly the milker also becomes a source of bacteria through his dusty clothes, unclean hands, uncut finger nails, coughing, or sneezing &c. This shows clearly the importance of cleanliness in both the cow and the milker, and their freedom from contagious diseases.

136. Bacteria and other sources.—

Among the other sources of bacteria the most important are the milk pots and water that is used for cleaning and washing purposes. The pots to be used for keeping milk should have a smooth surface, as a rough surface cannot be cleaned properly and bacteria thrive in the unclean portions very rapidly and contaminate the milk. Simply cleaning with hot water does not make the pots bacteria free, to achieve which steaming is quite necessary. This is possible where steam is available ; otherwise water must be

used. We have seen before that water from rivers, tanks, &c. contains bacteria, and when we have to use this the final washing should be with boiled water to minimise the number of bacteria. Cases of spread of disease through the use of contaminated water for washing milk utensils have sometimes occurred, and we have therefore to be very particular in this respect. After cleansing the pots they should not be kept in dusty places and where a dusty wind is likely to blow, because dust is likely to adhere to the pot surface and contaminate the milk and thus all the trouble taken in washing would be wasted. With all the precautions that are ordinarily possible, the vessels cannot be made bacteria free. There are always some bacteria on the surface and in order to ensure less contamination through this source milk should be kept in one vessel as far as possible, because the greater the number of pots in which milk is poured in succession the greater the surface area for milk contact, and hence the greater the contamination. The other articles that come in contact with the milk and add to the bacteria content are the strainers and measures. These should be kept quite clean and free from dust. Milk measures should on no account be kept on the floor or kept exposed to dusty winds but should be kept hanging and covered with a piece of clean cloth to protect them from flies and dust. This precaution is quite necessary when the churn in which the milk is kept is not provided with a tap to take it out, because in that case the measures have to be dipped into the milk every time the customers come, and this means more contamination at each dipping.

Among the bacteria that are associated with milk some are original to the milk while others are derived from outside sources. Those that are present in the fore milk are

original. The following types of bacteria commonly found in milk and its products are important.

137. Lactic bacteria :—

These bacteria are so named because they feed upon the milk sugar, the lactose, and produce lactic acid and carbon-dioxide as by products. The lactic acid thus formed turns the milk sour, acts upon the casein and coagulates it and the milk becomes semi solid. Lactic bacteria also act upon casein and decompose it, but their chief action is on lactose. Lactic bacteria are anaerobic in nature and therefore the changes brought about by these are uniform throughout the whole mass. These bacteria are most active at blood heat and multiply so rapidly that they smother the growth of other types that may be present in the milk. At a lower temperature their activity is retarded and that is why it takes longer to have good *Dahi* in winter and why it does not get sufficiently sour during this season. This also explains why milk keeps better in winter than in summer. In this connection it may be noted that cases of abnormal *Dahi*, that is with a disagreeable taste, flavour and consistency are noticed more in winter than in summer. The reason for this is that in winter the usual lactic bacteria are not so active due to low temperature and therefore other types of bacteria get a good chance for their growth and the stuff is spoiled. In summer the air temperature is very favourable for lactic bacteria to be very active and within a few hours we get good *Dahi*. On keeping it longer the acidity is increased and as the amount of the acid is increased the bacterial activity decreases and ultimately is stopped. At this stage other types of bacteria become active and spoil the taste and flavour by attacking proteids. The small quantity of butter milk which is used as a starter in

preparing *Dahi*, or for ripening the cream contains thousands of lactic bacteria and these bring about the usual changes. For this purpose the butter-milk should be quite fresh and slightly acid and should be the product of good *Dahi* because this contains the youngest and most active bacteria. Stale butter milk or *Dahi* that smells of butyric acid should never be used as a starter. The very smell of butyric acid is an indication of the presence of undesirable bacteria which spoil the quality of the product. Lactic bacteria are killed at the pasteurizing temperature (160° F.), as they are not spore-forming bacteria. Besides this specific type of lactic bacteria, there are others also which attack lactose and produce lactic acid, but these are not so common as the useful type. Some moulds also produce similar changes.

138. Gas forming bacteria :—

When these bacteria ferment milk or cream a quantity of gas is generated and many gas holes or cavities are formed in the mass of the substance. When the fermentation is carried too far, the *Dahi* or cream presents a blown-up appearance or froths over, and the coagulated casein becomes spongy and floats on the whey which is collected at the bottom of the vessel. These types of bacteria cause much trouble in the preparation of butter from either *Dahi* or cream. The gases make the substance viscous and this gives trouble in churning.

139. Bacteria acting on casein :—

These bacteria are of the anaerobic type. They break up the proteids of milk and form many bye-products. Among these, ferments, rennet-like substances, peptone-like substances, butyric acid, amido acids and gases like carbon-dioxide, ammonia, nitrogen and sulphuretted and phos-

phorette hydrogen are important. Ferments and rennet-like products coagulate the casein, while some redissolve it. Butyric acid and peptone-like products spoil the flavour and produce bitterness. The gaseous products like sulphuretted and phosphoretted hydrogen impart a nasty smell to the stuff. Bacteria of this type are most troublesome in dairying because they are of the spore-forming type. The normal lactic bacteria act as a check on the growth of these types under favourable conditions.

140. Bacteria producing a ropy consistency:—

Many kinds of bacteria produce ropiness by acting on the milk proteids. The ropiness of *Dahi* is due to these bacteria and it is more common in winter than in summer. Bacteria of this group are difficult to eradicate when once introduced into the dairy. Cases of slimy and ropy milk are very very rare.

Besides these groups there is another group of bacteria that produces colouring matter as a bye-product and imparts it to the milk, but this group is better known in Western countries. In our country coloured milks like red milk, blue milk are not observed. Only in cases of disease or injury to the udder is milk with abnormal colour seen, and when the cause is removed the milk reverts to its normal colour.

141. Pathogenic Bacteria:—

Under this head come the bacteria that cause diseases like cholera, diarrhoea, diphtheria, typhoid, and tuberculosis, and generally these get into the milk from outside sources. The commonest of these sources are contaminated water used for dairy purposes, and dust. If pure water is used and precautions are taken with regard to cleanliness in every

detail in dealing with the milk and its products there is no likelihood of contaminating milk in this way. CHOLERA BACILLI are killed at the pasteurizing temperature (160° F.) and according to Weigmann and Cunningham they are killed through the activity of acid producing bacteria, because they die in the presence of the acid produced. This shows how lactic acid bacteria help in preventing the spread of disease. Heating milk to 160° F. for 15 minutes kills typhoid bacilli. Tubercular bacilli are also killed at 160° F. Regarding tuberculosis it is worth noting that in Western countries cattle are more predisposed to this disease and the milk of the affected cows spreads it. For this reason examination of cattle for tuberculosis and the weeding out of the affected ones is quite necessary in Western countries. In our country the case is otherwise, because cases of tuberculosis in cattle are very rare. Only a few cases are reported from Northern India, especially the Punjab, but not a single case has been reported from Southern India. Dr. Lankester who was specially deputed by the Government of India to inquire into tuberculosis, states that the disease so far has been found only in cows; that he has not heard of a single case in which tuberculosis has been found in buffaloes, and that tuberculosis in man has, he believes, never been directly traced in India to tuberculosis in cattle. Regarding the contamination of milk with tubercle bacilli Dr. Joshi's investigations are the most important. Out of 741 samples of Bombay milk only 48 showed the presence of acid-fast bacilli, but he states in his book "Milk Problem in Indian Cities" that "*in not a single sample could tubercle bacilli be demonstrated by animal experiments.*" These results have been confirmed independently by those at the Bombay Bacteriological Laboratory, Parel, where 100 samples of cows' milk were recently examined for tubercle

bacilli, but in no instance did the guinea pigs develop tuberculosis." It is evident from this that there is no ground for any one to make much of tuberculosis in our dairying. At least at present it is so, but in days to come the present immunity of our dairy breeds is likely to be marred by the introduction of the foreign blood of Western breeds by way of crossing for raising the milk yielding capacity.

142. Keeping quality of milk and the bacterial content:—

The keeping quality of milk depends on its bacterial content, and in order to ensure this quality care has to be taken to keep the bacterial content as low as possible. The chief sources of contamination of milk are air dust, body of the cow and the milker, flies, the milk churns, milking pots, milk measures, the strainer and the customers' milk pots. Though these sources of contamination are many and varied in nature, the bacterial content of milk can be controlled successfully and brought to a harmless minimum if proper precautions are taken in dairy management and the handling of milk by maintaining rigorous cleanliness in every detail. It is not practically possible to produce and sell perfectly bacteria free milk in large quantities. That does not mean that we may be negligent in enforcing cleanliness in dairy management and in handling milk, but on the contrary it enjoins us to a very strict regard to cleanliness. The keeping quality of milk has much to do with the dairy profits and the public health and therefore we have to try our best to produce and sell milk having the highest possible feeding value, and as low a bacterial content as is possible. Dr. Joshi's investigations show that with the strictest precautions it is possible to get milk quite free from disease germs, and having a low bacterial content. In his investigations the average bacterial content was found to be 292 microbes per c. c. Recent investiga-

tions regarding bacterial content of milk carried out at the Pusa Research Institute also show that this is possible. The investigator observes: "the observations made at Pusa seem to give good ground for belief that there are no insuperable obstacles to the production of perfectly sound milk with a very low bacterial content conforming to the highest English standards."

143. Bacterial Standards and milk supply of cities:

In England "Grade A" milk must not contain more than 200,000 per c. c. and any bacillus Coli in 1/100-c. c. and "certified milk" more than 300,000 per c. c. and any bacillus Coli in 1/10 c. c. Dr. Joshi states, regarding Bacterial standards, for our country: "at the present stage of our knowledge it is questionable whether such a standard should be fixed for *legal* purposes." For *administrative* purposes he proposes the following for Bombay City:—

- (1) *Microbes per c. c.* :—The total number of microbes per c. c. should not exceed two millions during cold weather (November to March) and five millions during the hot and rainy seasons (April to October).
- (2) *Lactose Fermenters*:—These should be absent in at least 1 c. c. of the sample.
- (3) *Microscopic examination of the centrifugalized sediment* should show only a few leucocytes and perhaps a few cocci and bacilli, but pus cells and pathogenic streptococci should be absent.
- (4) *Pathogenic Microbes* e. g. tubercle bacilli, Cholera Vibrio, Bacillus Typhosus &c. must be *always absent*.

Our cities and towns derive their milk supply mainly from outside sources through many dealers in milk, and the milk thus obtained is found to be adulterated with water with only a few exceptions. Under these circumstances the city milk cannot but show high bacterial content. The investigations of Dr. Mann and his staff regarding the milk supply of Poona City are the first of their kind and their findings are worth noting regarding the extent of adulteration.

I. Samples purchased at the entrance of Poona City.

Seers per rupee.	Percent samples adulterated.	Parts of water added to 100 of milk.
4	all pure	...
5	64	29
6-7	50	47
8-9	92	72
10	all	117

II. Samples bought at Jogeshwari Milk Market in Poona City.

Seers per rupee.	Adulteration.
4	Pure.
5	16 per cent. of original milk.
6-7	One-half of added water.
8-9	135 parts of added water to 100 parts of original milk.

It will be noted from the above figures for the milk purchased at the entrance of the City that the adulteration varies directly with the cheapness of milk, the cheaper the milk the more the adulteration and the cheapest milk shows that 117 parts of water were added to 100 parts of milk. When the milk reaches the market in the city and the dealer sells it, the quantity of added water is raised 135 parts to 100 parts of milk. We can only imagine the degree of contamination and bacterial content of such bazar milk when so much water is added to it. Bacteriological examination of such samples would surely have been an eye-opener. Dr. Joshi of the Bombay Municipal Corporation was the first to carry out a bacteriological examination of the Bombay milk supply on an extensive scale and such an investigation has not yet perhaps been undertaken in any other of our cities. Dr. Joshi has done a great service to the public by his investigations. The summary of his bacteriological examination of Bombay milk is as under * :—

- (i) The milk Samples were examined as follows:—
 - (a) Enumeration of microbes per c. c.
 - (b) Lactose fermenters in dilutions of 1 : 10 to 1 : 10,000,000.
 - (c) Microscopic examination of centrifugalised sediment including search for leucocytes, pus cells, streptococci and staphylococci.
 - (d) Examination for tubercle bacilli including annual experiments cultural and other tests for typhoid, cholera, and enteritis germs and bacillus coli.

* Joshi's Milk Problem in Indian Cities.

Summary of results.

Sample description.	Microbes per C.C.	Lactose fermenters present in.	Strepto cocci present in.	B. Coli present in.	Remarks.
Milk from healthy cows and buffaloes drawn under strictest personal supervision, examined immediately.	396	Absent in 1 C.C. or less.	Absent ...	Absent ...	This shows that it is possible to get pure milk if proper precautions are taken in milking, etc.
68 of II class collected in sterile bottles with ordinary precautions examined after 3 or 4 hours.	17 millions...	4 samples or 5.9 % showed the presence 1 : 1,000,000	2 samples...	24 samples	This shows that if ordinary precautions are taken the bacterial content can be lowered to a half of that of Bazar milk.
240 of III class bought at random in the city from cattle stables, dairies, Ry. Stations, milk shops, vendors and hawkers.	36 millions...	75.8 % samples 1 : 1,000,000.	11.7 % samples.	93.7 % samples	This shows a very high degree of undesirable pollution.
118 of IV class Pasteurized milk from Govt. military dairy, Bombay.	13 millions in 1st series.	63.5 % in 1 : 1,000,000 96.6 % 1 : 10,000.	Absent ...	Absent ...	This shows the advantage of pasteurization and low temperature.

- (ii) Over 90 percent. of the samples examined bacteriologically were contaminated with microbes whose presence indicates dirt &c. As regards Tuberculosis out of 741 samples of milk examined during four years not a single sample showed the presence of tubercle bacilli.
- (iii) As regards adulteration four-fifths of the Bombay milk supply was adulterated.

From the above we can form some idea of the milk obtained in cities. The extent of adulteration and bacterial contamination are partly, if not wholly, responsible for high infant mortality. These investigations also make more imperative the boiling of milk, as obtained in cities, before it is put to any use.

PART IV

CATTLE BREEDING

CHAPTER XII

PRINCIPLES OF BREEDING

144. Variation :—

The unfailing variety which is met with among living things has led to the promulgation of a natural law called the Law of Variation. This universal variation among beings helps us in classifying them into divisions and subdivisions and further distinguishing them by appropriate class names. Any two individuals or units of a class, however closely related they may be, show variations whereby they can be distinguished from one another. Variation, in a general sense, is due to either the presence and absence of characters or to the development of the same characters in different degrees. The term "character", which will be used so often in connection with the rudiments of breeding, has different shades of meaning, but in a general way it may be taken to mean any detail of qualification by the presence or absence of which an individual or a group of individuals can be distinguished from another. An example will make the definition clear. The coat of cattle has a colour; whence the property of colour in the coat of cattle is a character of the cattle. A little closer observation will show that only

certain shades are to be observed in the body colours of cattle while others are normally absent e.g. green; so that green is not the colour character of the cattle. Some times the term character is used in another sense e.g. milk yield of cattle is regarded as one character by a breeder of dairy cattle although really it is a composite character depending upon digestion and assimilation of food, circulation of blood, nervous activity and the capacity of the mammary glands, each being a separate character by itself.

The variations that are observable between any two individuals of a breed may pertain (1) to the form and size of the body or its parts (Morphological Variation), or (2) to the material of the part (Substantive Variation), or (3) to the repetition of the parts (Meristic Variation), or (4) to the functional details of the body parts (Functional Variation). To possess horns is a character of the cow species and to have horns of a particular shape is another character peculiar to a breed of cow species. All variations in body conformation come under the first head while variations such as differences in the quality of milk regarding fat % or that of muscles, bones and skin such as stiffness, elasticity, strength etc. come under the second head. Variations in the number of parts of the body are comparatively rare in cattle. The only case of such a variation of somewhat frequent occurrence is the variation in the number of teats; cows with five teats are not uncommon. The mammary glands afford a very familiar example of variation in the functional details. The function of the mammary glands is to secrete milk, but the variation in the functional details as observed in the product of the glands causes so much difference in the quality of milk of individuals belonging to different species and breeds as is determined by colour,

flavour and the percentage of its constituents. Such a minute examination of the living world with respect to the existing deviations makes two points clear viz. (1) that all individuals do vary in some respect from one another and (2) that the seat of variation is in the character or its degree of development.

145. Causes of Variation:—

The various causes of variation may be grouped under two heads (1) External and (2) Internal. Among the external causes the following are important: the nature of land, food, water and climate of a tract, suppression of reproductive organs, use of organs, state of health, injury, excitement and exertion. Of the internal causes the most important are (1) changes occurring in the germ cells from their production to their maturity; (2) conditions under which fertilization takes place e.g. relative age, vigour and health; (3) activity of the cell contents and the cell division; (4) nutrition in the embryonic state and up to maturity; and (5) intra uterine accidental conditions. These causes being very complicated are difficult to grasp, but it may be well to remember that the difference, caused somehow or other in the activity of the cell contents, is the chief cause of all variations.

146. Heredity:—

Just as variation helps in distinguishing between individuals or groups of individuals, so does what is known as the law of resemblance help in classifying living things into groups such as species or breeds based on the similarity of characters or their degree of development. The greatest resemblance is found to be among individuals that have the closest blood relationship, for instance, that of parents and progeny or that existing between the progeny of the

same parents. Yet among these individuals variation is not absent. Regarding the similarity between the progeny and parents it may be said that the progeny derives its characters from the parents and thus the resemblance may be explained, or the parents may be said to transmit their characters to their progeny and hence the likeness. This is the second great law of nature and it is termed the Law of Heredity.

147. Inheritance and Variation:—

If a close observation of the living world were made to find out to what extent characters can be transmitted, it would be found that all characters were not equally inherited by, or transmitted to the progeny, some being more developed than others. Hence the words "like tends to produce like" are often used to express this law of heredity. The characters that are prominently transmitted to, or inherited by, the progeny are said to be "dominant characters" while those that are not visibly transmitted to or inherited by, the progeny are said to be "latent characters". Let us take a particular case of a bull white in colour, a cow brown in colour and their calf dark in colour. The three colours are characteristic of the cow species and are prominently developed in these three individuals, the dark colour of the calf being a latent quality in its parents. Heredity in this sense may, therefore, be understood to connote the distribution, transmission and development of the characters of the species in individuals of consecutive generations. The causes leading to transmission of characters are not well understood. Several theories have been put forward, but none have yet been found to explain thoroughly all cases of hereditary transmission seen in nature.

However the following two theories are worth noting :

Darwin's theory *:—

1. That all the component cells of a multi-cellular organism throw off inconceivably minute germs, or "gemmules" which are then dispersed throughout the whole system.

2. That these gemmules, when so dispersed and supplied with proper nutriment, multiply by self-division, and, under suitable conditions, are capable of developing into physiological cells like those from which they were originally and severally derived.

3. That, while still in this gemmular condition, these cell-seeds have for one another a mutual affinity, which leads to their being collected from all parts of the system by the reproductive glands of the organism; and that, when so collected, they go to constitute the essential material of the sexual elements—ova and spermatozoa being thus aggregated packets of gemmules which have emanated from all the cells of all the tissues of the organism.

4. That the development of new organism, out of the fusion of two such packets of gemmules, is due to a summation of all the developments of some of the gemmules which these two packets contain.

5. That a large proportional number of gemmules in each packet, however, fail to develop, and are then transmitted in a dormant state to future generations, in any of which they may be developed subsequently—thus giving rise to the phenomena of Reversion or Atavism.

6. That in all cases of development of gemmules into the form of their parent cells depends on their suitable

*From "Examination of Weismannism" by Romanes.

union with other partially developed gemmules, which precede them in the regular course of growth.

7. That gemmules are thrown off by all physiological cells, not only during the adult state of the organism, but during all stages of its development. Or, in other words, that the production of these cell-seeds depends upon the adult condition of the parent cells: not upon that of the multicellular organism as a whole.

Weismann's Theory :—

1. That life is immortal and continuous.

2. That the protoplasm is continuous in the case of multiplication by fission or germination.

3. That a multicellular organism is made up of two kinds of cell (a) "germ-cells" forming the reproductive part and (b) "somatic-cells" forming the remaining portion of the body.

4. That the "germ-plasm" or the contents of the germ-cells is continuous directly from generation to generation, and that heredity is brought about by the transference from one generation to another of germ-plasm having a definite chemical, and above all, molecular constitution.

5. That heredity depends upon the fact that a small portion of the effective substance of the germ-plasm remains unchanged during the development of the ovum into an organism and that this part of the germ-plasm serves as a foundation from which the germ-cells of the new organism are produced.

6. Sexual reproduction can proceed by reduction in the number of ancestral germ-plasms, a reduction which is

repeated in every generation, and as the germ-plasm is seated in the nucleus, the necessary reduction can only be produced by division.

7. That there must be a form of nuclear division in which the ancestral germ-plasms contained in the nucleus are distributed to the daughter nuclei in such a way that each of them receives only half the number contained in the original nucleus.

8. There must be two kinds of karyokinesis (1) by means of which all the ancestral germ-plasms are equally distributed in the daughter nuclei, that is, "equal division" and (2) by means of which each daughter nucleus receives only half the number of ancestral germ-plasms possessed by the parent nucleus, that is, "reduction division".

9. That the reduction in the number of ancestral germ-plasms must take place immediately before the commencement of embryonic development, or in other words at the time of maturation of the egg. That one polar body is expelled in the case of unisexual reproduction and two polar bodies are expelled in the case of bisexual reproduction on maturation.

10. Reproduction by fertilization necessarily implies a reduction to one half the number of ancestral germ-plasms inherited from the parents and that the second division of the egg-nucleus, and the expulsion of the second polar body represents such a reduction, one half of the ancestral germ-plasms remaining in the egg-nucleus, the original number being subsequently restored by conjugation with a sperm-nucleus.

11. That each of the two nuclei which unite in fertilization must contain the nucleoplasm of both parents and this

latter nucleoplasm once contained and still contains the germ nucleoplasm of the grand parents as well as that of all previous generations.

12. The nature of heredity is based upon the continuity of germ-plasm from generation to generation and upon the transmission of the nuclear substance in the process of fertilization.

All other theories rather occupy an intermediate position between Darwin's and Weismann's theories. For our purpose, however, it will be sufficient to note (1) that the carriers of heredity lie in the reproductive cells, especially in their nuclei, (2) that all characters which are congenital are hereditary to a greater or less extent, (3) that the use of organs, environment, and natural selection have a greater or less effect on the development of characters, (4) that causes of variation, and heredity as well, may be traced to the bearers of heredity, origin of reproductive cells and mode of reproduction, (5) that all hereditary characters and variations visible in individuals of a family, or of two families, or of one breed, or of two breeds of the same species, are governed by two great laws of nature namely (a) the law of variation and (b) the law of heredity. From our standpoint these two laws are very important, because variation makes it possible for us to select typical individuals for breeding purposes according to our standards and heredity helps us in fixing requisite qualities in the breed.

148. Irregularity in the transmission of characters :—

We have seen that characters are inherited to a greater or less extent by individuals ; some of them are developed to a greater extent than others and become pro-

minently visible ; the rest are not developed and are said to remain in a latent condition. Characters may remain latent in one or more generations and may develop in any future generation and become visible. A character, that was prominent in a remote ancestor but was not visible in the parents or in the near ancestors, may become visible in the progeny. This reappearance of a character of some ancestor in a progeny is called "Atavism" or "Reversion" and the particular progeny a "throw back". The causes regulating atavism are not yet fully understood but it is certain that the purity of blood of successive parents, closeness of blood relationship, uniformity in parents, longer period during which breeding is carried on in a particular line and strict selection of individuals for breeding in successive generations afford less chance for such reversion.

149. Prepotency:—

All individuals do not transmit their character equally to their progeny, some individuals transmitting more than others. Individuals transmitting their characters to a marked degree are said to be "Prepotent" and this quality is called "Prepotency". The purer the blood, the closer the relationship between parents and ancestors ; and the longer the period of breeding in a particular line the greater the prepotency and the more prepotent is the animal bred in this way. Individuals of both sexes are equally prepotent. The sire influences the herd to a greater extent than the dam, simply because he produces more progeny in a season than the dam. Supposing there is one sire for 30 or 40 dams, then he influences the herd 30 or 40 times as much as any one individual dam and that is why more care is necessary in his selection and why so much value is attached to him. Further, individuals bred similarly are not equally prepotent, as

prepotency varies with individuals. Strongly marked prepotent animals are comparatively rare and hence when the prepotency is in the desired character the utmost use is made of them in introducing that character into the herd by breeding. The prepotency in individuals cannot be judged from either body points or pedigree records alone ; the performance of the progeny of the individual is the sure test of the prepotency.

150. Heredity and Diseases :—

As regards diseases of animals, it is worth noting that some of the diseases behave as hereditary characters. Some diseases of nerves, blood, generative organs and respiratory organs are inherited to a greater or less extent, at least a predisposition for them is created in the progeny. This is of course multiplied when both the parents are affected with the same disease. In Western countries experiments have proved that the progeny of cows affected with tuberculosis are born healthy and can be kept free from the disease if proper care is taken in rearing, but the progeny tend more easily to develop the disease through contagion after birth. Body defects and abnormalities are not likely to be transmitted to the progeny ; consequently we see very few defectives in a group or breed of cattle.

151. Heredity and Sex :—

Transmission of hereditary characters is not restricted to a particular sex, it may take place through either sex. Thus the son may resemble the father more closely or he may resemble the mother more ; and so with the daughter. Characters of one sex may also be transmitted through the opposite sex. For example, the character of yielding large quantities of milk, which is of course the character of the female sex, may be transmitted through the male. The

Dairy bull having a heavy milking mother and grandmothers is prepotent markedly in transmitting the milk-yielding character to his progeny. The mother, and especially the grand mothers of the bull, thus occupy an important position in his pedigree record. This type of inheritance has a special importance from the dairy standpoint, because upon it depends the selection of the breeding bull and cows for dairy purposes. By proper selection of the bull and cows in each generation, the milk yielding capacity of the breed can be gradually increased from generation to generation. The milk yield of daughters in comparison with that of mothers shows the prepotency of the bull in this particular character. The influence of the bull regarding the milk yielding character is more marked in his daughters from inferior cows than in those from good ones. Dairy animals of both sexes inherit the character regarding the quality and quantity of milk up to a certain degree and to this degree they can influence their progeny irrespective of the sex. This shows the importance of looking to ancestral records of families when selecting individuals for breeding.

152. Correlation:—

Correlation expresses the inter-relations existing between any two characters or groups of characters. This inter-relation may be either positive or negative or there may not be any relation at all. When the increase in one character is followed by a corresponding increase in any other character, the correlation is "positive". When the increase is followed by a corresponding decrease, the correlation is "negative" and when there is no relation at all, that is, when characters are independent of one another the correlation is "zero". Correlation between body

measurements and body weight, capacity of udder and amount of milk, good digestion and amount of milk, are examples of positive correlation. Fatty condition of body and amount of milk, fleshy condition of udder and amount of milk, are examples of negative correlation, while body weight and eyesight is an example of zero correlation.

Correlation existing between two characters can be measured easily by means of Yule's formula given below.

Character.		M Present.	M Absent.
N Present	...	a	b
N Absent	...	c	d

Where a, b, c, d represent the number of cases observed in group. Then $\frac{ad - cb}{ad + cb}$ = Correlation between M and N.

It will be seen that correlation between any two characters is always expressed by means of a ratio. It is useful to the breeder because it helps him to proceed with breeding on right lines. It helps him in making a selection of individuals for breeding purposes and also helps him in watching the progress made by breeding.

153. Fecundity :—

The power of reproduction is called "fecundity" and it expresses both the number and frequency of the progeny. In nature fecundity varies according to the size and longevity of the organism. The smaller the animal, the greater is its fecundity. Buffalo, cow and goat may be cited as examples. In a fixed period, say, ten years, a goat produces more progeny than a cow and a cow more than a buffalo. Fecundity varies according to species, breed and

individuality as well. In breeding, closeness of blood relationship, advance in age, too much service, too fatty a condition, too much sugary food, lack of exercise, change in surroundings and companions, disease, too much nutrition, late breeding, nervous weakness and hybridization are the conditions which affect fecundity adversely while conditions other than these affect it favourably. From a dairy standpoint cows producing more progeny in a fixed period are more profitable because we can get proportionately more milk in that period. Bulls are surer in their power of breeding between their fourth and eighth year; afterwards fecundity gradually decreases. There should not be more than thirty or forty cows for every breeding bull in cattle herds in order to avoid exhausting the bull.

154. Œstrum :—

The heat period of females is called œstrum. Its duration is different in different animals. The period deserves careful attention as the mating of animals which takes place in its duration results in sure reproduction. Œstrum recurs fairly regularly but the interval varies in different species and breeds. This interval is affected by the state of health, nourishment, presence or absence of a young one, companionship with the male, artificial drying of the milch animals by irregular milking and diseases of the generative organs. The recurrence of the heat period stops in old age and this indicates the cessation of reproductive power in the individual. During œstrum, the vaginal flow takes place, the animal becomes disturbed bodily and mentally, likes to remain with the male, tries to cover other animals, becomes noisy and the milk yield is affected. If the herd has its own bull, mating takes place naturally during this period but in the absence of a bull arrange-

ments should be made to have the animal covered as soon as possible in order to make the mating fruitful. The duration of oestrus in the case of cows and buffaloes varies from 24 to 30 and 12 to 18 hours respectively and the interval between two periods varies from 3 to 4 weeks in both.

155. Maturity:—

When individuals become fit for reproduction they are said to be mature and this stage in their life history is called maturity. Maturity does not necessarily mean complete development of the body. Generally animals attain maturity before they are full grown; for example, full development of udder and full yield of milk is attained at the third calving of a cow, so also regarding other qualities such as full height, breadth, weight etc. Generally it is seen in nature that maturity is achieved earlier in animals of smaller size and shorter life. Change in climate and in the surroundings of an animal affect its maturity. In hot countries animals become mature earlier. Artificial feeding and rearing of domesticated animals and their companionship with individuals of the other sex hasten maturity. Too much nourishment affects maturity adversely. Maturity behaves like a hereditary character to some extent. Heifers of dairy breeds become mature earlier than those of working breeds. Early maturity among dairy animals has a favourable influence on the profits of the dairy, because it affects the proportionate cost of feeding and rearing and the value of the milk yield in any fixed period.

156. Sex:—

In higher animals sex differentiation is well marked, but milk glands and teats in males of some mammals are still to

be seen. The sex of the progeny can neither be regulated nor foretold; but as there are only two sexes, possible chances, according to the law of probability, are equal for both. Several theories have been put forward regarding the influence of relative vigour and age of parents, the relative freshness of the reproductive matter, the particular time in oestrus at which mating takes place, partial castration and spaying, and nutrition of females before and during pregnancy, but none is absolutely true in each and every case. All possible variations regarding the frequency, consecutiveness and number of progeny of either sex are observed. To a dairy farmer, a large proportion of the female progeny is, of course, economically preferable. Each sex has details of body conformation and of reproductive characteristics generally peculiar to itself; but variation in this respect is also seen, as individual animals occasionally have accessory characters of the opposite sex developed to a marked degree and observable change takes place on spaying and castration, and further, in old age change in accessory sex characters also takes place.

157. Nutrition :—

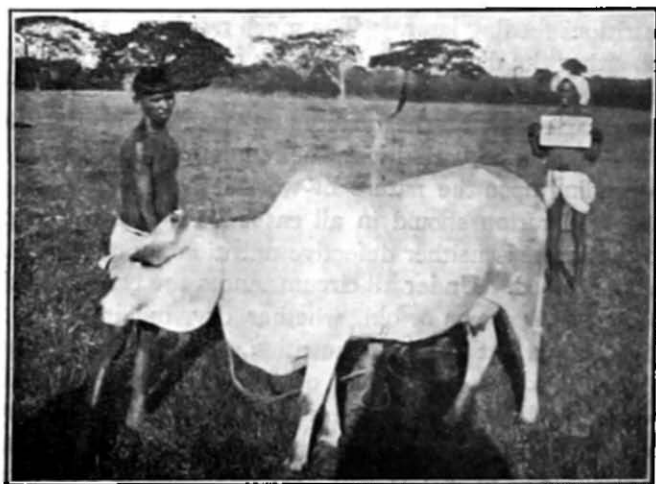
Nutrition is an important factor in animal breeding. Nutrition refers to digestion and the capacity for assimilation of food which an animal possesses and also indicates the power of an animal to turn the food it eats to some useful purpose. Hence the usefulness of the animal depends upon its capacity to respond to its feeding. If cattle are not given sufficient nutrition during the period of their growth they do not grow into useful animals. During infancy the animal's digestion and capacity for assimilation of food are at their maximum and hence in this period their growth is

most rapid. As the animal advances in age its assimilation capacity gradually decreases till the animal becomes full grown; then for some time there is neither increase nor decrease but afterwards the decrease again sets in and proceeds until the death of the animal. The facts noted so far should be enough to explain why particular attention must be paid to the nutrition of an animal, especially while it is young. The success of breeding depends partly upon proper nutrition. Actually the nutrition of the new animal commences from the time of conception or the fertilization of the ovum of the parent, and goes on increasing till it reaches its maximum at birth. Need for the supply of good nourishment to the pregnant animal will thus be quite clear. Poor and insufficient feeding of the young stock is very harmful to their digestive powers and their growth, and naturally animals so fed do not respond to careful and nutritious feeding later. Too much nutrition is also harmful, either the digestion is affected or a fatty condition is produced and the animal's fecundity is decreased. Nutrition varies with the quality and quantity of the food. These should be varied with the requirements of the animal depending upon the nature of work it has to do. Briefly the food ration should in all cases be properly balanced so that there is neither defective nutrition nor an avoidable waste of food. Under all circumstances the cattle whether young, fully grown or old, whether dry, milking or working—should get sufficient nutrition, the food being easily digestible so that a maximum of profit may be derived. The powers of digestion and assimilation are hereditary characters with a tendency to turning the food taken to a particular account, which is why food of the same quality and equal in quantity does not produce the same effect in animals differing in hereditary qualities. Liberal feeding

for instance induces a larger secretion of milk in good dairy breeds while in poor breeds it induces the tendency of putting on more fat in the body. Not only this but individuals of the same parentage may differ from one another in this respect. It will thus be seen that nutrition of animals is as important an item as heredity and selection in animal breeding.

158. Environment :—

Environment is capable of modifying the characters of cattle ; in reality, all breeds of cattle are formed by natural selection according to environment. The nature of land, kind and quality of food and fodder, quality of water and the climatic conditions help jointly in forming different breeds. In India, cattle in coastal regions are poor both in



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[Imp. Dept. of Agri.

Plate 7. Bengal Cow, Rangpur Farm. Yield : 3320 lbs. in 226 days.

work and milk capacity. Cattle in hilly tracts are small in size, hardy, active and fiery in temper and are good for all agricultural purposes. Cattle in plain alluvial tracts are large sized, mild in temper and are good both for agricultural and dairy purposes. On the coasts, specially of Bengal and Madras and the coast line bounding the Sahyadri mountains, the rainfall is high, climate is humid and the food and fodder is very poor in quality; hence cattle in those parts are small in size and are poor for work and milk. In hilly tracts where the air is drier, the land rocky and the fodder comparatively poor, the cattle are very hardy, active and spirited and have compact and strong bodies. In alluvial tracts, for instance in Gujarat, Rajputana and the Punjab, the land is soft, the air dry, rainfall is small and there is plenty of good fodder, and the cattle are therefore large in size, comparatively less hardy, mild in temper and hence the milk yielding capacity is well developed. In fact all the well known dairy breeds of India come from these dry alluvial plains of Gujarat, Sindh, Rajputana and the Punjab, while the best work breeds are found in the sedentary soil and rocky tracts and the poorest types of cattle are to be found along the Western and Eastern coast lines. Cattle become acclimatized to environment in course of hundreds of generations and thus form their own breed quite distinct in physical features and other qualities from those that are acclimatized to another set of environmental conditions. Punjab types of cattle for instance will never be found native in Himalayan tracts, and vice versa. In fact the development of all characters, under natural conditions, is chiefly regulated by the environment, the more important factors of which are the nature of land, the nature and supply of fodder and water and the climatic conditions. The decrease in the milk

yield of dairy breeds, when removed from their native place, is chiefly due to the change in the environment.

159. Average Type of a Breed :—

Average type of a breed is expressed by the mean values of all its measurable characters. If the extent of deviations were revised in a sufficiently large number of individuals of a breed it would be found that the majority of the individuals are closer to the average type. The mean value of a character may be regarded as the centre around which deviation takes place and so long as this centre, or the type, does not change, the breed is said to remain stationary. In a sufficiently large group, few extreme individual fluctuations on either side of the mean value do not affect the average type and therefore do not affect the breed when taken as a whole. There is always a maximum and a minimum limit for the development of character and all variations are always within these limits. In the improvement of a breed its average type must be watched closely because the improvement or the degeneration of the breed is indicated by a corresponding change in the average type.

160. Statistical Methods :—

In fixing the average type of a breed regarding any quality, we should have the measurements of that quality in at least 200 individuals, in order to find out the *mean value* and *indices of variation* of that quality. For our purpose the mean or the average value, average deviation, standard deviation, co-efficient of variability, probable errors of these; mode and modal co-efficients are quite sufficient. The methods of working out these are as under :—

Mean, or Average Value :—In statistical methods the "weighted arithmetic mean" is most suitable and is there-

fore usually worked out in statistical calculations. The rule to find out this is as under.

First divide the individuals or variates into different classes according to the quality measurements, each class varying from the other by a fixed measure in value, called "group value" or "class value". Then find the number of variates coming in each such class called "frequency". Then multiply each class value by the corresponding frequency, find the sum of these products and divide this sum by the total number of variates; the quotient thus obtained is the required mean.

Let us take for example the following average milk yields in a lactation of Sindhi Cows from different localities to find out the mean or the average yield of milk of the breed.

(Worked out from the figures from Smith's article on Sindhi Breed, Pusa Journal, September 1925 issue.)

Locality	No. of the cow	Lactation periods	Days in Milk average	Milk yield lbs. average.
Karachi	22	2	369'5	5402'5
	24	2	308'5	3772'0
	32	2	270'5	4508'5
	18	2	274'0	4566'0
	26	2	273'0	3568'0
	47	2	199'0	2571'0
	3	2	319'0	3574'0
	25	2	310'0	3431'0
	8	16	290'4	3924'1

Locality	No. of the cow	Lactation periods	Days in Milk average.	Milk yield lbs. average.
Mandalay	1	2	236'5	2634'5
	2	1	336'0	3087'0
	3	2	228'0	2048'5
	4	2	294'5	2956'0
	5	2	316'5	3341'5
	6	2	362'0	2992'0
	7	2	296'0	2202'0
	8	2	355'5	3872'0
	8	15	303'1	2891'6
Mhow	234	1	376'0	3841'0
	972	1	337'0	4885'0
	946	4	258'7	4553'5
	180	3	277'3	3505'0
	486	3	328'0	4346'6
	D 83	4	349'5	3245'5
	6	16	321'0	4062'7
Mysore Palace Dairy	44	6	278'6	3170'8
	96	5	248'8	2802'0
	112	7	285'1	2755'1
	722	6	352'5	3937'6
	5	3	247'0	2767'3
	30	4	273'5	2212'0
	102	12	288'0	2720'0
	142	7	227'0	2670'4
	8	50	275'0	2879'4
Coimbatore	25	2	318'5	2809'5
	27	4	226'0	2142'0
	28	1	351'0	3657'0
	29	1	283'0	3481'0
	33	2	307'0	3734'5
	34	1	293'0	2576'0
	24	2	319'0	5246'2
	25	2	313'0	5665'5
	8	15	301'3	3658'9

If we divide these cows into different classes, each class varying from the other by 500 lbs., according to their average milk yields and if we work out the necessary figures as per rule given above, these would be as under :—

Class No.	Class value (V) Milk lbs.	Frequency (f)	Product (V × f)
1	Below 2000	0	0
2	.. 2500	4	10000
3	, 3000	11	33000
4	.. 3500	6	21000
5	.. 4000	9	36000
6	.. 4500	1	4500
7	.. 5000	4	20000
8	.. 5500	2	11000
9	.. 6000	1	6000
	Total	38	141500

In the above table for class No. 2 the frequency is 4, which means that there are only four cows in the whole lot that have their average milk yields below 2500 lbs. In class No. 3 there are 11 cows having milk yields more than 2500 lbs. and less than 3000 lbs. In column 4 the figure 10,000 is the product $V \times f$, that is, 2500×4 . The totals, 38 and 141500, represent the total number of cows and the sum of the products in column 4 respectively. By dividing the total 141500 by 38, we get 3723.6 lbs. which is the average required. The formula for this is

$$\text{Average (A)} = \frac{S(V \times f)}{n}$$

where S is the sign of summation

V = the class value

n = the total number of individuals observed.

Average deviation :—The method of finding out this is to multiply the deviation of the class value from the mean as obtained above by its corresponding frequency, and the sum of all such products has to be divided by the total number of individuals. The quotient thus obtained is the average deviation. The formula for this is :—

$$\text{Average deviation} = \frac{S D f}{n}$$

(where D is the deviation from the average value.)

The average deviation in the above example would be worked out as under :—

Class No.	$D \times f$	Product.
1	0	0
2	1223'6 × 4	4894'4
3	723'6 × 11	7959'6
4	223'6 × 6	1341'6
5	276'4 × 9	2487'6
6	776'4 × 1	776'4
7	1276'4 × 4	5105'6
8	1776'4 × 2	3552'8
9	2276'4 × 1	2276'4
Total	38	28394'4

The average deviation = $\pm \frac{28394.4}{38} = \pm 747.2$ lbs. and the average milk yield of the breed would be expressed as 3723.6 ± 747.2 lbs. per lactation.

Standard deviation :—In working out the standard deviation the sum of the products of the squares of the deviations from the mean and the corresponding frequencies is to be divided by the total number of individuals. The square root of the quotient thus obtained is the standard deviation. The formula is

$$\text{Standard deviation} = \sqrt{\frac{\sum D^2 f}{n}}$$

The standard deviation in the present case would be worked out as under:—

Class No.	$D^2 \times f$	Product.
1	0 ...	0.0
2	(1223.6) ² × 4 ...	5988787.84
3	(723.6) ² × 11 ...	5759566.56
4	(223.6) ² × 6 ...	299981.76
5	(276.4) ² × 9 ...	687572.64
6	(776.4) ² × 1 ...	602796.96
7	(1276.4) ² × 4 ...	6516787.84
8	(1776.4) ² × 2 ...	6311193.92
9	(2276.4) ² × 1 ...	5181996.96
Total ...	38	31348684.48

Thus the standard deviation

$$= \sqrt{\frac{31348684.48}{38}} = \sqrt{824965.38} = \pm 908.2 \text{ lbs.}$$

By multiplying the standard deviation by 0.7979 we get roughly the average deviation.

Co-efficient of variability:—The variations explained above represent a concrete number, that is they are expressed in terms of the same units as the mean and therefore these cannot be compared to those that are expressed in other units. In order to avoid this, the variation is expressed as percentage calculated on the mean. This percentage is the co-efficient of variability. This is found by dividing standard deviation by the mean, and the quotient thus obtained is multiplied by 100 and the product is the required co-efficient. This is usually expressed by the letter "C".

The formula is

$$C = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

The co-efficient of variability in the present case would be

$$C = \frac{908.2}{3723.6} \times 100 = 24.39\%$$

The following formulas would be useful in working out the "probable error" (E).

Probable error of the mean, or (E_A)

$$E_A = \frac{\text{Standard deviation}}{\sqrt{\text{No. of individuals}}} \times 0.6745$$

Probable error of the standard deviation

$$= \frac{\text{Standard deviation}}{\sqrt{2 \times \text{No. of individuals}}} \times 0.6745$$

Mode and modal co-efficient :— When the individuals are divided into different classes according to the class values, the class with the highest frequency represents the “mode” and when this is expressed as percentage on the total number of individuals it expresses the “modal co-efficient”. The example of this is given in Art. 163. When the number of individuals is very small and the classes are too many when compared to the total number of individuals, there is likelihood of getting more than one mode. When the number of individuals is increased or when the classes are reduced in number by a change in their value, we get one mode provided the group of individuals is homogeneous and representative of the breed. In this connection may be mentioned the “Median” which is the central individual or value having 50 per cent. of the individuals below, and 50 per cent. above it. Thus it will be seen that the mean, mode and median are the central values lying near each other. When the individuals are arranged in an “array”, that is, in either descending or ascending order according to their values, the central value or the individual is the median. The mode and the median thus found by the inspection of the classes and the array respectively are empirical and not theoretical. The theoretical relation of these is as under :—

$$\text{Mode} = \text{mean} - 3 \times (\text{mean} - \text{median})$$

CHAPTER XIII

BREEDING AND BREEDS OF CATTLE

161. Cattle breeding and standard of excellence:—

Before proceeding with breeding the breeder should be prepared to devote all his attention to his work with patience, and to spend as much as the work requires without expectation of immediate profits; and, further, he must not be discouraged at the slow rate of improvement of his herd. It requires years of patient and careful work to achieve an appreciable improvement, because cattle multiply very very slowly. To test one generation means a period of three or four years. He should study thoroughly the local breeds and should know their strong as well as weak points. The climatic conditions, supply of food and fodder and the requirements of the people round about should also be taken into consideration. He must always keep in mind that the breeding business is risky and very expensive, it is lengthy and once taken in hand it should be continued at all costs till the desired result is obtained. The ideal of breeding, the goal which has to be reached, is often called the "breeding standard" or "*standard of excellence*". This must be clearly defined and should be based on utility. "*Fancy standard*" has no value from a utility point of view; thus a particular curl of the horns of cattle is simply a fancy point and does not influence at all the milk yielding or working capacities. Cattle may be bred with a "single pur-

pose" such as quality and quantity of milk or work capacity, or with a "double purpose" so as to combine these two qualities to maximum advantage. The breeder should not keep his goal or breeding standard in his mind, but should commit it to writing so that the results of breeding may be compared with it and the progress made tested; and in case the standard changes slightly it may be easier to watch the result. He must understand the value of keeping detailed and genuine records of his work as in the absence of such records it is not possible to watch the progress and to trace the probable cause of either failure or success.

162. Selection:—

The next stage after fixing the standard is to gather the material for breeding purposes and this involves careful selection of animals according to the standard of excellence. The females should be chosen from a local breed which has to be improved because they are required in large numbers. The stud bull should be carefully selected from a superior family or breed. Selection of a bull is very important, because on it depends the chance of success or failure and progress towards the goal. The bull is more valuable than any other animal in the herd, because he influences the strain of the future generation to a greater extent. In selecting stud bulls the animal should be judged from its body points and its ancestry so that an error, if any, may be on the right side. The body point requirements vary with the breeding standard, thus the body points of dairy cattle differ from the body point requirements of work cattle as will be quite clear from the following. *Draft cattle* are strong, and possess a stout big frame. The barrel is round with strong and well developed muscles of the shoulder and thigh. The neck is rather

short and thick. The hump is well developed. The legs are comparatively short, thick and with big joints

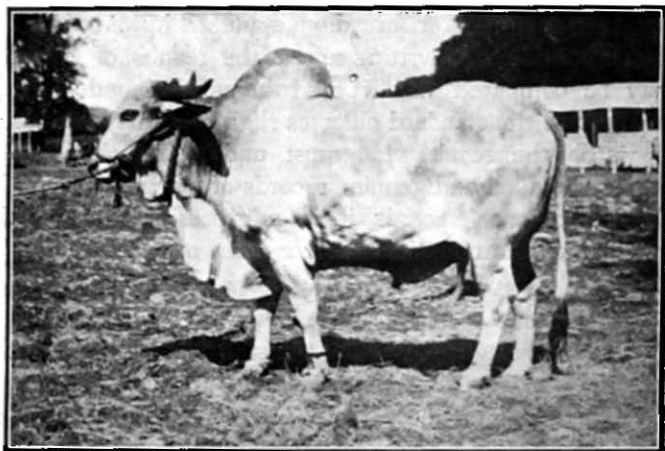


Plate 8. Krishna Valley bull—work type.
Note the strong massive build.

and large hoofs. The back is rather level. In some of the breeds the dewlap is well developed. Draft cattle appear heavy in the front portion. The head is carried high, eyes are prominent and full of spirit. Their temper is fiery, and they have a hardy constitution. In cows of working breeds the udder is small, the milk vein is not well developed, yield of milk is small and they breed late. The Amrit-mahal, Krishna-Valley, Malvi, Nimari, Kanwaria and Kheri breeds are typical work breeds. Our best *dairy breeds** are short in height and have more or less a wedge-shaped frame. The Sindi and Montgomery breeds, for example, have thick barrel and short legs and horns. Gir

* For body points of an American dairy animal, see plate 11.

or Kathiawari cows have comparatively long legs and peculiarly curled long horns. Generally our dairy breeds have their backs sloping to the front. Ears are long, well developed, and of a rich yellow colour inside. Eyes are large, prominent and mild. Skin is thin with fine smooth hair. The milk vein is well developed. The udder is large with a good milk capacity. The teats of Sindi and Montgomery cows are of moderate size and length, while Gir cows have long teats. Temper of dairy breeds is mild. Dairy breeds are less hardy in constitution. These cows are thick and heavy in the hind quarters. They breed rather earlier than draft breed cows. Our typical dairy breeds are Sindi, Montgomery, Hisar, Gir and Mewati. The *double purpose* breeds combine the characters of draft and dairy breeds. They have a good work capacity and a moderate milk yield. Among double purpose breeds may

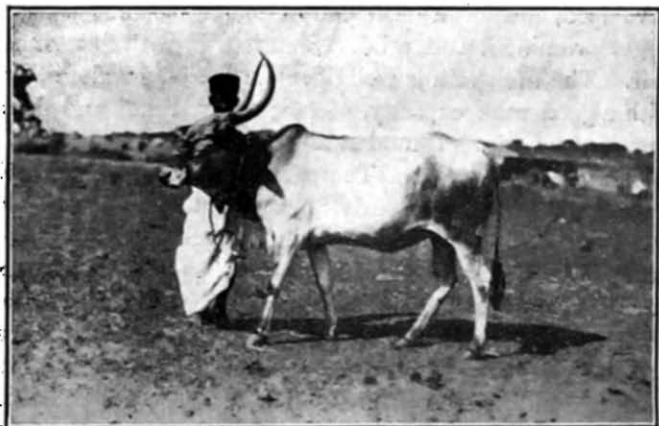


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Plate 9. Amrit-mahal Pair. Age—7 years.
Harihar Cattle Show, 1927.

be mentioned, Hisar, Mewati, Kosi, Kankreji and Nellore breeds.



By Courtesy]

[Imp. Dept. of Agri.

Plate 10. Amrit-mahal Cow—Work Type.

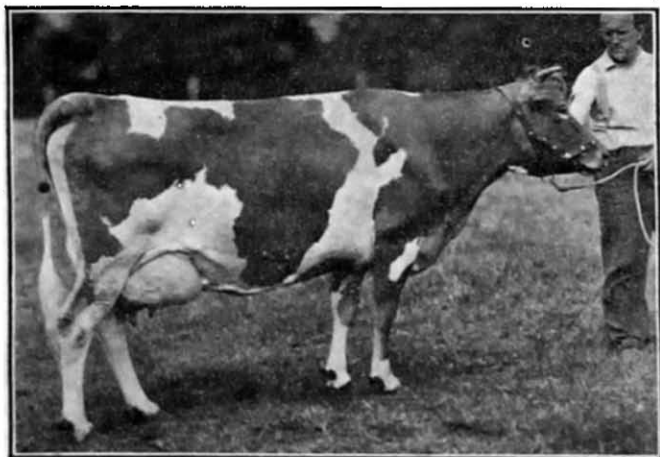
As regards pedigree or ancestral history, at present, we have to depend on what the owner of the animal may tell, in the absence of pedigree records. Government breeding stations and Military and Civil Government Dairy farms have begun keeping a sort of pedigree record recently but as yet not a single breed or herd register is published for public benefit. So, there are practically no written pedigree records of Indian breeds and we have to depend on the description given by the owner regarding the parents of the animal to be purchased. Animals resemble their immediate ancestors more closely in hereditary qualities and hence the history of immediate ancestors is most important in cattle selection. The closeness of resemblance with immediate ancestors will be clear from the following

figures worked out on the supposition that the offspring shares 50% strain from each parent.

Generation backward Closeness of resemblance.

1st	...	$\frac{1}{2}$
2nd	...	$\frac{1}{4}$
3rd	...	$\frac{1}{8}$
4th	...	$\frac{1}{16}$
5th	...	$\frac{1}{32}$
6th	...	$\frac{1}{64}$
7th	...	$\frac{1}{128}$

and so on. The selection of the stud bull for a dairy farm should be carefully made. The mother and grand-mothers of the bull should be heavy milkers to ensure the transmission of heavy milking qualities in his progeny. In the selection more importance should be attached to the quality

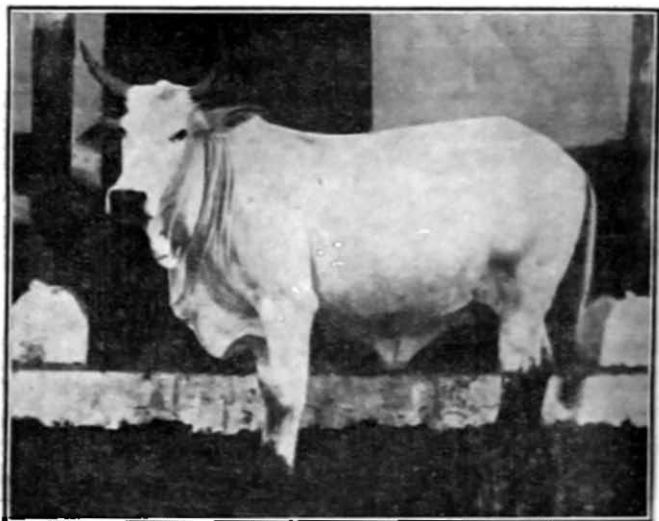


By courtesy] [Imp. Dept. of Agrl.
Plate II. Guernsey Cow "Countess Prue," U.S. champion butter
 fat producer. 18,626'9 lbs. milk and 1,103 lbs. butter in one year.

of the family than to an individual because in good families a larger number of individuals of good qualities are expected.

The animal to be selected should be healthy and free from any body defects. The same disease or defect should not occur in the families or in the individuals to be combined. The ancestors should be free from any hereditary disease or defect. If the same disease or defect be present in both parents, it is more likely to be multiplied in the progeny; and, if any were present in any of the ancestors but not visible in the existing individual, it is likely to become apparent in any of the future progeny.

The individual to be selected should be young because



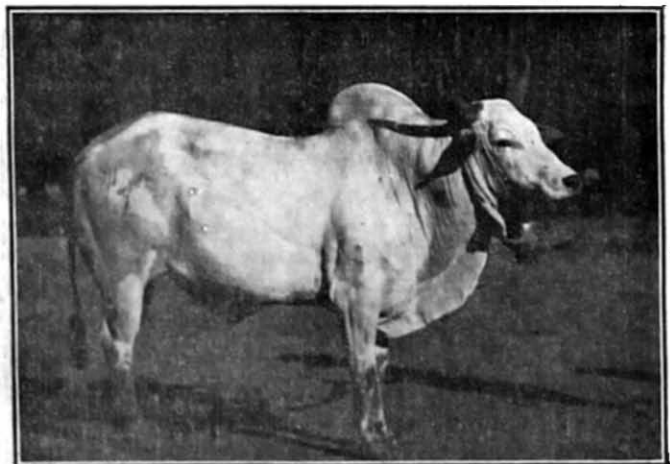
[By courtesy]

[Imp. Dept. of Agri.]

Plate 12. Malvi Cow—work type.

It will then be full of vigour, do breeding work for a longer period and hence produce more progeny. It is better to select animals in their fourth year; but if there is a specially good but older animal, it may be purchased to improve the breed or herd. The age of cattle is determined by inspection of the incisors according to the following table :—

<i>Age.</i>	<i>Milk teeth.</i>	<i>Permanent teeth.</i>
1st month	8 sharp chisel shaped	0
1st year	8 worn with round surface.	0
Towards the end of 2nd year.	6 worn with round surface.	2
2½ years	4 " " "	4
3 years	2 " " "	6
After 3½ years	0 " " "	8



[By courtesy]

[Imp. Dept. of Agri.

Plate 13. Malvi Bull—work type.
Note strong compact build.

After 4th year or 5th year the age is judged only approximately according to the extent of the wearing of the teeth. Milk teeth are bright, white and chisel shaped; permanent teeth are not so white, but rather pale yellowish in colour.

The general appearance, colour etc. should be characteristic of the breed or family to which the individual belongs, but in this respect allowance should be made for individual variations. Each and every individual of a breed or family will not exhibit all characters of that breed or the family to the same extent, because only some of them are developed prominently, some only moderately, others remaining in a dormant condition. Uniformity among the members of a breed or family depends on the uniformity in the conditions under which breeding is carried on for generations together, and hence wide differences from "average"

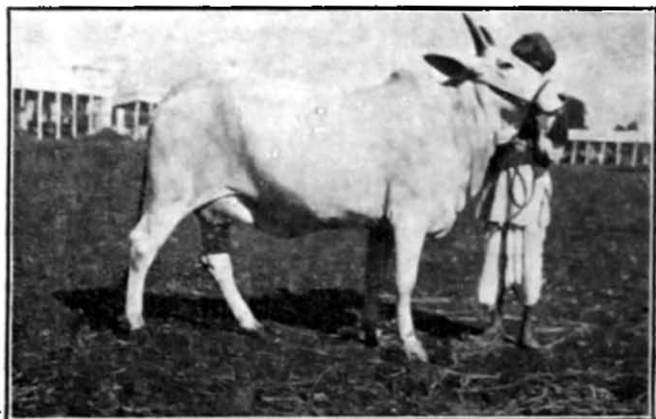


Plate 14.—Hissar Cow—Double-purpose type.

or "type" of the breed or family exhibited in any individual show lack of uniformity in these conditions and indicate corresponding impurity of blood. One point must be remembered, especially regarding colour, in Montgomery and Gir breeds. For instance, brown, white, or mixture of white and brown in any proportion are characteristic colours, and hence there is a large range of variation: white and brown may be found mixed in any proportion, or there may be any shade of brown ranging from light yellowish brown to deep dark brown so that the animal is likely to be taken as dark coloured when seen from a distance. Such is also the case with the variation in shape, inclination and curl of horns, curvature of forehead etc.

It may take one some time to make a selection since this should not be done hurriedly like the selection of cloth for our coat or shirt. The real worth of the animal is known by remaining with it for some time and by handling it, because in this manner its good and weak points are known. The "mark system"* of selection should be followed; each quality should be given some marks according to the fixed standard of excellence and out of this maximum for each quality the animal under examination

* The British Dairy Farmers' Association recommends the following scale:—

- 25 for every pound of fat produced.
- 4 " " " " S. N. F. " " " " " "
- 1 " " " " milk " " per day, average of 2 days,
- 1 " " ten days after calving subtracting 1st 40 days with a maximum of 12 points.

Deducting 10 for fat and S. N. F. if below 3 and 8.5 each respectively.

should be given marks according to its merits and the animal securing the highest number of marks should be selected. Marks should also be deducted for undesirable points in the animal under examination. Thus individuals

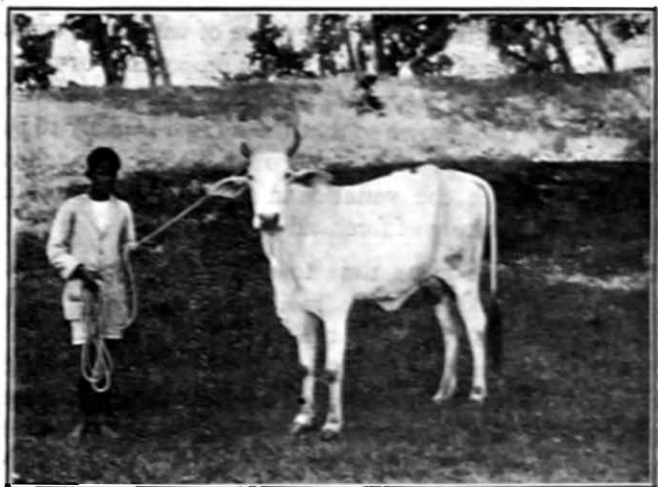


Plate 15. Nellore Cow—Double-purpose type.
(Honor Cattle Farm.)

of good ancestry and of "round excellence" should be chosen for breeding purposes. We may not be so very strict in selecting the first female stock, but we should make a rigorous selection of the stud bulls for breeding purposes. With all this, pedigree and body points alone are not sufficient to indicate the real worth of the bull, but the performance of his progeny is the real and accurate test of the quality of the bull. This will be seen from the table on the opposite page.

Daughter.			Dam.			Difference from the milk yield of the Dam.
Name.	No.	Best Lact. yield, lbs.	Name.	No.	Best Lact. yield, lbs.	
			<i>Good Type Sire.</i>			
Ashrafi	... 211	4670	Panji	... 39	4665	+5
Chakli	... 203	4317	Padmini	... 56	4094	+223
Akli	... 231	5046	Rasuli	... 132	4812	+234
Jamali	... 237	4420	Divali	... 77	3827	+593
Devaki	... 213	5349	Gomti	... 75	3346	+2003
Chabili	... 187	4729	Rami	... 78	3764	+965
Parvati	... 245	4037	Rajni	... 76	4867	-830
Gopi	... 219	5121	Foorsi	... 103	320	+4801
Soondri	... 248	4223	Makhni	... 28	4407	-184
Kadambari	... 243	6347	Jardi	... 47	4979	+1368
Abadi	... 238	4624	Durgavati	... 136	3139	+1485
			<i>Bad Type Sire.</i>			
Hanmanti	... 399	4848	Kaveri	... 133	4786	+62
Himmati	... 348	1728	Gomti	... 75	3346	-1618
Goli	... 305	410	Mootki	... 122	3435	-3025
Hasni	... 339	2620	Imani	... 138	6200	-3580
Halia	... 393	1619	"	... "	"	-4581
Rati	... 358	1445	Dhoonki	... 181	3240	-1795
Haldi	... 379	3064	Chakli	... 203	4317	-1253
Hundi	... 383	3624	Kapurni	... 283	3195	+429
Hatia	... 386	1324	Radhia	... 279	3520	-2196
Hiali	... 353	675	Thakurni	... 250	3923	-3248

(Henderson—Pusa Journal Vol. X, Page 364.)

163. Statistical Methods of Judging Cattle:—

L. The relative merits of cattle, individually or in a group, can be judged correctly only by statistical methods. For this purpose we must have genuine records of individuals separately or of the whole herd. Suppose we have to judge the quality of a particular herd of 28 cows from a milk yield stand-point and compare it with another herd, the average yield per lactation of 28 cows of the herd of a particular breed is as under :—

Cow No.	Yield in lbs. per lactation.	Cow No.	Yield in lbs. per lactation.
1	1135	15	1635
2	1734	16	2768
3	2291	17	2051
4	1949	18	1574
5	3086	19	1368
6	1188	20	1382
7	2215	21	1852
8	2311	22	2452
9	2705	23	2062
10	1927	24	1377
11	2080	25	1177
12	2832	26	1791
13	1281	27	2203
14	2071	28	2198

If these cows be divided into different groups, each group varying from the other in milk yield by 500 lbs., for the sake of simplicity the number of cows in each group will be as follows :—

Group.	Group Value.	No. or frequency.	Product of Group Value and Frequency.
1	below 1000 lbs.	0	0'0
2	.. 1500 ..	7	10500'0
3	.. 2000 ..	7	14000'0
4	.. 2500 ..	10	25000'0
5	.. 3000 ..	3	9000'0
6	.. 3500 ..	1	3500'0
Total		.. 28	62000'0

From this the mean yield of milk per lactation for this group of 28 cows = $\frac{62000'0}{28} = 2214'3$ lbs.

Secondly the above figures show that group 4 has the largest number of cows, i.e. in this cow herd the majority have the yield between 2000 and 2500 lbs. per lactation. This is the tendency of the majority of the cows and hence it expresses the "type" of the whole herd. Technically the number 10 of group 4 is called "mode" and it is expressed as percentage (Modal co-efficient). Thus the modal co-efficient of the cow herd in question is $\frac{10 \times 100}{28}$, that is 35'7 % of the cows are representing the

average type of the herd. In this way we can find out the mean and modal co-efficient of any other herd of cattle regarding any measurable character and compare them with those of other herds and thus we can find out which is the superior.

2. Another method of judging cattle is to find out milk yield in a lactation per 1000 lbs. of body weight or number of dry days or milk yield in one year and then compare. For this we require body weights of different

individuals and their respective milk yield, etc. For example we take a group of 5 Montgomery cows and another of 5 Delhi buffaloes for comparison, taking the necessary figures as under :—

Buffalo Delhi breed.	Length.	Girth.	Body wt. lbs.	Milk yield in a Lactation in lbs.	Milk yield in one Lactation per 1000 lbs. wt. of body.
Tara ...	5'-0"	7'-0"	1411	3401	2410
Chandia ...	5'-0"	6'-9"	1312	3676	2801
Murri ...	5'-0"	7'-0"	1411	5178	3669
Kasturi ...	4'-11"	6'-0"	1019	4749	4660
Gabni ...	4'-8"	6'-9"	1224	4253	3474
Average ...	4'-11"	6'-8"	1275	4251	3402·8

Cow Montgomery breed.	Length.	Girth.	Body wt. lbs.	Milk yield in a Lactation, lbs.	Milk yield in one Lactation per 1000 lbs. wt. of body.
Badami ...	5'-0"	5'-4"	819	3436	4195
Lalia ...	4'-6"	5'-0"	648	3285	5069
Kabria ...	4'-5"	5'-5"	746	2724	3651
Rosi ...	4'-5"	5'-2"	679	4122	6070
Barthani ...	4'-5"	5'-0"	636	2904	4566
Average ...	4'-6"	5'-2"	705	3294	4710·2

Delhi Buffalo.	Average dry days in a year.	Average Milk lbs. in a year.	Average dry days in a year.	Average Milk lbs. in a year.	Mont. Cow.
Tara ...	163·5	3607·3	149·0	3295·3	Badami.
Chanda ...	214·0	2449·0	144·0	3122·3	Lalia.
Murri ...	107·0	4307·3	119·5	2709·0	Kabria.
Kasturi ...	221·0	3248·0	156·5	3591·6	Rosi.
Gabni ...	144·0	3577·5	139·5	2901·6	Barthani.
Average ...	169·9	3437·8	141·7	3123·9	Average;

These figures show that Montgomery cows yield more milk than Delhi buffaloes weight for weight of the body. But the milk-yield in a period of one year of Delhi buffaloes is more than that of Montgomery cows and as regards the period of dry days in a year Delhi buffaloes remain dry for a longer period than Montgomery cows. Similarly the cattle can be judged from the stand-point of food consumed and milk yielded in a year or from the stand-point of butter yield or fat percentage, etc.

3. Relative merits of cattle can be judged by finding out the correlation between any two characters. For instance we take the above group of 5 Montgomery cows and work out the correlation between the body weight and milk yield per lactation.

Let the average weight—705 lbs. = X

and „ „ milk yield—3294 lbs. = Y

Then the relative merits with respect to X and Y of the individuals of this group are as under :—

Cow Nos.	Weight.	X=705 lbs.	Milk Yield.	Y=3294 lbs.
1	819	+	3436	+
2	648	—	3285	—
3	746	+	2724	—
4	679	—	4122	+
5	636	—	2901	—

If we arrange the frequencies with respect to the excess or the deficiency with respect to X and Y according to Yule's method (Art. 152) they work out as :—

		More than X.	Less than X.
More than Y	...	1	1
Less than Y	...	1	2

Hence the correlation between the body weight and milk-yield $= \frac{2 \times 1 - 1 \times 1}{2 \times 1 + 1 \times 1} = \frac{2 - 1}{2 + 1} = \frac{1}{3} = 0.3$ for this particular group of Montgomery cows.

In this way correlation between milk yield and butter yield or butter fat % or food consumed, etc. can be worked out and groups or individuals compared and their relative merits determined.

4. Percentage figures worked out from dairy records regarding different items would also be useful in comparing relative merits of cattle herds. The following figures from a dairy record serve as an example :—

	Herd No. 1 Average figures.	Herd No. 2 Average figures.	
Per cent. Cows	76·8	51·9	Number. .
.. Buffaloes	23·1	48·1	..
.. Calvings in a year	85·6	67·5	..
.. Milking cattle	58·9	60·2	..
Calves fed per 100 adults ...	114·6	96·0	..
Concentrated food fed per 100 adults per year.	1619·4	2925·5	Maunds.
Milk yield per 100 adults in a year.	1772·3	3106·7	..
Food units per 100 units of milk.	68·3	69·0	

164. Mating :—

Cattle chosen according to all the points discussed above should be mated. Cattle differing too much in age and size should not be mated. We must be very careful in avoiding mating with inferior and nondescript bulls. In combined herds inferior bull calves should be castrated or sold and only selected bulls should be allowed to serve the cows. When the bull is allowed to be with the herd while grazing, mating often takes place if there be a cow in heat. But it is a better plan to have a separate enclosure for mating in order to control mating on desired lines, that is, mating of only chosen animals. Mating will not take place if the cow is not sufficiently in heat. In some cases companionship is also an important factor as some cows show a sort of choice for a particular bull and hence will not stand to another bull. Some bulls lose their mating power temporarily on change of place and change

in neighbours. Old age, too much service, little exercise; too much sugary food and too much fat in the body adversely affect the mating power of bulls. When the cow is in heat she is much disturbed and hence does not eat her usual quantity of food; this helps in a way the retention of germinal substance in the womb. After mating the cow should not be disturbed or made to run or walk long distances, food should be withheld for some hours and for some two or three weeks she should not be given oil cakes or other heating foods. These precautions help retention of semen and thus help fertilization to some extent. Generally one service is sufficient in a heat period to ensure fertilization but sometimes two are required.

165. Crossing:—

Mating of individuals of two separate breeds is called crossing and the progeny is called a "cross" or "cross-bred", and it inherits nearly 50% qualities of the two breeds. From a dairy stand-point male crossbreds are useless for breeding purposes; the female crosses are better in milk yielding capacity than their mothers provided the sire is of a good milking breed. Interbreeding of crossbreds makes no improvement in their progeny and hence only the first crosses are superior to the inferior parent but inferior to the superior parent. For a more or less permanent improvement either "inbreeding" or "grading" must be followed. By crossing, the uniformity secured in the progeny is the least, because the breeding conditions are most favourable for variation. The improvement in the first cross and the stability of the progeny of crosses when interbred will be clear from the following:—

$$\begin{array}{ccc}
 & \text{(Superior) A} & \times & \text{B (Inferior)} & \\
 & | & & | & \\
 \text{C(male)} & & & & \text{D(female)} \\
 (\frac{1}{2} \text{ A} + \frac{1}{2} \text{ B}) & & & & (\frac{1}{2} \text{ A} + \frac{1}{2} \text{ B}) \text{ 50\% improvement.}
 \end{array}$$

But if C & D are crossed with C' & D' obtained from A & B' there would be no improvement.

$$\begin{array}{c} C \times D \\ | \\ K \end{array}$$

as $K = (\frac{1}{2}C + \frac{1}{2}D') = \{(\frac{1}{4}A + \frac{1}{4}B) + (\frac{1}{4}A + \frac{1}{4}B')\} = (\frac{1}{2}A + \frac{1}{2}B)$
 No further improvement, B and B' being of the same type.

266. Grading:—

In this method sires of superior blood are chosen for breeding, and improvement in the inferior herd is effected gradually from generation to generation. The progeny is usually termed a "grade". Cows of inferior type are chosen and for each generation a fresh sire of superior blood is used and thus superior blood is introduced into the herd and the same method is followed with the graded females as well as in each successive generation. This method is the safest of all methods of breeding carried on for improving inferior herds. If a superior milking quality has to be introduced in common cattle, a number of common cows and a bull of superior milk strain are selected and mated. Then, about half of the progeny of this first generation would be females and these would have nearly 50% superior blood in them and thus they would be superior to their mothers in their milk yielding capacity. The first generation "grade-females" would be the female stock for the second generation. These are to be mated with a fresh bull of superior strain and so on for every successive generation. Thus it will be noted that each sire can be used only for three or four years as female calves attain puberty in their third or fourth year, and thus it is possible to avoid inbreeding. The rate of improvement effected in

this manner will be quite clear from the following, supposing that the progeny inherits 50% of strain at each generation.

Generation.	Superior Blood.	Inferior Blood.
1	$\frac{1}{2}$	$\frac{1}{2}$
2	$\frac{3}{4}$	$\frac{1}{4}$
3	$\frac{7}{8}$	$\frac{1}{8}$
4	$\frac{15}{16}$	$\frac{1}{16}$
5	$\frac{31}{32}$	$\frac{1}{32}$
6	$\frac{63}{64}$	$\frac{1}{64}$
7	$\frac{127}{128}$	$\frac{1}{128}$

From the above it will be seen that the seventh generation is very nearly equal to the superior strain.

67. In-breeding :—

In this method of breeding, mating of close relations is brought about e.g. father with daughters or grand-daughters, brother with sister, and the like. This method is followed (1) when the utmost use of a specially good individual must be made for fixing its special qualities in its progeny, (2) for increasing the prepotency of sires, (3) for bringing about uniformity of type and (4) for cutting short the period required for reaching the desired standard. But this method has its own risks and disadvantages e.g. (1) if a wrong selection is made the defects are exaggerated in the progeny (2) the progeny becomes delicate and more susceptible to disease (3) fecundity is decreased (4) more or less degeneration of the herd is caused (5) it is difficult to find out the stage of breeding at which it is to be discontinued to avoid the bad effects of this method. Thus it will be noted that in-breeding is the short cut for fixing the desired qualities, but as it is risky it is followed only occasionally by experienced cattle breeders. When the relationship of the individuals

chosen for breeding is not so close as to cause in-breeding, the term "Line-breeding" is used. The relationship up to great-grandson or great-grand-daughters indicates in-breeding and a wider relationship than this indicates line-breeding. Line-breeding is followed for improving the breed by raising the general standard in any desired line.

168. Indian dairy breeds:—

We have quite a number of cattle breeds but only a few of them can rightly be called dairy breeds. Our dairy breeds have not yet been properly studied and so there is very little accurate information regarding their characterist-

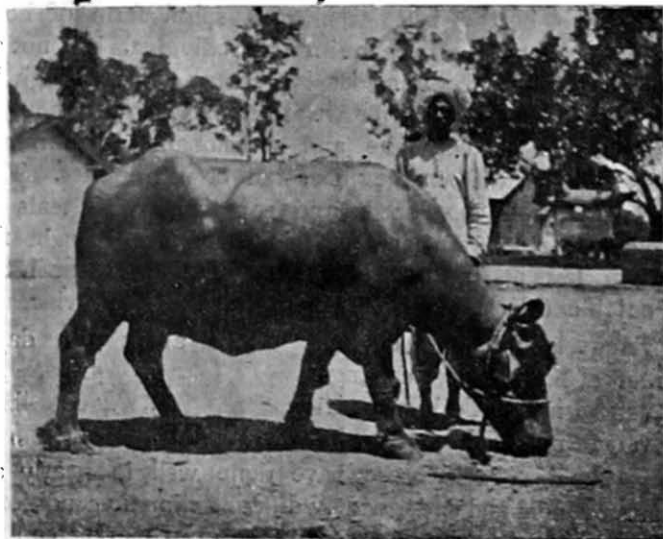


Plate 16.—Delhi Buffalo.

ics from a dairy standpoint. In the following articles short descriptions of more important buffalo and cow breeds kept

in dairies are given. The figures regarding the milk yield etc. may differ and hence may not be applicable to each and every locality, however, they will be sufficient to show the relative merits of our different breeds.

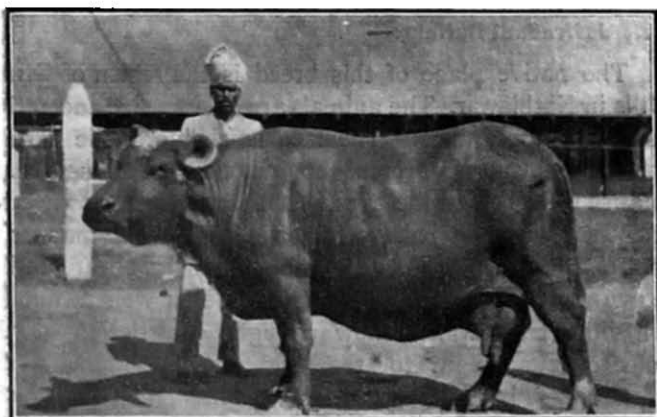
169. Delhi or Murrah Buffalo:—

The native place of the Murrah buffalo is the Rohtak District of the Punjab. The animals of this breed are the heaviest milkers of all the Indian breeds. They are of large size and shapely in form when compared with the Jaffrabadi Buffalo. The head is comparatively small, shapely and clean cut with characteristic horns turning upwards and curling inwards in spiral form. In animals of the best strain, this spiral form of horn is more marked while in inferior individuals it is not so complete. The body colour is generally black though in some animals it tends to brown to some extent. The eye-balls are sometimes white and occasionally white markings are met with on the face, tail or extremities. The udder is well developed and capacious with teats of moderate size. Animals of this breed are brought for sale to fairs at Amritsar, Jabajgarh, Gulushah, Hissar in the Punjab and Kosi, Makhkhanpore in the United Provinces.

Average lactation period	about 314 days.
Interval between two calvings	" 514 "
Average milk-yield in a lactation	" 4700 lbs.
Average milk-yield per day in a lactation	" 14 "

Animals of this breed have done well in nearly all parts of India and under widely differing climatic conditions. Murrah buffaloes as purchased in the open market can be depended upon to yield 3500 to 4000 lbs. of milk in a lactation, as per latest available data.*

*Smith—Journal for A. H. and Dairying Vol. I, Pt. 4.



By Courtesy]

[Imp. Dept. of Agri.

Plate 17.—Sindi Murra buffalo—Bangalore Farm.
Yield 8489 lbs. in 359 days.

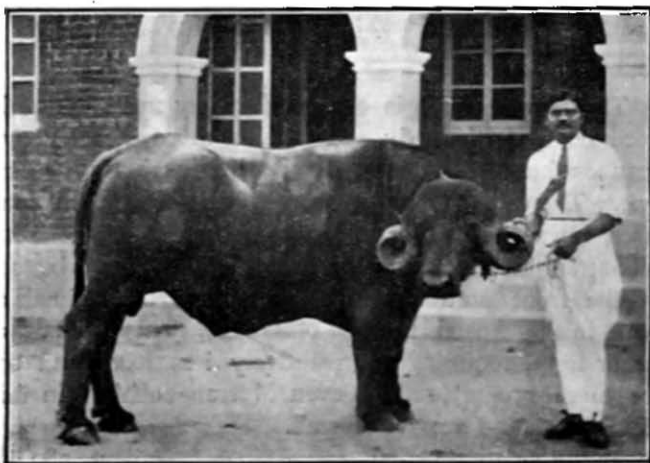
170. Surti Buffalo:—

The Surti Buffalo is of comparatively small stature but more compact in body. It is also more shapely with clean cut head. The horns are not long as in the Deccani type. The colour is black but has a tendency, in many cases, towards a slight brown colour. In animals of better milk strain grey or light brown hair patches may be seen on the front portion of the chest. The best animals are found in the Anand District of Gujrat. The animals are rather light, requiring comparatively less food, and thus are more profitable than even Murrah buffalo. In milk-yield they stand next to Murrah.

Average Lactation period	about 380 days
Interval between two calvings	" 510 "
Average milk-yield in lactation	" 4100 lbs.
Average milk-yield per day in lactation	" 11 "

171. Jaffrabadi Buffalo:—

The native place of this breed is the region of Girnar Hills in Kathiawar. The animals are of large size and rather coarse in appearance. The face is characteristic with a specially developed frontal bone so that the horns appear to arise from behind the eyes. The horns turn downwards and then curl and behave rather in an opposite manner to that of Murrah buffalo. Animals of this breed are rather heavy in the forequarters. The udder is well developed with long teats which show a slight constriction at the point of attachment to the udder. The animals are good milkers but are rather more expensive in feeding and hence are not so profitable as Murrah and Surti buffaloes.



[By Courtesy]

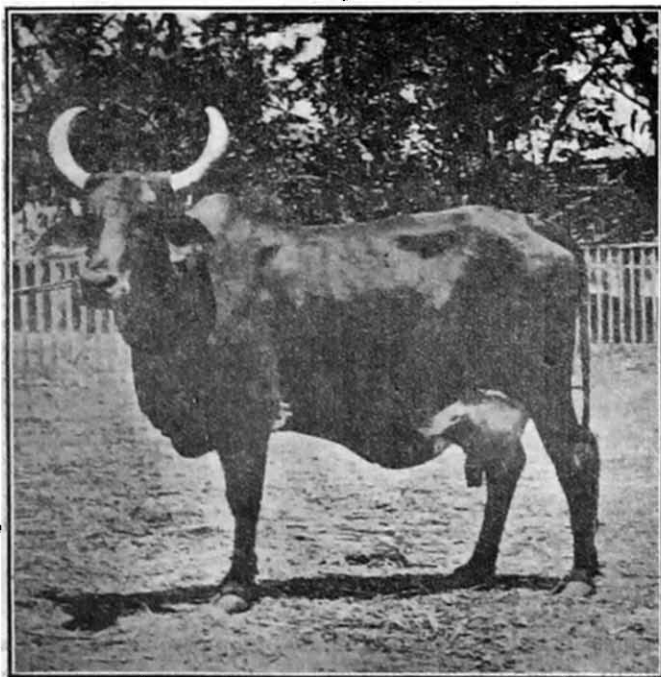
[Imp. Dept. of Agri.

Plate 18. Jaffrabadi Buffalo bull.
Property of the Maharaja of Baroda.

Average Lactation period	about 380	days.
Interval between calvings	" 480	"
Average milk-yield per lactation	" 4500	lbs.
Average daily milk-yield in lactation	" 10	"

172. Sindi Cow:—

This breed is found near Karachi. The animals are of moderate size. The body is comparatively compact, deep



[By Courtesy]

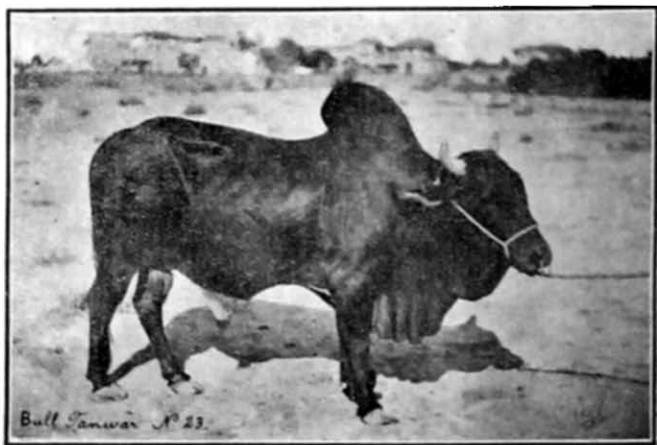
[Imp. Dept. of Agri.]

Plate 19. Sindi Cow, No. 721, of Bangalore Farm.

Yield—7272 lbs. in one lactation.

and broad. The face is rather short with short and blunt horns, and the muzzle is broad. The neck is short and thick. The usual colours are red, brown or dark brown. The udder is large and a little fleshy. The cows are heavy milkers for their feed and hence more profitable.

Average lactation	about 350 days
Average interval between 2 calvings	„ 444 „
Average milk-yield per lactation	„ 3400 lbs.
Average daily milk-yield in lactation	„ 9 „



By Courtesy]

[Imp. Dept. of Agri.

Plate 20. Sindi Bull, "Tanwar." Willingdon Farm, Karachi.

This breed resembles the Montgomery breed of the Punjab in general appearance. Recent figures regarding the performance of the cows of this breed given by Mr. Smith, go to show that they do fairly well in different parts of our country.

173. Gir Cow:—

The cattle of this breed are found in the tract of Girnar hills in Kathiawar. Gir cows are taller and larger in size than Sindi Cows. Their usual colour is red or brown or a mixture of red and white. The forehead is generally bulged out with a characteristic horns sweeping back with peculiar curl. The ears are long and pendulous. The whole head is characteristic of the breed. The dewlap and sheath are well developed. The teats are comparatively long. The general appearance is rather coarse. The cows are good milkers.

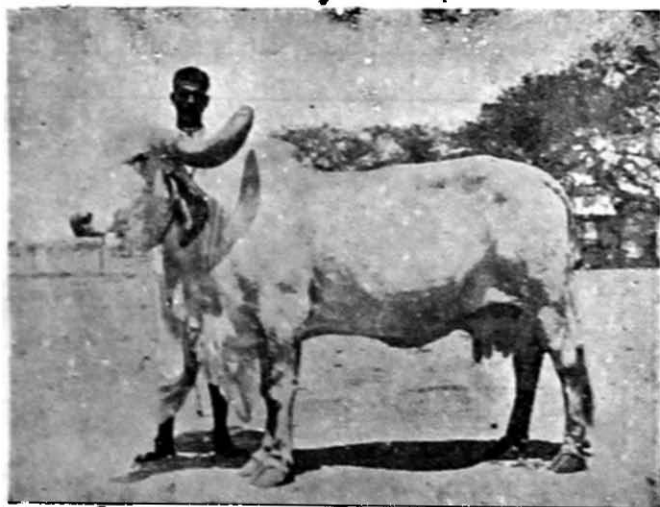
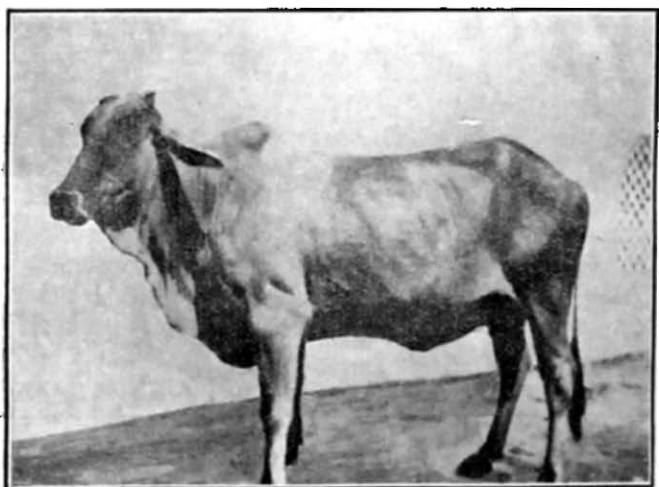


Plate 21. Gir Cow.

Average lactation period	about 310 days.
Interval between two calvings	" 460 "
Average milk-yield per lactation	" 3200 lbs.
Average daily yield in lactation	" 10 "

174. Mewati Cow:—

This breed is found in Mewat. This is a tract consisting of a part of Bharatpur and Alwar States and a part of the Gurgaon District of the Punjab. Mewati cattle resemble the Hissar cattle, but they are smaller in size. The usual colours are white and grey but some times mixtures of black, white and brown are met with. When the colour is grey the shoulder and back are darker in shade. The head is small and clean cut, the horns are of moderate size and curve upwards and inwards. The ears are long and pendulous and the forehead is wide with prominent eyes. The tail is of medium length and tapering. The dewlap is moderately developed and the sheath is small. This breed



[By Courtesy]

[Imp. Dept. of Agri.]

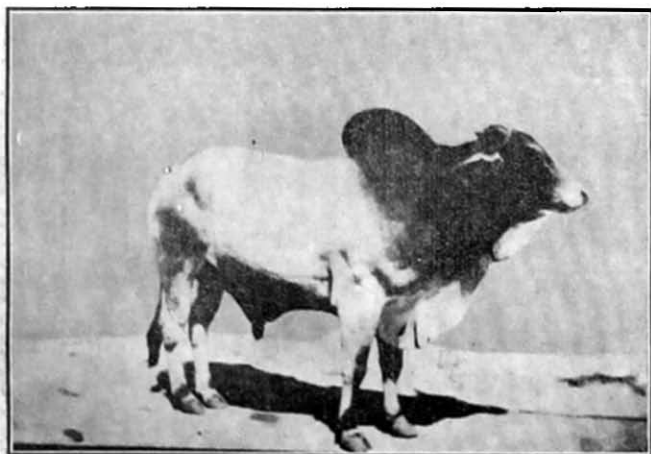
Plate 22.—Hariana Cow, "Daisy", M. D. Farms.**Yield—8195 lbs. in one lactation.**

is noted for its milk-yield as well as agricultural capacity, and hence is a "double purpose breed".

Average lactation period	about 270 days.
Interval between two calvings	" 390 "
Average milky yield per lactation	" 2000 lbs.
Average milk-yield per day in lactation	" 7 "

175. Hariana Cow:—

This breed is also known as Hissar or Hansi. It is found in the Hissar and Rohtak districts of the Punjab. The colour is grey white, the face is rather long and pointed with a broad and slightly bulged forehead. The eyes are large and prominent. The horns are of moderate size, curve inwards and are upright. The ears are long and pendulous. In grey animals the dark colour becomes



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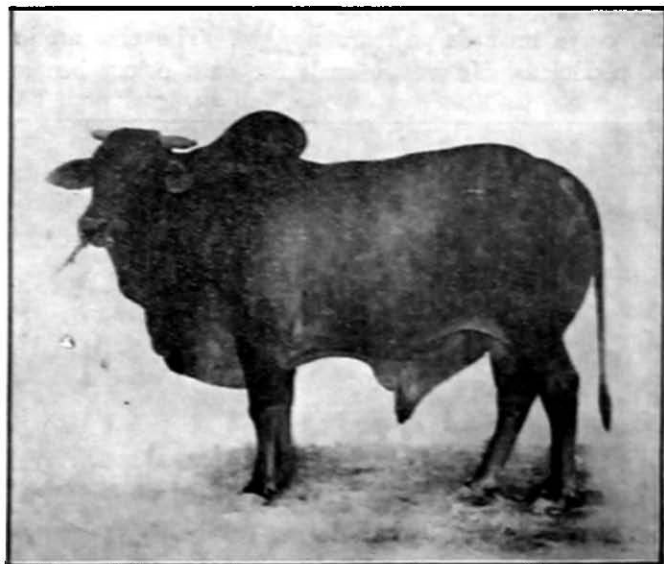
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Plate 23.—Hariana Bull, "Chieftain".
Military Dairy Farms Dept.

deeper in shade on the neck, shoulder and hind quarter. The tail is moderately long and tapering. The udder well developed with teats of moderate size. All parts of the animal are well proportioned. The cows are good milkers and can be had in the cattle fairs of Hissar, Jhansi, Sirsa and Amritsar. The Haryana cows are superior to Mewati in milk-yield and work capacity while in other details they resemble them.

176. Montgomery Cow:—

This breed is also called "Sahiwal breed". It is found in the Montgomery district of the Punjab. The cows

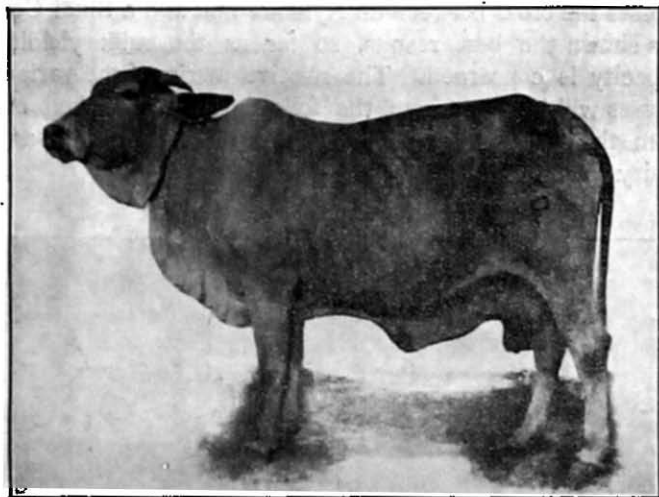


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[Imp. Dept. of Agric.]

Plate 24.—Montgomery Bull, "Robert".
Property of Pusa Farm.

this breed are comparatively shorter than the Harianas. The horns are short and blunt. The head is comparatively short and rather clumsy with a broad muzzle. Usual colours are red, white and red mixed, and brown. The dewlap is well developed. Sheath is comparatively large.



By Courtesy]

[Imp. Dept. of Agri.

Plate 25.—Montgomery Cow, "Googni", Pusa Farm.

Yield—6457 lbs. in 307 days.

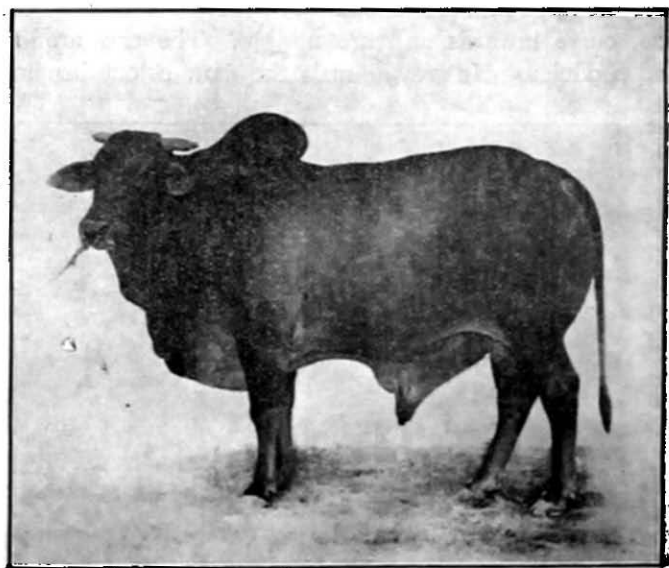
and rather continuous with the udder. The cows of this breed are heavy milkers.

Average lactation period	about 264 days.
Interval between two calvings	" 413 "
Average milk-yield in a lactation	" 3200 lbs.
Daily average yield in lactation	" 12 "

deeper in shade on the neck, shoulder and hind quarters. The tail is moderately long and tapering. The udder is well developed with teats of moderate size. All parts of the animal are well proportioned. The cows are good milkers and can be had in the cattle fairs of Hissar, Jahazgarh, Sirsa and Amritsar. The Haryana cows are superior to Mewati in milk-yield and work capacity while in other details they resemble them.

176. Montgomery Cow:—

This breed is also called "Sahiwal breed". It is found in the Montgomery district of the Punjab. The cows of



By Courtesy]

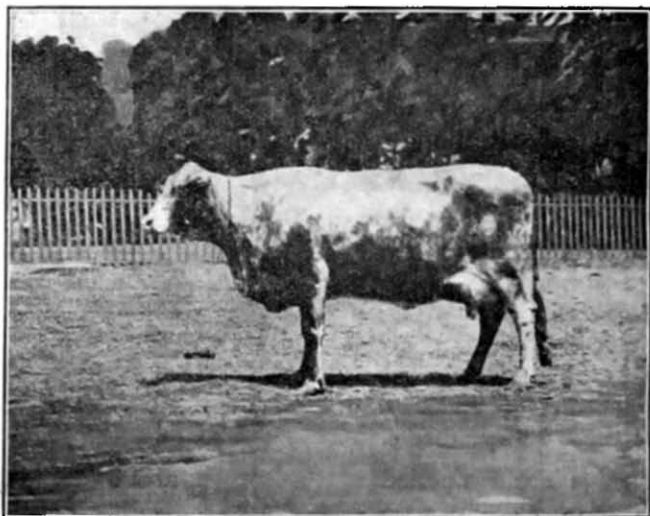
[Imp. Dept. of Agri.

Plate 24.—Montgomery Bull, "Robert".
Property of Pusa Farm.

The cattle of this breed can be had in the fairs of Sirsa, Amritsar, Jahazgarh and Hissar.

177. Cross Breed —

The crossing of Indian cows with English bulls is practised in some Military Dairy Farms and of the various crosses the cross between an Ayrshire bull and a Sindi Cow has shown the best results, so far as the milk yielding capacity is concerned. The relative merits of the various crosses will be seen from the following table worked out from the data published in the Journal of Dairying and Dairy Farming in India.

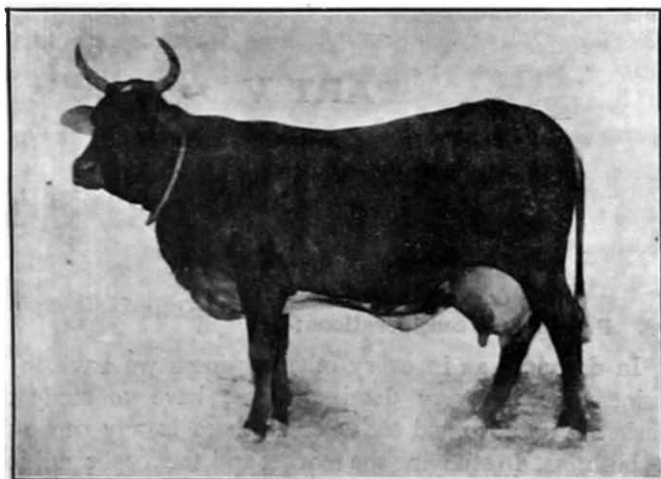


[By Courtesy]

[Imp. Dept. of Agri.]

Plate 26.—Ayr—Hissar Cow, "Jill", Bangalore Farm.

Yield—145,000 lbs. in 15 years.



By Courtesy]

[Imp. Dept. of Agri.

Plate 27.—Ayr—Montgomery Cow, "Alibi", Pusa Herd.

Yield—12,028 lbs. in 304 days.

Table showing the relative merits of various crosses:—

Name of Cross.	Average of	Milk yield in lbs. per lactation.		Station.
		Cross.	Dam.	
Short Horn X Sindi ...	19	3813·6	1887·2	Qnetta.
" X Hansi ...	5	3750·6	1699·2	Bangalore
Ayrshire X Hasni ...	16	4596·4	2112·1	"
" X Hasni ...	1	4798 0	2734·0	Kirkee.
" X Hissar ...	3	3925·6	1575·3	Mhow.
" X Sabiwal	4	3670 5	1767·0	Bangalore
" X Sahiwal	9	3275·0	1536·2	Mhow.
" X Sindi ...	14	4717·5	2323·0	Kirkee.
" X Sindi ...	2	3754·0	1656·0	Mhow.

PART V

CHAPTER XIV

DAIRY ECONOMICS

178. Preliminary considerations:—

In dairying, as in every other business we have to be business-like in every detail and we have to study the market in order to find out whether there is any scope for the business. In studying the market and the local conditions we should know (a) the population of the town or city, (b) infant mortality, (c) the condition of the people, (d) approximate quantity of milk consumed daily, (e) number of milch cattle kept privately, (f) number of cattle owned by dairy-men and gwalas, (g) amount of milk supplied from outside, (h) number of tea shops, hotels and sweetmeat shops, (i) market rates of milk and its products and the quality of these, (j) general education standards and tendencies of the people with regard to the quality and rates of milk and its products. The study of these items should give us a definite idea as to the approximate requirements of milk and its products and the advisability of starting a new dairy concern. Should the conditions indicate the advisability of starting the business, the next step would be to ascertain what proportion of the market could be secured and what would be the milk requirements at the very start. Should it be thought that 5 maunds of milk could be sold daily, it would be advisable to arrange for 4 maunds of milk to start with

because some of the anticipated customers might drop off in the very beginning. Besides, when the capital is limited, it is risky to speculate and start the business on a large scale. To make a small beginning in business, and to develop it gradually in proportion to the experience obtained and the credit established, is always safe.

When the quantity of milk we wish to supply is fixed, the next thing to do is to see what capital would be required to start the business, and this we cannot do unless we settle on what lines the dairy is to be run. Dairies may be divided into three classes with regard to the livestock. (A) Dairies run on the lines of the *Gwalas*, where the milch cattle, milking, or those that are about to deliver are purchased and are sold as soon as they become dry, requirements of food stuffs being purchased by the month or fortnight. (B) In these, milch cattle are purchased and maintained during their dry period and not sold. The fodder may be either purchased or grown or partly grown or partly purchased. (C) In these, the milch cattle are bred with a view to breeding cattle of a better strain thus to improve the breeds. The fodder is grown on the dairy land. The C type dairy farms require the greatest capital investment and the A type dairies require the least comparatively. In order to estimate the capital investment we have to take into consideration the items of initial and current expenditure, these being (1) land, (2) buildings, (3) livestock, (4) dead stock, (5) feeding, (6) labour, (7) sundries. A rough estimate of the current and initial expenditure on these items would give us some definite idea of the capital requirement. The next thing is to look to the items of income in order to see the margin of profit. The estimated margin of profit should help us in deciding whether it is worth while to invest so much capital.

The items of income are (1) sale of milk and its products (2) sale of live stock, (3) Manure (4) Sundry receipts.

179. Land :—

Land for dairy farms may be either purchased or taken on long lease ; in the former case much initial capital investment is required, while in the latter case the rent of the land becomes an item of current expenditure. For dairy farms land is required for buildings, fodder cultivation and grazing. Open air and healthy surroundings and a supply of good water are the important points in the case of land meant for buildings, soil fertility and irrigation facilities in the case of fodder lands, and quantity and quality of grass in the case of grazing grounds. Besides these, means of communication like roads and distance from the market must also be taken into account. The price of the land may vary from Rs. 50 to Rs. 1,000 or more per acre according to the quality, situation and other local conditions. Similarly the rent also may vary from a few annas to Rs. 50 or more per acre. Purchase of land requires much initial capital but it becomes the dairy property and it can be improved and thus it adds to the dairy profits in the long run. When the land is taken on lease, there is no initial expenditure but it does not become the dairy property and therefore the dairy farmer is not likely to carry on improvements and would be rather inclined to look to only year to year returns. These considerations and the capital available determine whether the land should be purchased or taken on lease. The *gwala* system of dairying does not require any land except a place for a cowshed, and therefore it does not involve capital expenditure on this score. But in other systems land is required to the extent of 1 to 4 acres per head of cattle according to the nature of land, the amount of fodder to be

grown and the number and size of buildings to be erected. The landed property of some dairies and farms is given for information and reference in the following table :—

Dairy or cattle farm.	Area acres		Animals		
	fodder	grazy	Adults	calves	other than cattle
Lyallpur Agricultural College Dairy.	18	...	23	42	
Rayankhere ...	250	200	83	91	
Hossur Cattle Farm	120 800 for hay	380	177	202	30 horses, 30 pigs and 200 sheep.
Coimbatore Agricultural College Dairy.	20	40	55	16	
Guntur Buff. Breeding St.	...	75	20	26	
Pusa Agricultural Insti. Dairy.	540	100	144	212	
Chowkvari Dairy, Almora.	1000	1200	250		

180. Buildings :—

Of the various buildings required in dairy farming, the cowshed and the dairy rooms are most important and these buildings, like land, are expensive items and involve much capital in the beginning. The details of the buildings with regard to the sanitation, comfort, convenience and the durability involve better workmanship and good building materials and these mean more expenditure. The buildings built by contractors are not worth the expenditure because of the contractors' share and various commissions and the quality of the material used.

If we purchase our own building material and look to the construction work ourselves, with the same expenditure

we shall have far better buildings. It is always more economical to do away with the contractor and do the work ourselves, but this of course requires some experience of the market and building work. When the capital at our disposal is limited, first class building material may not be used. Second grade material would serve the purpose and this alone would not mean the sacrifice of sanitation, comfort, or convenience. To reduce the expenditure on buildings we may reduce the number and dimensions of rooms to a convenient limit, because this means less building material and labour. In the dairy rooms we may do away with gaudy marble slabs and glass or porcelain tiles, but we cannot afford to do away with the cemented walls and water tight floor and gutters. Similarly we can do away with the first-class tiles for the roof of the cowshed, ordinary tiles or corrugated iron sheets serving equally well. The walls for the cowshed are not necessary and may be dispensed with; ordinary pillars serve the purpose and these render the shed more sanitary by causing better ventilation. But in no case can we afford to do away with the pucca floor and water tight drains, because this means making the cowshed insanitary and losing the valuable manure. We have to use our discretion in selecting building material. Second class bricks would do for the walls, but for the floor and drains only first class bricks should be used. The brick work of the walls may be done partly with mud and partly with lime, but the masonry work of the floor and drains should always be with first class lime and cement. In the construction work our point should be to economise, but we should avoid false economy. That is it should not be at the cost of efficiency. The expenditure on building per sq. ft. of the plinth area may vary from Rs. 1½ to 4, according to the quality of the material used and workmanship. We

should not forget to prepare the plans of the buildings to be built showing the various details, because they help us in estimating the quantities of the material required and the total cost. The plans are also very useful in checking the construction work from time to time. Below are given figures of the various items of expenditure in building a cowshed and these give some idea of the expenditure on various items. The cowshed was built ten years ago and the brick work was partly in lime and partly in mud.

<i>Item</i>				<i>Percent expenditure.</i>
Bricks	...	...	...	25'0
Timber	...	...	...	17'0
Lime	...	...	...	17'0
Tiles	...	...	...	8'0
Concrete	...	...	...	3'6
Iron	...	...	...	1'5
Surkhi and Cement	...	...	...	1'0
Miscellaneous	...	...	...	1'5
Labour	...	...	...	25'0

The expenditure per sq. ft. of plinth area was Rs. 1-4-0. For calculating the quantities of material required for building purposes—see Appendix F.

481. Live Stock :—

Live stock is the very foundation on which the whole structure of dairying is raised and just as the stability of a building is dependent on the firmness of its foundation so prosperity in dairying mainly depends upon its live stock.

Great care is, therefore, required to be taken in selecting the dairy cattle and in maintaining this dairy foundation in a sound and healthy condition. Milk is the chief product of the dairy and the income of the dairy depends on the quantity and quality of its milk. We have, therefore, to give all our attention to the production of as much milk of the best quality with as little expense as possible. For this we require cows and buffaloes of the best milking strain to start with and in order to obtain best returns from these we have to give them proper food and comfort. The various dairy breeds are described in Chapter XIII and the points to be taken into consideration in purchasing cattle are given in Art. 162. These should be borne in mind in building up the dairy herd. The *guala* system of dairying is most harmful, because it means that all dry cows and buffaloes are sold, and almost all of them meet their fate at the slaughter house. This is a very heavy drain on dairy breeds. We are already experiencing the bad result of this drain. The low milk yield, scarcity of really good animals and the difficulty in obtaining dairy animals, even of average type, in sufficiently large numbers are to be attributed partly, though not wholly, to this. To look only to the profits for the time being, by selling cows and buffaloes as soon as they become dry, is a short-sighted policy and as such deserves strong condemnation. There are difficulties in maintaining dry cattle, but the problem has to be solved in other ways than leading dry dairy cattle to the slaughter house.

Twenty years ago it was not difficult to purchase average dairy animals in sufficiently large numbers as at present and this shows the utility of maintaining dry stock on the dairy farm. Maintaining dry dairy animals protects the breeds against this drain and thus helps the dairy industry in-

directly. The fact that really good dairy animals are becoming more and more scarce shows the importance of making the utmost use of the best animals by improving and retaining their strain by way of proper breeding. Those dairy farms where this practice is followed have to be commended, because their policy is prudent and farsighted, and beneficial to the dairy industry and national wealth. If the present treatment of dairy cattle is allowed to continue unrestricted, a time will come when we will have to look to foreign countries for the supply of dairy animals as well. This is one of the big problems in dairy economics presuming, of course, that we do not narrow down our vision to the present day profits alone. It is an intricate problem and involves co-operation among dairy concerns, education of the people who deal with cattle, and help from the State to tackle it successfully.

As said before, the chief product of the dairy is the milk and therefore it is certain that the greater the quantity of the produce and the better the quality, the larger are the profits in dairying ; and this is mainly dependent on the performance of the live stock. Looking to the growing demand for milk, the present day yield of cows and buffaloes is quite discouraging and presents a gloomy future if serious efforts are not made to improve the present state of affairs by way of proper feeding, breeding and protecting the dairy animals from slaughter. In Vedic times we had cows (Shatodana) which yielded sufficient milk to serve one hundred men, that is over one maund. We need not go as far back as the Vedic time. The records of Aini Akabari in the 16th century show that the milk yield was 20 seers per day, and even in the last century buffaloes yielded 20 seers and cows 16 seers of milk. At present such

animals are rarely found among indigenous breeds. When reviewing the first edition of this book in the *Agricultural Journal of Pusa*, the authoritative reviewer (W. S.) says : "It is a practical impossibility to-day to go into the market and purchase any reasonable number of either Gir, Mewati or Montgomery cows which would give the yield of milk per lactation quoted by Mr. Ghare and it would be a very difficult matter and take a very long time to obtain in commercial quantities either Sindi cows, Delhi, Jaffrabadi or Surti buffaloes which would come up to the standard given." This is sufficient to bring home the deplorable condition of our dairy breeds leaving aside the cross breeds. If we wish our dairy industry to prosper, we have to improve our indigenous dairy breeds and if we expect profits in dairying we must keep good heavy milkers on our farms and build up our herd by proper feeding, selection and breeding.

182. Cows v. Buffaloes :—

In our dairies we have to keep both cows and buffaloes; cows are lighter in body weight, require less food, give less milk, and their milk is not so rich in butter fat as compared to that of buffaloes. Cows are cheaper than buffaloes, but the latter are heavy milkers and from an economic point of view we should have both cows and buffaloes. Dairies can be run only with the buffaloes, but it would not be profitable to have only cows and no buffaloes. Comparatively very few people want cows' milk now-a-days which is preferred only for drinking and infant feeding ; for household economy buffalo milk is preferred to cows' milk because it yields more butter, *ghee* and buttermilk. All the *gwalas* prefer buffaloes to cows. The majority of them keep only buffaloes and a comparatively small number keep only a few cows.

The figures for Poona City given by Dr. Mann are worth noting in this respect. They are as under :—

(Showing the relative proportion of cows and buffaloes in Poona City in 1913.)

	Cows.		Buffaloes.	
	No.	Per cent.	No.	Per cent.
Private owners	1126	73·5	406	26·5
<i>Gwalas</i> ...	224	19·75	932	80·25
Total ...	1350		1338	

The survey of the Madras Dairy Trade (1917) shows that 686 registered cattle yards in the city contained 1339 cows and 2988 buffaloes, the number of these kept by private owners being left out of account.

This shows clearly that the buffalo is essentially a milk animal and is as important as the cow, in some respects even more important. There appears a tendency to disregard the buffalo. Whatever the reason may be this tendency is harmful. We cannot afford to neglect the buffalo, it deserves equal treatment with regard to protection against slaughter and improvement in her milking strain by proper breeding as is being given to the cow. Among the various cow breeds, the Montgomery breed occupies the first position as the heavy milker and among the buffalo breeds the Delhi breed comes to the forefront as the heavy milker. In the following table the relative merits of some breeds are given :

Delhi v. Surti Buffalo (W. Smith.)

Item.			Delhi.	Surti.
Average Yield per lactation	lbs.	...	2509	2762
.. Body weight	..	...	1350	900
.. Fat % in milk	..	...	7.5	8.4
.. S. N. F.	...	...	10.14	10.82
Percentage in full milk	...	}	Equal in both.	
.. drying off	...			
Average ration per day—				
Chaffed Karbi	lbs.	...	20	15
Tur chuni	..	...	1	1
Bran	..	...	3	3
Groundnut cake	..	...	1	1
Linseed cake	..	...	1½	1½
Molasses	..	...	½	½
Salt	oz.	...	2	2
Average cost of feeding per day	...	...	Rs. 0-9-4	Rs. 0-8-2
.. Price per head	...	...	.. 239-0-0	.. 126-0-0

Montgomery Cow v. Delhi Buffalo.

Item.	Montgomery Cow.	Delhi Buffalo.	
Average body weight	lbs....	705 ± 61.4	1275 ± 123.0
.. Milk per lactation	.. ...	32¼ ± 687.8	4251 ± 570.0
.. .. 1000 lbs. body weight	.. .. lbs.	4710 ± 687.4	3402 ± 638.0
.. .. in a year	.. ..	3123 ± 241.5	3437 ± 489.0
Ratio of yearly yield to lactation yield.		1 : 1.05	1 : 1.23
Ratio of body weight to lactation yield.		1 : 4.3	1 : 3.4

Figures based on data obtained from the
Telinkheri Dairy, (Clouston).

Details.	Expenditure for 100 animals.		
	Delhi Buffalo.	Local Buffalo.	Arvi Cow.
	Rs.	Rs.	Rs.
Interest and depreciation at 10% on the cost of 100 animals.	1,500	900	600
Interest and depreciation at 6% on the cost of corrugated iron sheds and staff building.	480	480	480
Cost of food including grazing.	6,887	6,050	3,787
Pay of staff	1,620	1,620	1,620
Expenditure total...	10,487	9,050	6,487
Receipts—			
Milk yield ... Seers	92,400	73,480	43,400
Price of Milk Rs.	11,550	9,185	5,106
Calves 75	750	750	1,225
Receipts total ...	12,300	9,935	6,331
Profit or loss Rs.	+1,813	+885	-156

These three tables also show the different ways of comparing different breeds in order to find out their relative merits. The prices of the dairy cattle vary according to their milk yield, age, the purity of blood and local conditions. Twenty years ago the price of a cow varied from Rs. 25 to 35 plus Rs. 4 to 8 per seer of milk yielded every day. At present the prices are nearly doubled. The number of

animals to be purchased in starting a dairy has to be determined according to the estimated supply of milk and to find this number the formulas given in Appendix E may be used. The purchase of cattle to start the dairy requires much capital investment and this sum, together with what is required for the land and buildings, consumes nearly the whole of the capital required in starting the dairy, while the interest on this large sum becomes one of the items of recurring expenditure.

183. Dead Stock :—

Initial capital required for the purchase of dead stock is not so much as in the case of land, buildings or live stock. But the amount will vary according to (a) the expanse of business; (b) whether it is intended to deal in milk alone or in other milk products like cream, butter, as well, (c) whether it is intended to grow fodder on dairy land and (d) whether the dairy produce is to be transported to distant places or disposed of locally. The usual dead stock requirements are given in Appendix D which may be useful. In purchasing the dead stock we must take into account the price and quality of the article and the quality has to be determined according to (a) the material of the article, (b) durability, (c) ease and convenience in handling it, (d) ease in repairing and (e) availability of the spare parts as in the case of implements and machinery. In purchasing dead stock it must be remembered that cheap things do not prove cheap in the long run. To reduce the recurring expenditure on dead stock we should handle the articles very carefully. Proper fitting, cleaning, oiling, timely repairs and proper use enhance the life of the dead stock and thus we derive the greatest benefit from it. From an economical point of view, only those things should

be purchased which will be in regular use, because idle dead stock means idle capital and idle capital means loss. It follows from this that surplus quantities of articles beyond the usual extra requirements should not be purchased and stocked. The chaff-cutter helps to economise in fodder and labour and is therefore a necessity in dairying. One chaff-cutter with wheel and two blades is sufficient for a herd of 30 animals, but when the number of cattle is a hundred or more and when steam power is available a power chaff-cutter would be economical. One beam balance to weigh up to 2 maunds for fodder and a small one to weigh up to 5 seers for concentrated food are enough for a small herd and a large table balance would be more convenient for large herds when the food and fodder requirements have to be weighed before feeding every day. A large table balance is necessary for weighing the cattle only on those dairy farms where scientific work has to be done, as for example, feeding experiments. Similarly in purchasing milk vessels, cream separators, butter churns etc., the quantity of milk, cream etc. to be treated should determine their number and capacity. Cream separators and butter churns should be purchased on trial, the buyer retaining the most efficient and convenient ones for use. There should not be more than 0.2 and 0.3 % butter fat in the separated and butter milk respectively. It would pay in the long run to spend on milk testing apparatus, because that would help us in finding out (a) whether our operations like cream-separating, butter-making are done properly, or if there is much waste of butter fat, (b) whether our cows are responding to the feeding with regard to the butter fat content, (c) the relative merits of cows with regard to the quality of milk, and (d) in determining the quality of milk and its products that we have to supply daily to our

customers. The milk testing apparatus helps in determining where the fault lies and how it should be corrected. Similarly with every item of dead stock we should look to its utility and always avoid false economy.

184. Feeding :—

In dairy economics the feeding of cattle is most important, because it directly concerns the expenditure on feeding stuffs and the produce in the form of milk. We have a variety of foods and fodders and of these we have to choose those that are comparatively cheap yet still effective. It is more economic to grow fodder on our land than to purchase it. We may take for example *Jowar*. It costs on an average Rs. 20 for cultivation and in return we get on an average 300 maunds of green fodder. Thus for one rupee we get 15 maunds of the stuff while the same quantity would cost Rs. 3 to 4 if we were to purchase it. Similar is the case of every other fodder. Ensilage is also economical as we get plenty of green stuff in the rainy season and it can be preserved in a silo at a nominal cost. Similarly hay-making is economical when we have good grass land. In this case the first cutting may be put into the silo and the second cutting may be turned into hay.

Concentrated foods have generally to be purchased and in this case we should remember that the cheapest stuffs are not economical as these are of bad quality containing an admixture of dust and other refuse matter, or they may be damaged by insects or may be mouldy and rotten. In feeding we should allow just sufficient quantities of fodder and concentrated food so that there may not be any waste and at the same time the cattle may not be underfed. The subject of nutrition is treated in Chapter V

and the methods of balancing the rations are given in Article 36. This information should be borne in mind when preparing rations. From an economic point of view, the relation between the cost of food consumed and the value of milk yielded or that between the nutrients supplied and milk yielded or the cow cost of milk production are very important. The following may be cited simply to study this relation.

(A)

Herding.	Herd No. 1 Average of 5 years.	Herd No. 2 Average of 3 years.
Per cent. cows	76·8	51·9
.. buffaloes	23·1	48·1
.. animals in milk ...	58·9 ± 6·8	60·2 ± 4·9
Conc. food per 100 adults per year	1619·4 ± 236·8 maunds.	2925·5 ± 105·5 maunds.
Milk per 100 adults per year ...	1772·3 ± 214·1 maunds.	3106·7 ± 209·7 maunds.
Food units per 100 of milk ...	68·3 ± 8·05	69·0 ± 1·9

(B)

Data for American cows according to Woll :—

Cows.	Dry matter for 100 lbs. of milk.	Dry matter for 1 lb. of butter.
Best	89 lbs.	20 lbs.
Medium	105 ..	24 ..
Poorest	125 ..	28 ..

These figures simply show the relation between the food consumed and milk yielded and do not include other

expenses which have necessarily to be taken into account in ascertaining the real cost of milk production. This is done by finding out the cow cost of milk production, which will be made clear from the following:—

(C)

American Average of 407 cows and 19 bulls (Dairy Science, Vol. III, Page 182.)

Milk production	2,806,277 lbs.
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Expenditure—

Food other than pasture	27,538·52 \$
Pasture	1,928·33 „
Man labour	10,193·90 „
Live Stock depreciation	...	...	5,922·83 „
Interest on stock	...	...	2,372·16 „
Horse labour	...	...	2,274·38 „
Use of buildings	...	...	2,019·72 „
Miscellaneous	...	...	1,740·17 „
Use of equipment	...	...	350·83 „

54,340·84 \$

Returns not milk—

Manure	3,695·17 \$
Calves	2,166·00 „

5,861·17 \$

Net cost	48,479·67 \$
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Net cost per 100 lbs. milk	1·73 „
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This cost of milk production is based on the following rates.

Per 100 lbs. of milk production.

(a) Labour 2·29 hours at 0·25 \$ per hour

(b) Rates of food stuffs

Grain	55·00	\$	per	ton
Silage	6·00	"	"	"
Hay	10·00	"	"	"
Other fodder	6·00	"	"	"

(D)

Milk production per head per year		2205 lbs.
Expenditure per head per year—		
Feeding	... ..	209·2 Rs.
Labour	... ..	34·0 "
Sundries	... ..	30·0 "
Depreciation on Buildings		12·5 "
" " dead stock		0·6 "
" " live stock		9·0 "
		<hr/>
		295·3 Rs.
<i>Receipts other than milk</i>		
Value of a calf	... ..	15·0 Rs.
Manure	... ..	10·0 Rs.
		<hr/>
		25·0 Rs.
Net cost of milk production		270·0 Rs.
Cost of production of 100 lbs. of milk		12·5 Rs.

This cost is based on the actual figures from a small running dairy concern and is calculated on the whole herd and not on the milking cows only.

Of the above, C and D give us the right idea of the cost of milk production. It should be the aim of the dairy

farmer to reduce this cost, that is he should aim at the production of large quantities of milk most economically.

185. Grazing:—

The problem of grazing is closely connected with the feeding of cattle and is very important in dairy economics. Besides the advantages given in Article 58, good grazing ensures economy in feeding and therefore every dairy farm should have its own grazing ground. Ancient legislators, like Manu, laid down rigid rules regarding grazing land and accordingly every village had a common pasture of its own where the village cattle grazed every day. Grazing was provided even in forest areas by engaging hunters for protecting cattle from beasts of prey. But at present the conditions are quite otherwise and want of grazing land is the main grievance of cattle owners and dairymen. The main difficulty in maintaining dry animals, especially in big cities, is the grazing, and that is why the majority of *gwalas* in big cities lead their dry milch cattle to the slaughter house. To stop this drain on dairy cattle and to improve the cattle breeds in general State help is quite necessary. If cattle get good grazing throughout the day, they require only a nominal stall feeding in addition to the special feed of concentrates, which is given only when the animal is in milk.

186. Labour:—

The labour engaged on dairy farms is an item of expenditure and therefore the number of men engaged should be just sufficient for the work. In dairies where only milk is to be sold skilled labour is not necessary, but it is quite essential where milk products like cream, butter, have to be prepared and where breeding and other scientific work

has to be carried on. Skilled labour means more pay and more expenditure, but we should not be inclined to engage less skilled labour with less pay when the nature of work demands more skill, because that would be false economy. A less skilled man is likely to spoil the work and this would more than counterbalance the saving in pay in the long run. In this respect we have to use our discretion. Besides the skill and wages of labour, the purity of mind and body, that is, the moral character and health are very important items that have to be taken into account. In the dairy room every article meant for sale is edible and can be spoiled very easily; in the cowshed we have the cows, the very foundation of dairying, which can be spoiled even for good without much trouble; and outside the dairy compound we have our customers which can be set upon us with ease, and if the men engaged on dairy farms mean mischief they can do so and bring us to a loss. From this point of view the character of the labour engaged in dairying is more important even than the pay. These considerations clearly show that in selecting labour for dairying we have to choose only those who are god-fearing, kind-hearted and bearing a good moral character, who can do their work properly and who are sound in body. At the same time for men of this kind we must pay such wages as will make them quite contented.

187. Sundries :—

Items of expenditure under this head are the various articles required in connection with cattle, and miscellaneous articles used in the general working of the dairy farm. Expenditure on these is generally fairly constant, but the expenditure on medicine and veterinary help may vary very much according to the cases of common illness,

epidemic diseases and accidents. Proper handling of dead stock enhances their life and the longer the period the article remains serviceable the less is the expenditure on it. The expenditure on sundries on a dairy farm varied from Rs. 10.3 to Rs. 20.9 per head per year and the average of 8 years was Rs. 13.4. These figures may vary according to local conditions, but ordinarily the sundry expenses per head should in no case exceed Rs. 15 a year.

188. *The economics of the life of a dairy animal:—*

In dealing with the economics of the life of a dairy animal, we have to take the average animal into account in examining the various aspects from an economic point of view under average conditions.

The period of life may be divided into three parts, the first from birth to the first delivery, covering a period of 5 years roughly, the second part, from the first delivery onwards till she no longer serves a useful purpose as a dairy animal, roughly covering a period of 8 to 10 years, and the third, from her 15th or 17th year onwards through old age to her death. From our point of view only the first two parts are important and we have therefore to deal with these. As said before we have to take an average cow and average conditions in examining the economic aspects, and for that we have to start with some authentic data. The following data and the examples worked out with these as basis are simply to show how the economic life of the dairy animal should be studied. The figures cannot be applicable to any and every locality as these are likely to vary, but for all that, they are genuine and will serve our present purpose.

(Some useful data from a running dairy concern.)

Cows in milk	...	...	59.2 %
Calvings in a year	...	...	86.8 %

Drying off	...	...	75.7 %
Deaths of adults	...	...	1.4 %
" calves	...	...	4.7 %
Dry fodder per 100 adults	...	5,649	mds.
Green fodder	" "	...	11,604 "
Concentrated food	" "	...	1,563 "
Milk yield per year	" "	...	1772.3 "
Ratio concentrated food to milk (on whole herd)	...	...	1 : 1.13
Ratio food units to milk (on whole herd)	...	...	1 : 1.48

Average expenditure per cow with a calf per day.

Food.	Amount.	Rate.	Cost.
Feeding.	S.	Chh.	Annas. Pies.
Dry	6	0	a 1½ md. per Re. 1 72
Green	10	0	" 4 " " " 1 00
Oil			
Cake	1	0	" 16 Sr. " " 1 00
Chuzi	0	8	" 16 " " " 0 60
Bhusi	1	8	" 1½ Ra. per md. 0 10.8
Salt	0	1	" 2 " " " 0 06
Total feeding charges			... 5 1.6
Shelter and comfort	...	...	... 0 10.5
Labour	...	...	... 1 67
All other sundry expenses	...	...	... 0 6.4
Total other charges			2 11.6

For calculations the feeding charges may be taken as annas 5 and charges for shelter, labour and sundries may

together be taken as annas 3 per day, so that the total upkeep charges come to annas 8 a day per cow with a calf.

In the first part of the life period, that is, till the first delivery, we have to spend on her. While its mother suckles the calf no separate account of the expenditure on it is kept during the first year as the calf is associated with its mother in working out the expenses. From the second year the expenses may be worked out separately as under :—

(Cost of feeding in rearing a calf.)

Item.	Quantity Seers.	Period days.	Rate per Re.	Cost.	Total cost.
<i>2nd year—</i>					
Dry fodder ...	3	365	60 Sr.	18 4 0	
Green	6	"	4 mds.	13 11 0	
Oil cake ...	$\frac{1}{2}$	"	16 Sr.	11 6 6	43 5 6
<i>3rd year—</i>					
Dry fodder ...	4	"	60 Sr.	24 5 4	
Green	6	"	4 mds.	13 11 0	
Oil cake ...	$\frac{3}{4}$	"	16 Sr.	17 1 9	55 2 1
<i>4th year—</i>					
Dry fodder ...	5	"	60 Sr.	30 6 8	
Green	8	"	4 mds.	18 4 0	
Oil cake ..	1	"	16 Sr.	22 13 0	71 7 8
Total ...					169 15 3

From the above table the feeding charges up to the end of the 4th year come to Rs. 170 roughly and to these the charges for shelter, labour and other sundry items at the rate of annas 3 per day have to be added. These come to Rs. 205 roughly for the three years and when added to the above feeding charges the rearing charges come to Rs. 375 for

the first part of the economic life of the cow. When the interest on this, which comes to roughly Rs. 25, is added to the above, the total cost of rearing up to the first delivery comes to Rs. 420. In the above calculations the fodders are supposed to have been purchased but when the fodder is grown on the dairy land the feeding charges would consequently be reduced.

Next we have to examine the second part of the life period of the cow and for this we may take the following average figures of a breed as the basis for calculation.

Average interval between calvings	...	395 days.
„ lactation period	...	235 „
„ milk yield per lactation	...	2,000 lbs.

With the help of these data let us see what would be the feeding charges for the period between two calvings. The period between two calvings, i.e. 395 days, may be divided into three parts, regarding the feeding, as under :—

1st part :—235 days, lactation period with full lactation period ration, i.e. for maintenance and for milk.

2nd „ :—130 days, dry period with maintenance ration only.

3rd „ :—30 days, dry period but with full lactation period ration allowed before delivery for nutrition.

The feeding charges at the rate of annas 5 per day for the milk period ration and annas 2½ for maintenance roughly work out as follows :—

		Rs.	as.
1st part :—235 days	× 5 annas	...	73 7
2nd „ :—130 „	× 2½ „	...	20 5
3rd „ :—30 „	× 5 „	...	9 6
<hr/>			
Total days : 395		Total charges :	103 2

To this we have to add the charges for shelter, labour and other sundry charges together at the rate of annas 3 a day, and this comes to Rs. 74 and anna 1 for the total period of 395 days which is the interval between two calvings. The total upkeep charges would then be Rs. 177 and annas 3 per calving.

We have seen before that the total charges up to the first delivery amount to Rs. 420 which have to be realized as depreciation reserve capital during the period of 9 calvings. The interest to be charged on Rs. 420 spent on rearing up to the first delivery may be at 6 per cent. and that on the depreciation reserve may be at 4 per cent., as under :—

(Interest on rearing charges upto the first delivery and on the depreciation reserve capital.)

Calvings.	Debited Interest at 6%		Credited Interest at 4%	
	Capital.	Interest.	Capital.	Interest.
	Rs.	Rs. as. p.	Rs.	Rs. as. p.
1	420	27 4 9	.....	.....
2	360	23 6 4	60	2 9 7
3	300	19 8 0	120	5 3 2
4	240	15 9 7	180	7 12 9
5	180	11 11 2	240	10 6 4
6	120	7 12 9	300	13 0 0
7	60	3 14 4	360	15 9 7
8	.....	.....	420	18 3 2
Total ...		109 2 11		72 12 7

The *death rate* among adults is also an economic aspect, because death of cows means a sudden and large loss, and a provision on that score has to be made. It is rather difficult to fix the average death rate in dairy cattle as the figures are likely to vary so widely. The death rate, 1·4

per cent. in adults may be taken in calculating the death rate charges which would be 1·4 per cent. of Rs. 420—the cost of rearing up to the first delivery. This comes to Rs. 5 and annas 14 a year and for the period of 10 years to approximately Rs. 58.

Statement of the economic aspects of the life of the dairy cow.

Income.			Expenditure.		
Head.	Amount.	Total amount.	Head.	Amount.	Total amount.
	Rs.	Rs.		Rs.	Rs.
<i>Milk—</i> 2000 lbs. X 9 lactations at 10 lbs. a Re.	1,800	1,800	Rearing charges upto the first calving.	375	
<i>Calves—</i> 9 at Rs. 25 each.	225	439	Interest on above rearing cost roughly.	45	420
<i>Manure—</i> At Rs. 13 X 9 periods.	117		Upkeep charges during the pe- riod of 9 calv- ings at Rs. 177 each.	1,593	1,593
<i>Interest—</i> On deprecia- tion reserve capital of Rs. 420.	72		Interest on Rs. 420.	109	109
<i>Price of cows—</i> After 9 calvings	25		Death rate charges during the period.	58	58
		2,239	Balance ...		2,180 59
		2,239			2,239

The next step would be to see the sources of income and to work out the amount that would be credited. The sources of income are milk and its products, calves, manure, the

interest on the depreciation reserve capital and the selling price of the cow at the end of the second part of her economic life that is roughly at the age of fifteen. The milk yield per lactation period may be taken at 2,000 lbs. and valued at 10 lbs. per rupee and calves may be valued at Rs. 25 each on an average. The manure obtained in the calving period of 13 months each may be valued at Re. 1 per month, and the selling price of the cow at the end of the economic period may be taken as Rs. 25. The statement of the economic aspects of the life of the dairy cow would then be as shown on page 279.

189. Marginal Cow and Marginal Dairy:—

The above figures show that in the case of the average cow out of the total income of Rs. 2239, Rs. 1,800 are realized through the sale of milk alone and the income through all other sources amounts to Rs. 439 only. The main item of expenditure on her is the upkeep charge during the economic period which amounts to Rs. 1593 while all other heads of expenditure amount to Rs. 587 only. Another important point that has to be noted is that a cow that gives less than 2000 lbs. of milk in a lactation period is a source of loss. We may note that the balance of Rs. 59 on the expenditure side is equivalent to 590 lbs. of milk at 10 lb. a rupee. If the total amount of milk of the 9 lactations were to be less by 590 lbs., that is, if the yield per lactation were to be $\frac{2000 \times 9 - 590}{9} = 1934.4$ lbs. the total income would just equal the total expenditure and there would neither be any loss nor any gain. Thus according to the above calculations the average lactation yield of 1934.4 lbs. indicates the "o" point and the yields above it are positive and profitable while all yields below it are

negative and indicate a loss. The lactation yield of 2000 lbs. may be called the "marginal yield" and the cow whose average lactation yield is 2000 lbs. may be said to be the "Marginal cow" and the dairy that is run with such cows may be called a "Marginal dairy concern". Let us take for example the case of the herd of 28 cows mentioned in Article 163 and suppose a dairy is run with this herd of cows. If we refer to the table in the same Article in which the cows are divided into several groups according to their average lactation yields, we see that the herd contains 14 cows whose lactation yields are below 2000 lbs. while those of the remaining 14 cows are above it. Thus the expensive cows equal the profitable ones in number but the total milk yield value of the cows in the 4th, 5th and 6th group taken together more than counterbalance the deficit in milk due to the 14 poor cows of the first three groups. Simple calculation would show that the extra yield when compared to the marginal yield, of the good 14 cows when distributed over the 28 cows comes to only 214.2 lbs. per lactation per head and this shows that the dairy with such cows is only a marginal dairy.

190. Dairy Data :—

The whole structure of economics is based on facts and figures and we cannot have these unless we regularly keep account of every detail of dairy business. We know our position in the business only with the help of the account books. The cash book tells us whether we are losing or gaining, the cattle registers help us in marking profitable cows from the expensive ones, and their hereditary qualities, the cream and butter registers show whether our working concerning these is sound, the analytical records show us the quality of our produce and the cultivation book

shows the outturns of fodders. When the accounts are kept properly and regularly for years, we get sufficient facts and figures from which we can draw definite conclusions which may be useful to us and others in the conduct of the business. Western countries like England, America, Germany and Holland etc. owe their progress in the dairy industry to the pen and account book of the dairyman and the breeder. In our country, it is really very painful to state, the circumstances are very discouraging. At present at least it is impossible that attempts to collect sufficient genuine data should succeed. Evidently the reasons for this may be in some cases want of regular and proper accounts or unwillingness to co-operate and give out the facts and figures, while in other cases it may be lack of consciousness of responsibility lying on the head of the dairymen. It is true that we have to look to our own present day needs first, but it is equally true that we owe our due to the public and to the generations to come. Neither we nor the generations to come can make any progress in the absence of properly kept accounts and the data derived from these. When we compare the rations of our cows with those given in Western countries we find them to be disproportionate when compared to the milk yield. Our dairy breeds are poor in milk yield as compared to Western breeds. We have to improve our breeds, but it would not be possible to proceed in this direction in the absence of facts and figures regarding the characteristics of our dairy breeds. Proper accounts and co-operation among dairymen are the necessities. In such a vast country with widely differing conditions, the findings of one dairyman are bound to vary from those of another placed in a distant part, but the inferences drawn from the data obtained through co-operation of all the dairymen would certainly show us where we

are and how we should proceed for further improvement. Even to study the relative merits of our dairy breeds alone, we require the co-operation of scores of dairymen and genuine data from accounts of hundreds of cows and buffaloes. This should show clearly the importance of willing co-operation among dairymen, at least so far as the educational and scientific side of dairying is concerned and of the regular and proper dairy accounts. The dairy student particularly should note this, because he is the dairy manager of to-morrow. As we are expected to be moving in the market, to be visiting customers' houses, to be inspecting the fodder crops in the field, to be in the butter room watching the operations and to be in the byre looking to the feeding and patting our cows, we are also expected never to forget our pen and account book if we wish to study the economics of our dairy business and if we wish ourselves and our country to prosper.

191. Dairy Accounts:—

In running a dairy farm we have to keep proper accounts of every department of dairying as without such accounts we cannot know whether we are losing or gaining. We have to keep (1) account of cattle and their feeding, (2) account of milk and its products, (3) account of customers and other people with whom we transact business, (4) account of fodder growing, (5) account of establishment and other miscellaneous items. Forms of more important items are given in the following pages and they will be found very useful in preparing the various registers required. Besides these we are required to have the ordinary books, such as cash book, ledger, receipt book, memorandum book, dead stock register &c.

FORM NO. I.—HERD RECORD.

284

This form is useful to show the details of the live stock and in making a valuation at the end of each year.

(For Cows.)

Name and number.	Date of birth or purchase.	Price if bought.	Breed.	How disposed.	Price if sold.	Valuation at the end of the year.	Remarks.

(For Calves.)

Number.	Date of birth.	Sex.	Dam & Sire.	How disposed.	Remarks.

MANUAL OF DAIRY FARMING

FORM NO. II.—INDIVIDUAL RECORD OF CATTLE.

This will help us in judging the quality of each individual animal. If a record of feeding each individual animal be kept and one column of expenditure on feeding be added to this we can find out the relative merit of each animal.

Name.....

Breed.....

No.....

Date of birth or purchase.....

Date of service.	Date of calving.	Calf sex.	Date of stopping milk.	Lactation period (days.)	Milk yield (seers.)	Yearly milk yield (seers.)	Remarks.

FORM No. III.—MILK YIELD REGISTER.

285

This is very useful in comparing the milk yields of different cows in any particular part of the lactation period and also in finding out the irregularities in milk yield and in tracing their probable causes.

(MILK YIELD IN SEERS.)

Name or No. of the cow.												
Date.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.	M.	E.
Total of the month ...												
Total up to date ...												

MANUAL OF DAIRY FARMING

FORM NO. IV.—CREAM AND BUTTER RECORD.

This is useful in controlling the work in the butter house and in tracing the cause of variations in the percentages of cream and butter obtained.

Date.	Cream.				Butter.			
	Milk Separated.	Cream got.	Percentage Cream to Milk.	Remarks.	Cream Churned.	Butter got.	Percentage Butter to Cream.	Remarks.

FORM NO. V.—MILK TESTS RECORD.

288

This is useful in judging the quality of milk of individual animals or of the whole herd and in tracing the cause of variation from usual figures.

Date.	Sample No.	Details of the sample.	Observed Temperature.	Observed Hydrometer reading.	Corrected Hydrometer reading to 60° F.	Fat %	Total solids %	Solids not Fat %	Remarks.

MANUAL OF DAIRY FARMING

FORM No. VI.—FOOD AND FODDER RECORD,

This form is useful to show the expenditure on food and fodder of individual animals or of the whole herd.

Cow (Name or No.)

Date.	Hay.		
Total of the month ...			

FORM NO. VII.—FOOD AND FODDER ABSTRACT.

(Periodical.)

290.

Live stock.	No.	Hay mds.	Lucerne mds.			Remarks.
Cows (milch) ...						
Buffaloes (Milch) ...						
Bulls ...						
Bullocks ...						
Young stock ...						
Dry Cows ...						
Dry Buffaloes ...						
Total ...						

MANUAL OF DAIRY FARMING

FORM NO. VIII.—CULTIVATION RECORD

This form will be useful in showing the cost of cultivation of different fodder crops and their yields.

Field No.....

Area.....

Season and Crop.....

Date.	Operation.	Labour.	Charges.	Remarks.
				<p><i>(The remarks regarding seed rate, manure, weather conditions, irrigation, harvesting, yield, etc. should be written in this column so that we may get full information regarding the fodder crop.)</i></p>
				<p>Total ...</p>

APPENDICES

APPENDIX A.

AV. COMPOSITION OF FOODS AND FODDERS.

(From Departmental Publications.)

Green Fodders.

Name.	Moisture %	Oil %	Proteids %	Carbo-hydrates %
Jowar ...	69·52	0·48	1·36	14·81
Oats ...	83·51	0·37	0·94	9·00
Sarson ...	86·13	0·47	2·00	4·64
Nagli ...	80·83	0·48	1·94	7·85
Barley ...	79·62	0·45	2·46	8·20
Lucerne ...	78·03	0·76	3·40	11·55
Senji ...	84·40	0·36	2·69	6·16
Guinea grass ...	67·47	0·94	2·25	16·53
Moth ...	74·70	0·89	3·20	12·00
Kangni ...	76·79	0·54	2·08	10·08
Maize Silage ...	81·87	0·21	0·77	9·44
Jowar Silage ...	60·52	0·65	1·89	21·37
Am-Sorghum ...	64·05	.. ..	1·51	15·66
Wheat green ...	82·65	0·40	1·87	7·56
Maize green ...	88·92	0·31	1·13	4·65

Straws and Bhusas.

Name.	Moisture %	Oil %	Proteids %	Carbo-hydrates %
Jowar ...	8·91	2·46	3·21	46·22
Oats ...	9·88	1·97	3·00	41·31
Rice ...	10·22	1·23	2·56	40·46
Wheat ...	8·71	0·98	3·01	37·93
Tur ...	8·81	4·40	11·01	44·67
Gram ...	8·41	2·27	3·65	45·86
Kulith ...	5·60	2·63	5·25	49·66
Wal ...	9·92	3·72	13·37	43·04
Urd ...	15·96	1·70	11·19	39·14
Mung ...	13·30	2·52	10·88	40·35
Pea ...	8·57	3·02	10·84	42·63
Grass good ...	9·77	.....	4·54	46·47
Grass poor ...	11·04	.....	1·77	45·21

Grains, Seeds and Bye-products.

Name.	Moisture %	Oil %	Proteids %	Carbo-hydrates %
<i>Grains :-</i>				
Jowar	10.71	3.69	9.71	72.38
Bajra	8.77	5.33	9.52	73.52
Oats	10.47	5.69	7.68	59.38
Barley	12.39	1.85	6.62	71.55
Maize	10.58	4.81	9.66	71.59
Wheat	13.33	1.76	9.74	70.18
Gram	9.98	4.39	18.14	57.94
Gwar	9.83	2.81	27.29	48.18
Kulith	8.82	0.80	18.18	62.29
Pea	10.56	0.93	20.12	61.34
<i>Oil Seeds :-</i>				
Cotton seed	9.82	18.65	17.31	31.15
Linseed	5.80	40.31	17.91	26.12
<i>Cakes :-</i>				
Niger seed	7.42	9.30	38.56	25.48
Til	10.23	12.51	30.56	29.75
Safflower	9.71	7.05	34.88	27.19
Ground nut	6.49	10.82	38.02	26.31
Linseed	11.72	9.69	29.57	35.02
Rape	10.38	9.53	30.06	33.77
Mustard	8.01	10.54	32.52	35.55
Cotton seed	12.06	6.23	19.78	38.89
Ground nut and niger mixed	8.38	8.63	36.00	26.97
Rape and Cotton seed mixed	9.45	7.80	24.28	40.30
Cotton seed meal	8.32	4.60	5.84	50.17
Rice bran	8.21	8.31	5.72	34.25
Wheat bran	10.02	3.67	11.75	61.47

APPENDIX B.
CO-EFFICIENTS OF DIGESTIBILITY
(KELLNER.)

Feeding Stuff.	Proteids.	Oil.	Carbo- hydrates.
<i>Green fodders :—</i>			
Pasture grass	75	66	79
American maize	65	72	73
Green Sorghum	62	85	78
Oats flowering	75	70	63
Barley flowering	70	62	73
Lucerne in flower	81	45	72
Soja beans	75	54	73
<i>Hays :—</i>			
Meadow Hay medium	57	51	64
Millet hay	63	53	59
Lucerne hay medium	68	53	62
<i>Straw, Chaff, Husks :—</i>			
Wheat straw	4	31	37
Oat straw	33	36	46
Barley straw	25	39	53
Rice straw	45	47	32
Bean straw	49	57	68
Pea straw	60	46	64
Wheat chaff	26	43	33
Oats chaff	38	48	49
Rice husks	10	67	35
Earthnut husks	36	96	39
<i>Roots and Tubers :—</i>			
Potato	51	...	90
Mangels	70	...	95
Turnips	73	...	92
Cabbage	80	84	95
<i>Grains :—</i>			
Oats	76	80	76
Barley	70	89	92
Maize	72	89	95
Field beans	87	83	91
Peas	86	65	93
Vetches	88	92	100
Soja beans	89	90	69
Linseed	91	86	55
Cotton seed	68	87	50
Locust beans	68	53	95

CO-EFFICIENTS OF DIGESTIBILITY—(Continued.)

(KELLNER.)

Feeding Stuff.	Proteids.	Oil.	Carbo- hydrates.
<i>Industrial Products :—</i>			
Wheat bran	79	71	71
Wheat flour	86	92	83
Barley bran	85	87	86
Barley meal	72	38	99
Pea husks	71	73	90
Brewer's grains fresh	73	86	62
Brewer's grains dry... ..	71	88	60
Rape cake	81	79	76
Linseed cake	86	92	78
Cotton seed meal decort.	86	94	67
Cotton seed meal undecort.	77	93	52
Earthnut cake	90	90	84
Palm nut cake	75	98	77
Coconut cake	78	97	83
Poppy cake	79	92	64
Sesame cake	90	90	56
Molasses	52	...	91
<i>Animal Product :—</i>			
Cow's milk	94	100	98

APPENDIX C.

FEEDING STANDARDS.

I.—*Wolff Lehmann Standard.*

For 1000 lbs. body wt.

	Dry M.	D. f rot.	D. Carb.	Oil D.	Alb. Ratio.
<i>Maintenance</i>	18	0·7	8·0	0·1	1 : 11·8
<i>Cow 22 lbs. milk</i>	29	2·5	13·0	0·5	1 : 5·7

II.—*Swedish "Feed-unit" Standard.*

1 lb. of standard grain feed is the unit such as corn, barley.

Food required to equal

1 feed unit.

Corn wheat, barley	...	...	1·0 lbs.
Cotton seed meal	...	...	0·8 "
Oil meal	...	...	0·9 "
Wheat bran, oats	...	...	1·1 "
Lucerne hay	...	...	2·0 "
Oat hay, Oat and pea hay	...	...	2·5 "
Corn stover	...	...	4·0 "
Lucerne green	...	...	7·0 "
Sorghum, corn, oats green	...	...	8·0 "
Carrots	...	...	8·0 "
Rape green	...	...	10·0 "
		Prot.	Feed units.
Maintenance		0·65	6·60
1 lb. milk		0·045-0·05	0·33

III.—*Haecker Standard.*

	Dig.	Cr. Prot.	D. Carbo.	D. Fat.
Maintenance		0·700	7·00	0·100
1 lb. milk	3 % Fat.	·047	·20	·017
"	3·5 "	·049	·22	·019
"	4·0 "	·054	·24	·021
"	4·5 "	·057	·26	·023
"	5·0 "	·060	·28	·024
"	5·5 "	·064	·30	·026
"	6·0 "	·067	·32	·028
"	6·5 "	·072	·34	·029
"	7·0 "	·074	·36	·031

IV.—Savage's Standard.

	Dig. Cr. Prot.	T. Dig. Nutri.
Maintenance	0·700	7·925
1 lb. milk of 3·0 % Fat.	0·057	0·287
" 3·5 "	0·061	0·319
" 4·0 "	0·065	0·350
" 4·5 "	0·069	0·379
" 5·0 "	0·073	0·405
" 5·5 "	0·077	0·431
" 6·0 "	0·081	0·457
" 6·5 "	0·085	0·484
" 7·0 "	0·089	0·508

V.—Eckles Standard.

	Dig. true Protein.	Net Energy Therms.
Maintenance	0·500	6·00
1 lb. milk of 3·0 % Fat.	0·050	0·26
" 3·5 "	0·052	0·28
" 4·0 "	0·055	0·30
" 4·5 "	0·058	0·33
" 5·0 "	0·062	0·36
" 5·5 "	0·066	0·40
" 6·0 "	0·070	0·45
" 6·5 "	0·075	0·50

VI.—Armsby Standard.

	Dig. true Protein.	Net Energy Therms.
Maintenance	0·500	6·000
1 lb. milk of 3·0 % Fat.	0·043	0·224
" 3·5 "	0·045	0·232
" 4·0 "	0·049	0·265
" 4·5 "	0·052	0·291
" 5·0 "	0·055	0·315
" 5·5 "	0·058	0·338
" 6·0 "	0·061	0·361
" 6·5 "	0·064	0·385
" 7·0 "	0·068	0·408

VII.—Woll-Humphrey Standard.

	Dry M.	Dig. Crude Prot.	T. Dig. Matter
Maintenance	12·5	0·70	7·9
less than 0·5 lb. fat	16·2	1·18	10·6
0·5-0·75 ..	18·7	1·49	12·3
0·75-1·00 ..	21·1	1·80	14·1
1·00-1·25 ..	23·6	2·11	15·8
1·25-1·50 ..	26·0	2·43	17·6
1·50-1·75 ..	28·5	2·74	19·3
1·75-2·00 ..	30·9	3·05	21·1

VIII.—Modified Wolff Lehmann Standard.

	Dig. Cr. Prot.	Total dig. Nutrients.
Maintenance	0·700	7·925
1 lb. milk containing		
2·5 % Fat	0·045-0·053	·256
3 % ..	·047-0·057	·286
3·5 % ..	·049-0·061	·316
4 % ..	·054-0·065	·346
4·5 % ..	·057-0·069	·376
5 % ..	·060-0·073	·402
5·5 % ..	·064-0·077	·428
6 % ..	·067-0·081	·454
6·5 % ..	·072-0·085	·482
7 % ..	·074-0·089	·505

APPENDIX D.

DAIRY EQUIPMENT.

Connected with Cattle.

Ropes, chains, pegs, baskets, brooms, brushes, towels and dusters, strings, wooden spades or rakes, buckets, sticks, stools, marking irons, needle, wooden hammer, lanterns.

Feeding of Cattle.

Chaffcutters, grain and cake crushers, baskets, rakes, steeping vats, balances with weights, sacks, buckets, carts, scythes, spanners, lubricating oil, sharpening stone.

Fodder growing.

Ploughs, cultivators, harrows, hoes, clod crushers, picks, crowbar, khurpas, water lifts, carts, baskets, sacks, seed drills, yokes, ropes, chains, measuring tape or chain, spades, balance with weights, tools for ordinary repairs.

Milk.

Herd recorder, milk cans of various sizes, milk measures, milk strainer, milking pots, buckets, muslin cloth, pasteurizer and cooler, seals and seal pincers.

Cream.

Cream vessels and vats (China or ordinary), buckets, strainer, floating thermometer, cream separator, temperature can.

Butter.

Churn, strainer and sieves, scoops and scotch hands, butter worker, butter box or ice chest, enamelled buckets, beater, butter colour, salt, butter paper and cloth, ready reckoner, balance, marble table, butter prints.

Analytical work.

Sampler, sample bottles, butyrometer with test tubes etc. complete, amyl alcohol, sulphuric acid, hydrometer, thermometer, Richmond's scale, spirit lamps, preservatives, balance.

Miscellaneous.

Towels, cloth, soap, soda, dusters, brushes, brooms, lubricating oil, lamps, Pot. permanganate, boiler, fuel, oil feeders, spanners, time piece, lamp, registers and account books, drying racks and stands, balance with weights, matches, spirit, quick lime, copper sulphate, office equipment and fly papers.

APPENDIX E.

DATA FOR DAIRY ESTIMATES.

Live Stock :—

$$(a) \frac{\text{Mds. of milk required daily} \times 40}{\text{Av. daily yearly yield in Sr. of a cow}} = \text{No. of cows required.}$$

$$(b) \frac{\text{Mds. of milk required daily} \times 40}{\text{Av. daily yield in a lactation in Sr. of a cow}} = \text{No. of milking:}$$

cows.

(c) In a herd about 60 per cent. cows remain in milk.

(d) One stud bull is required for every 30 to 40 cows.

(e) One pair of bullocks is required for every 6 to 8 acres.

Land :—

 $\frac{1}{2}$ to 1 acre for fodder growing and $\frac{1}{2}$ to 1 acre for grazing per head.

Menial Staff :—

1 boy for every 20 calves.

1 man 25 cows while grazing.

1 10-12 cows for cleaning the shed and food distribution.

1 for milking.

Food and fodder :—

(a) *Conc. food*— $\frac{3}{4}$ the milk yield for cows and 1-2 seers for bullocks and 2-4 seers for stud bulls roughly.(b) *Bulky fodder*—Dry fodder 2-10 and green 5-20 seers according to the kind and quantity of fodders available per head daily.(c) *Silage*—25 to 35 % loss in silage making.**Depreciation** :—Live stock 10 % ; dead stock 10 % ; Buildings 3 %.**Calves** :—Roughly 4 calves in 5 years.**Manure** :—60 to 100 mds. according to method of preservation and amount of water, litter etc. added per head.**Milk** :— $2\frac{1}{2}$ to $3\frac{1}{2}$ and 4 to 5 seers daily yearly average of cows and buffaloes respectively.

APPENDIX F.

BUILDING MATERIAL FOR ESTIMATES.

- (1) **Brick work, 1st class** :—Bricks 1520, size $9 \times 4\frac{1}{2} \times 2\frac{1}{2}$ allowing 5% wastage.
Slaked lime 16 cu. ft.
Sand 24 ..
- (2) **Brick work, 2nd class** :—Bricks 1350, Slaked lime 20 cu. ft.
Sand 30 cu. ft.
- (3) **Brick and mud work** :—Bricks 1350, Mud 30 cu. ft.
- (4) **Concrete trap metal** :—Metal 100 cu. ft. Sand 46 cu. ft.
Lime slaked 23 cu. ft.
- (5) **Concrete of broken bricks** :—Broken bricks 100 cu. ft.
Sand 25 cu. ft. Lime 25 cu. ft.
- (6) **Cement concrete** :—Cement 20 cu. ft.; Sand 40 cu. ft.
Broken stone 100 cu. ft.
- (7) **Pointing masonry** :—Slaked lime and Sand $1\frac{1}{2}$ each.
- (8) **Pointing brick work** :—Slaked lime and sand 2 cu. ft. each.
- (9) **Cement pointing** :—Cement and sand $\frac{3}{8}$ cu. ft. each.
- (10) **Lime plaster** :—Lime and sand 6 cu. ft. each.
- (11) **Cement plaster** :—Cement and sharp sand 4 cu. ft. each.
- (12) **Brick floor** :—

Bricks No.	Lime cu. ft.	Sand cu. ft.	Concrete cu. ft.	Bricks.
650	6	9	50	Laid on edge.
375	4	6	50	flat.

- (13) **Roof** :—Country round tiles 2200
Bangalore tiles ($16 \times 9\frac{1}{2}$)—150.
- (14) **Wire fencing** :—Angle iron, $5\frac{1}{2} \times 2 \times 2\frac{1}{2}$ —2 cwt.
Galvanized iron wire No. 4, 500 ft.
Strain hooks with nuts 7.

The quantities given above are for 100 ft. cubic, superficial or running as the case may be.

(From P.W.D. Specifications.)

GLOSSARY

Ajwain :—	Bishop's weed (<i>Carum copticum</i>) a condiment.
Arhar :—	Region pea, (<i>Cajanus indicus</i>), a pulse.
Bajra :—	Bulrush millet, (<i>Pennisetum typhoidium</i>) a cereal.
Bhusa :—	The stuff left behind after threshing and separating the grain of such crops as wheat, barley, etc.
Bhusi :—	Husk of pulse seeds.
Chappar :—	Thatch of grass, straw, etc.
Chavali :—	Cow pea, (<i>Vigna catieng</i>), a pulse.
Chuni :—	A bye product obtained in preparing Dal from pulses. It contains some husks and small broken piece of cotyledons and embryo of pulse seeds.
Chhatak :—	A weight = 1/16 of a seer = 2 ozs. roughly.
Dabi :—	Milk curdled with normal lactic fermentation.
Dal :—	Cotyledons of pulse seeds (without husk).
Ghee :—	Clarified butter.
Guari :—	Cluster bean, (<i>Cyamopsis psoralioides</i>), a pulse.
Gur :—	Raw cane-sugar
Haldi or Haldi :—	Turmeric, a condiment.
Jowar :—	Great Millet (<i>Sorghum vulgare</i>) a cereal.
Kachcha :—	In the text indicates earthen, without masonry work.
Karbi :—	Dried straw of cereals like Jowar.
Kharif :—	Rainy season (June to September).
Khowa or Khoya :—	Milk reduced to semi-solid consistency by boiling and evaporating water.
Kutthi :—	Horse gram, (<i>Dolichos biflorus</i>), a pulse.
Lota :—	A metal pot.

GLOSSARY

Maund (md) :—	A weight = 40 seers = 80 lbs. roughly.
Mawa :—	See Khowa.
Moht :—	A leather or metal sheet basket used for raising water for irrigation, a water lift.
Mung :—	Green gram, (<i>Phaseolus radiatus</i>) a pulse.
Nala :—	Small water course.
Phol :—	See Bhusi.
Pucca :—	In the text means with masonry work.
Purda :—	A curtain.
Rabi :—	Cold season (November to April).
Seer :—	A weight = 1/40 maund = 2 lbs. roughly.
Sonf :—	Fennel (<i>Foeniculum vulgare</i>), a condiment.
Soya :—	A condiment (<i>Paucidanum graveolens</i>).
Tatti :—	A structure made of grass, straw, etc., to serve the purpose of a curtain or wall.
Til :—	Sesame (<i>Sesamum indicum</i>), oil seed.
Tur :—	See Arhar.
Urd :—	A pulse (<i>Phaseolus mungo</i>).
Wai :—	A pulse (<i>Dolichos lablab</i>).
Zira :—	Caraway (<i>Cuminum cyminum</i>).

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