

**CITRUS BY-PRODUCTS  
AND  
UTILIZATION OF WASTES.**

**S. K. Mitra M. S., Ph. D.**

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BY

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## PREFACE.

Considering the abundant production of citrus fruits in India it seems that we have not availed ourselves of the great industrial opportunity that this delicious fruit offers to many parts of the Semi-tropical world. During the last two decades the industrial development of citrus in the Western world has advanced very rapidly. It is on the basis of utilization of the surplus and waste fruits by well-developed scientific methods to manufacture various kinds of by-products that the citrus industry in Europe and tropical America has been brought to a success.

The main purpose of this publication is to give the people a general idea of the by-products that can be easily made by those interested on the subject on a rather small capital. Besides, it will, without doubt, give an opportunity to our housewives to prepare various kinds of chatneys etc. for every day use.

The materials for this work have been collected from various sources of which a partial bibliography has been added to the end.

SYLHET.  
*March 3, 1922.*

} **S. K. Mitra.**  
Economic Botanist to the  
*Govt. of Assam.*

## CONTENTS

	Page
1. Introduction ...	1
2. Present Status of Citrus ...	4
3. Area and Distribution of Citrus ...	7
4. Oils and Perfumes from Citrus Fruits ... ..	23
5. Citrate of Lime and Citric Acid ...	44
6. Canning and Preserving of Citrus Fruits ... ..	48
7. Citrus Fruit Juice ... ..	54
8. Citrus Fruit Syrups ... ..	64
9. Citrus Fruit Extracts and Spirits ...	68
10. Candied Preparations ... ..	73
11. Citrus Fruit Preserves ... ..	81
12. Pastry Preparations ... ..	87
13. Confectionary Preparations ... ..	92
14. Miscellaneous Use of Citrus Fruits ... ..	94
15. Conclusions ... ..	95
16. Bibliography ... ..	98
17. Appendix. ... ..	101

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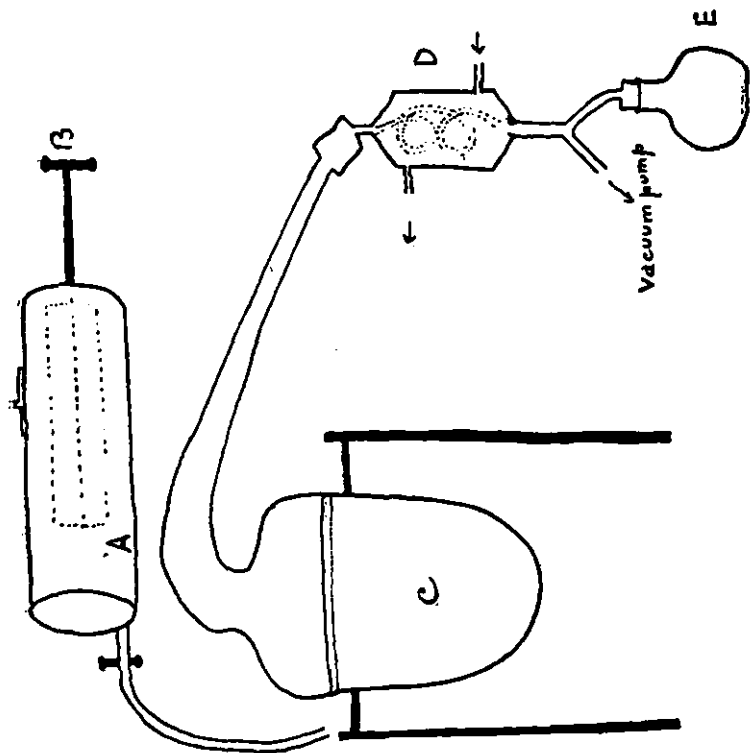


Fig. 1. Vacuum still.

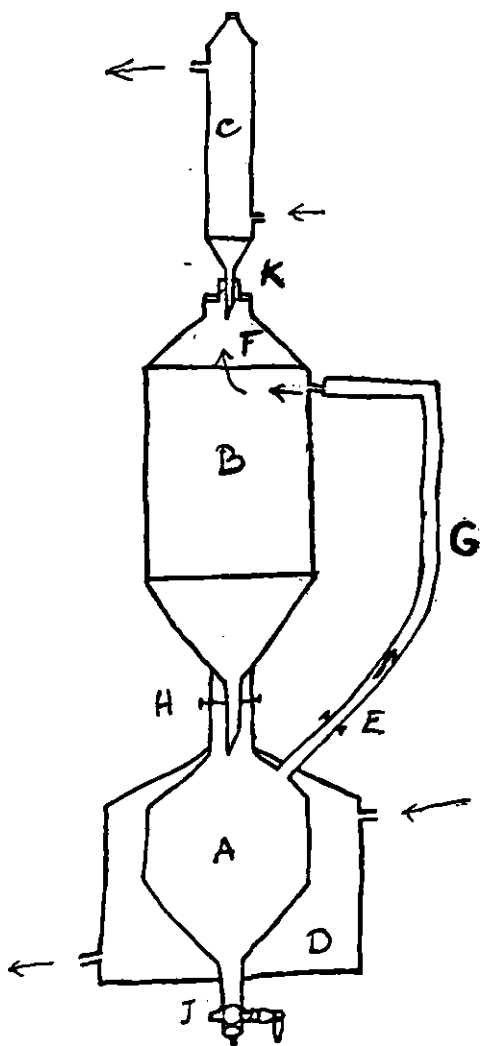
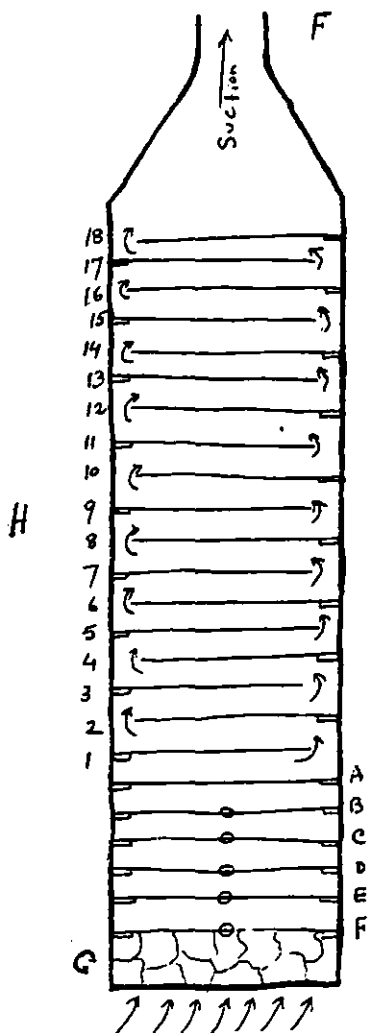


Fig. 2. Continuous distillation apparatus.  
 (After F. Rabak.)



**Fig. 3. Apparatus for treating flowers by the Eflourage process.**

*(After F. Rabak.)*



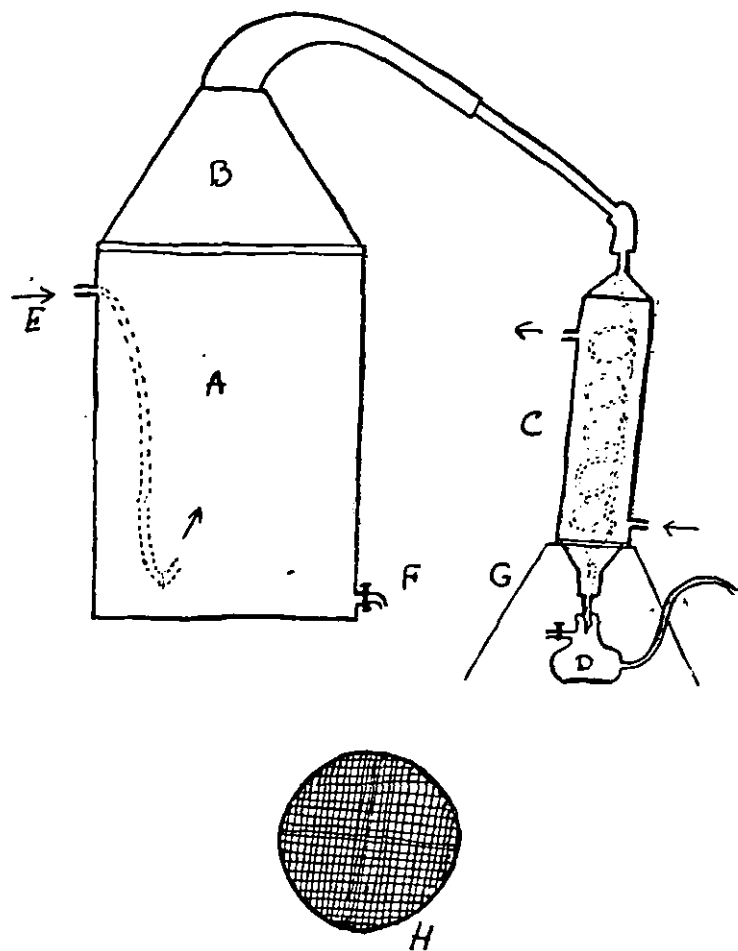


Fig. 4. Distillation apparatus for flowers.  
(After Rabak.)

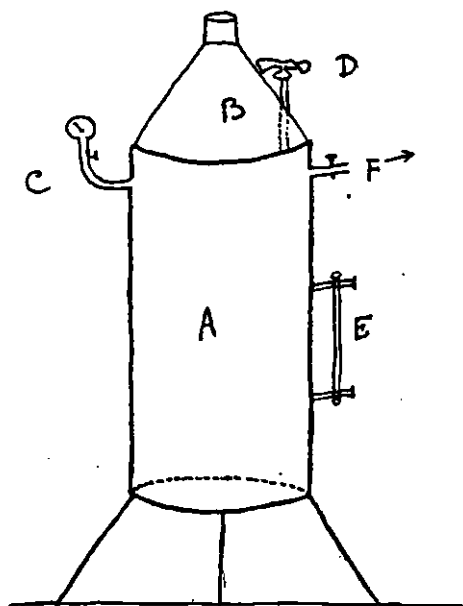


Fig. 5. Steam Generator.  
( After Rabak )

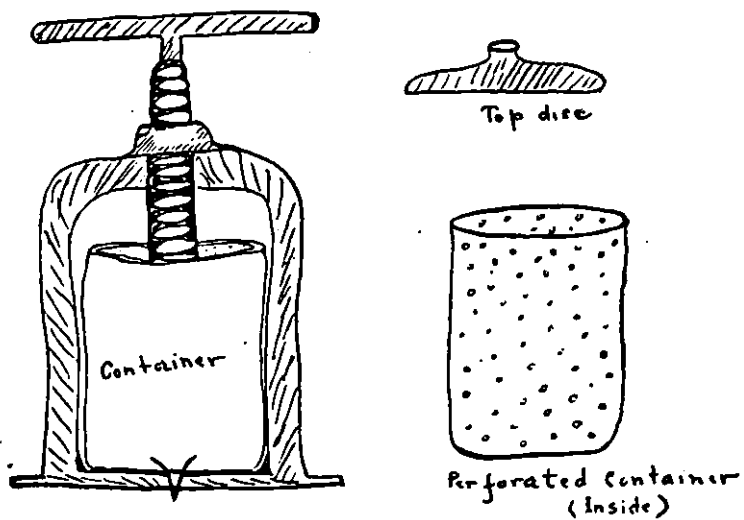
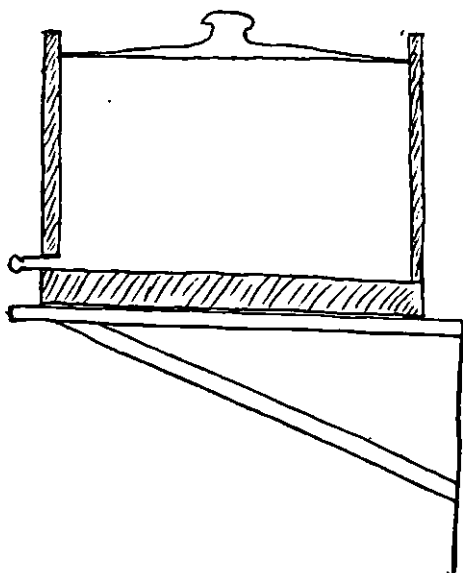
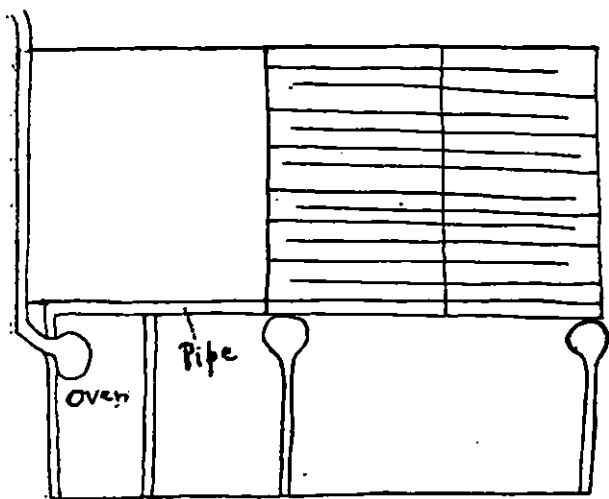


Fig. 6. Screw press.



**Fig. 7. Stone Jar for Candy-making.**  
*(After Pacrette.)*



**Fig. 8. Drying Oven.**  
*(After Pacrette.)*

# CITRUS BY-PRODUCTS AND UTILIZATION OF WASTES.



## I. INTRODUCTION.

ALTHOUGH the citrus industry in India is very old and the fruits are found to be grown all over the country more or less on a large scale, yet, it has not been developed sufficiently to bring a commercial success. The industry is entirely in the hands of those who have little or no knowledge of the industrial phase of such an enterprise.

Considering the present status of our citrus industry in different parts of the country it seems that 30 p. c. or 40 p. c. of the crop is wasted, without any return whatever, due to rough handling, insect and fungus pests, wind falls etc. Such a deplorable condition of our citrus industry urges us to think of some remedy that can save the growers from this utter loss.

So far as the present status of the citrus industry is concerned, it cannot possibly improve, unless our growers and business-men know how to utilize the wastes so as to manufacture by-products out of them. The following table shows very clearly the amount of citrus by-products imported to India from 1917 to 1921, as has been kindly reported by the Director General of Commercial Intelligence, Calcutta :—

### Imports of Citrus Products.

Year ending 31st March	Essential Oils.		Jams and Jellies.		Citric Acid.	
	Gals.	Rs.	Cwts.	Rs.	Cwts.	Rs.
1917	19,204	4,85,310	27,980	13,66,545	Not available	
1918	23,368	5,10,570	13,352	5,92,080		
1919	23,719	5,41,770	16,475	8,66,490		
1920	26,862	7,28,200	7,129	3,00,230		
1921	38,532	16,71,550	16,658	11,17,040	373	1,30,330
Eight months April to November, 1921.	16,994	4,14,660	6,497	5,23,413	25	6,742

The current prices of citrus by-products are comparatively very high. The following is a partial list of quotations at the Calcutta market :—

Lemon oil @ Rs. 6/8/- per lb.	
Orange oil @ Rs. 1/12/- per oz.	
Calcutta citrate @ Rs. 8/- per lb.	
Citric acid @ Rs. 3/12/- per lb,	
Marmalade @ Rs. 7/- per doz.	} in 1 lb tins.
Jellies @ Rs. 7/- per doz.	
Lime Juice @ Rs. 4/8/- per gallon.	

From the above data one can easily understand the importance of citrus by-products from the industrial point of view. The problem that confronts us is to establish by-product plants in different sections of the country where the citrus fruits are grown in abundance and thus supply the demands of many of our daily necessities of life. Such an attempt would not only open new lines of enterprizes to engage the enthusiastic young men of business, but at the same time minimise the enormous amount of unnecessary importations of many articles of commerce.

In fact, it is due to the lack of proper training, knowledge and information to adopt

scientific practices that our growers and manufacturers are labouring hard, to-day with little or no commercial success. It is our earnest belief that with the introduction of scientific methods among our people, who are engaged in such enterprises, the present status of our citrus industry is sure to be on the increase in the near future, bringing in at the same time prosperity and wealth to the growers as well as the nation as a whole.

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## II. PRESENT STATUS OF CITRUS.

AT present the citrus industry of the world on a large commercial scale is limited to the temperate regions, of which the following are the most important :—

(1) Southern Europe (Palestine, Italy, Sicily and Spain).

(2) West Indies (Jamaica, Trinidad and Bahamas).

(3) Southern Africa (Cape Colony).

(4) Florida.

(5) California.

It is these five regions of the earth that supply the bulk of the oranges of the world-

market to-day. Besides, it is undoubtedly true that some of the most important commercial varieties of which the famous Washington Naval orange stands at the head, have found a foothold in the United States, both in Florida and California and especially in the latter.

The oranges of commerce are grown in many parts of India from the foothills of the Himalayas to Cape Comorin and the Island of Ceylon, and also from Karachee in Sindh to Manipur in Assam, more or less on a commercial scale. There are five centres of orange industry in India, which may be stated as follows :—

1. Khasi Hills in Assam.
2. *Nagpur* in Central Provinces.
3. Lower ranges of Eastern and Central Himalayas (Nepal, Sikkim, Garhwal and Kumaon).
4. *Delhi* (the land watered by the Jamuna or the Ganges).
5. The Deccan or Southern India (*Poona*, Coorg, Mysore, Shevaroy and Nilgiri hills).

Besides, Ceylon and Burma produce a good deal of oranges on a large scale enough to supply the local markets.

Apart from sweet oranges of commerce other varieties of oranges are also grown. The



introduced Blood and Jaffa oranges are doing well in Ceylon, United Provinces, the Punjab and the Western Ghats. There are other oranges of native origin, both sweet and sour, as the Khatta, Ladoo, etc. which are grown here and there. The Seville or wild oranges are not cultivated, but they are found all over India.

In most of the places of commercial importance, the industry is entirely in the hands of the ignorant ryots. These men grow crops according to the traditional methods in which their forefathers have done under hardships of all sorts. In most of the places in India the soil and climate are marvellously adapted to the cultivation of oranges. It is the mere ignorance on the part of the growers in their methods of cultivation that has caused a great deterioration of the orange groves in various parts of India, till they have reached their present deplorable status. Besides the gradual depletion of soil fertility by centuries of crop production and periodical attacks of insects and fungi are the immediate causes that compelled many growers to give up the cultivation of oranges. Although there are few exceptions in some localities in Central India, Ceylon, Delhi

and elsewhere, on the whole the industry is not in the ascendant but has remained in a quiescent stage to bring wreck and ruin to many growers.

Aside from oranges India products abundantly Lemons, Limes, Citrons, Pomeloes of which there is no data. These are mostly locally consumed. As there is no by-product plants where these fruits can be utilized to advantage, they are mostly sold at a very cheaper rates with little or no profit to the grower. With the development of by-product industry in this country there is a great commercial prospect of these commodities as that of Sicily and Italy. The writer is of opinion that with the gradual development of education and adoption of scientific means, the citrus industry might be improved, so as to keep up the name and fame of the native home of citrus, especially oranges awake in the minds of the people both at home and abroad.

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### III. AREA AND DISTRIBUTION OF CITRUS.

The orange in India is a very common fruit known equally to rich and poor, young and old.

It is one of the most important commercial fruits and is cultivated in orchards and groves in various localities. Although the orange industry is one of the important agricultural enterprises and is the mainstay of thousands of people, yet the total area of the industry is not definitely known.

It is due to the limited scope left to the agricultural department in the development of Indian agriculture, the acreage under cultivation is not known, but the area of the cultivated orange-land is undoubtedly great and extensive. This large area under cultivation is not the criterion of a well-developed industry, but in consideration of the enormous population and extensive area of the country, it is very small. Notwithstanding the fact that India is a very old country, she has not availed herself of the natural resources that she has at her disposal.

The distribution of the sweet orange in India may be stated under three distinct geographical divisions after Dr. Bonavia as follows :—

1. The Northern Region :—Nagpur, Delhi, Alwar, Gargaon, Lahore and Multan.

(a) **Nagpur District:**—Oranges are the most important fruit-product in this district.

They are called Nagpur Santara. In 1903-04 there were more than 1000 acres in cultivation in gardens. The industry is increasing here very rapidly. At present the area is about 1200 acres. There are a number of orange-gardens newly planted in the vicinity of the city of Nagpur. The fruits of Nagpur have a high reputation. The amount of fruits exported in 1919-20 has been reported to be 885,970 mds.

**Amaraoti District:**—It is the second important orange-centre in the province. There are about 365 acres of orange cultivation in this district.

**Akola District:**—Oranges are grown here on a commercial scale more or less. There are about 140 acres under cultivation. Both Wardha and Bhandara district produce oranges. There are about 65 acres under cultivation in Wardha district from which about 1340 baskets have been shipped to other places in 1919-20. (Data supplied by the Director of Agriculture, Central Provinces.

(b) **Delhi District:**—Oranges are grown in the groves mostly with other fruit-trees. There are a number of groves near both sides of the Jamuna river and the great canal. The

oranges are of good quality. The area of the cultivated groves is about  $2\frac{1}{2}$  sq. miles, as reported recently.

(c) **Alwar District:**—Oranges are produced here in the plains scattered all over the district. The area is not known.

(d) **Gargaon District:**—The oranges are grown here on the hillsides from 800-1500 feet above the sea level. The trees are found to grow scattered with other fruit trees.

(e) **Lahore District:**—The oranges are grown in the vicinity of the town, but Gujranwalla, Lodhiana and other places produce oranges to a certain extent which are sent mostly to Lahore.

(f) **Multan District:**—The oranges are grown in a scattered way in the interspaces of other fruit-trees. The trees do not grow well without shade. Irrigation is needed.

In Hyderabad (Sindh) the orange trees are one of the common fruit-trees of the district. Most of the oranges are locally consumed and are shipped to Karachee to a certain extent.

(g) **Lucknow:**—Excellent oranges are grown in groves, which are scattered all round the district. The oranges are found to grow

with other trees. Some of the introduced varieties have secured a foothold very well. The famous Imambag garden produced a large number of varieties, both native and introduced.

In Rajputna oranges are found to grow in many scattered places where the soil and climate are favourable to them. They are said to be one of the chief fruit products in Ajmere, Jaipur, Bharatpur and vicinity.

2. The Western and Southern region.—Poona, Shevoroy and Nilgiri hills, Mysore, Coorg and Ceylon.

(a) **Poona District:**—Poona may be called the centre of orange industry in Bombay Presidency. Oranges are grown in many parts of the district especially in the foothills. In the plains they are also found scattered with other cultivated fruit-trees.

In Bombay Presidency almost the whole of the area in Gujrat consists of lemons or sour limes, about a quarter of the area in the Deccan similarly consists of this crop, the balance being almost entirely of oranges and sweet lemons. The area of the Konkan almost entirely consists of pomeloes. In Sindh 70 p. c. consists of lemons and sour limes and the rest almost

entirely of oranges and sweet lemons. According to districts the approximate acreage under cultivation at present as has been kindly supplied by Dr. Mann, Director of Agriculture, Bombay is as follows :—

Citrus fruits in the Bombay Presidency :—

<i>District.</i>	<i>Acreage.</i>	
<b>1. Gujrat</b>		
Ahmedabad ...	...	108
Khaira ...	...	88
Panch Mahals ...	...	14
Broach ...	...	11
Surat ...	...	52
	<hr/>	
	Total :	273
<b>2. Deccan</b>		
East Khandesh ...	...	212
West „ ...	...	18
Nasik ...	...	172
Ahmednagar ...	...	740
Poona ...	...	1787
Sholapur ...	...	100
Satara ...	...	36
	<hr/>	
	Total :	3065

<i>District.</i>	<i>Acreage.</i>	
<b>3. Konkan</b>		
Thana	...	16
Kolaba	...	2
Ratnagiri	...	
Kanara	...	6
	<b>Total :</b>	<b>24</b>

Total Bombay Presidency 3452

<b>4. Sind</b>		
Karachi	...	25
Larkhana	...	52
Sukkur	...	192
Hyderabad	...	103
Nawab Shah	...	105
Thar & Parkar	...	20
Upper Sind Frontier	...	21
	<b>Total :</b>	<b>518</b>

The common varieties grown in Bombay Presidency are known as Mosambi, Local Santras Nagpur Santras, Kavala and Ladoo.

(b) **Shevoroy hills:**—Orange trees grow in the foothills even at an elevation of 1500 feet above the sea level or more. In and around



the Shevoroy hills the Seville oranges are found to grow wild. Besides some of the sweet oranges of the Suntara type are also found wild in many scattered places. Here the oranges grow rather in a semi-wild state.

(c) **Mysore**:—Oranges are grown in various parts of the State. In Siddapore, Chittaldroog district, the villages are found to grow oranges more or less in scattered places. The oranges are of good quality and are one of the chief agricultural enterprises of the district. There are a few new plantations at Bangalore. The area in the State is not known.

(d) **Coorg**:—The sweet oranges here are mostly loose-skinned and are very common. The oranges are said to grow in a semi-wild state. The Seville oranges are found to grow wild. There is no regular garden and the orange trees are found to grow with other fruit trees. The entire area of cultivation is not known.

(e) **Nilgiri hills**:—The oranges are found to grow here even 2000 feet above the sea level. Seville oranges are found to grow wild in almost every place. Sweet oranges are grown in a scattered way. It is a sanatorium. Many foreigners and influential Indians have their

quarters in the hills. Some of the amateur gardeners have been trying to grow oranges in a systematic way.

**North Arcot District:**—The oranges here are grown to a limited extent and are largely sent to Madras. They are grown mostly in the district of Salem, the vicinity of Ambar and the neighbouring villages in the Vellore Tulak. Oranges are also grown to a certain extent in the Karvethagar Zamindari.

In Banganapalle (Madura district) oranges are grown to a certain extent and are sent to Madras.

In Belgaum district oranges are grown with other cultivated fruit trees. The Batavi Leboo, a kind of Pomelo, is very important here.

In Chodavarum (Godavery district) oranges are one of the principal products of the forest. Sweet oranges are found to grow wild. The oranges are scattered with other fruit trees.

In Narasapur (Godavery district) the gardens of Palakollu stand unique in the cultivation of the Batavian orange (Batavi Leboo) said to be introduced by the Dutch settlers in 1662.

In Hyderabad district the oranges are grown to a large extent in and around

Aurangabad, Osmanabad, Parbhani and Nirmal, and also elsewhere. They are also found to grow in private gardens.

In the North Canara district oranges are found to grow in the higher altitudes on the foothills, even above 1500 feet above the sea level.

In Ganjam district oranges are found as one of the forest products, where they grow in a semi-wild stage.

(f) **Ceylon:**—In Ceylon oranges are grown both in the foothills at an elevation of 1100 feet above the sea level and in the plains. The district of Hakhala is the most important orange centre. There are many gardens here and several introduced varieties are also grown. Seville oranges are found to grow wild all round the foothills. There are a few gardens at Kandy, but the foothills are found to grow sweet oranges luxuriantly.

**Nicobar Islands:**—Oranges are produced to a certain extent in Nicobar Islands. This is a convict settlement. There are no regular gardens.

3. The Eastern Region.—Nepal, Bhutan, Sikkim, Assam and Burma.

(a) **Nepal.**—Orange trees grow very luxuriantly in the foothills of the Himalayas even at an elevation of 5000 feet above the sea-level. Oranges grow here in a semi-wild stage. The Seville oranges are found to grow well all over the country. The oranges are famous for their sweetness.

(b) **Bhutan:**—Oranges grow semi-wild. They are one of the most important fruit-products. The sweetest oranges of India are grown here. There are no regular orchards. Oranges grow mostly in the foothills.

(c) **Sikkim.**—The cultivation at Sikkim is followed in the same semi-wild state as that of Nepal. Oranges are generally brought to Darjeeling and are sometimes sold in the market as Darjeeling oranges. They have a very high price in the market. These oranges are very sweet.

(d) **Assam.**—This is known to be the home of sweet oranges. The hill tracts, known as Garo, Khasia, Jaintia and Naga hills, are the centres of the eastern orange industry. The orange trees are very common and are found in the form of gardens. The oranges are of the Santara type and are sweet. Seville oranges are found to grow in the hills and plains of Assam.

The chief centre of Khasi Hill orange distribution is Chaatak. It is from this place that oranges are generally distributed all round Bengal mostly by boats. The following as a data of the export trade of the Surma Valley oranges, as supplied by the Director of Land Records and Agriculture of Assam for the last thirteen years is given below : —

<i>Year</i>	<i>Quantity</i>	<i>Value in Rupees.</i>
1901—02	74,000	280,000
1902—03	"	"
1903—04	"	"
1904—05	38,460	206,722
1905—06	135,213	586,467
1906—07	51,296	275,716
1907—08	14,949	157,045
1908—09	53,646	348,699
1909—10	29,837	238,696
1910—11	50,612	319,238
1911—12	55,516	321,134
1912—13	104,714	544,514
1913—14	65,906	313,133
1914—15	100,031	...
1915—16	38,313	...
1916—17	86,406	...
1917—18	45,304	...
1918—19	67,686	...
1919—20	43,918	131,753

The oranges at Chaatak are sold @ Rs. 30/- to Rs. 35/- per Khasia-hundred (three thousand oranges make one hundred).

There are a few places of commercial importance in the Khasia hills as follows :—

1. **Dwara Nongtyrmon** :—Dwara Bazaar is the centre of this district. Oranges are the principal agricultural product in this place. The Pelly State (native) is also an orange-growing district.

2. **Khyrim** :—Oranges are the principal product and are grown in gardens.

3. **Nalai Sohmat** :—Oranges are the important product under cultivation.

4. **Chala** :—Oranges are the principal product and are grown in gardens. Much damage was done in this quarter by the earthquake of 1896 which completely ruined the industry. At present the industry is rising to a certain extent.

5. **Maodin and Naolong** :—Oranges are produced in abundance. They are mostly sent to Sylhet.

6. **Cherrapunji** :—Oranges are grown in the slope of the hills with other trees such as jackfruits, tejpat and areca palms. Oranges are

sent to Chaatak via Thariaghat. Chaatak is the centre of distribution of Khasi hills oranges to Bengal markets.

**7. Barapunji & Parapunji :—**Oranges are grown here on a commercial scale in the form of gardens as in Cherrapunji. The Punji lands are specially suited to the growth of citrus trees. These oranges are shipped to Chaatak by boat.

**8. Lakhat :—**It is also a growing centre. The gardens are almost the same as in the Punji-proper. The oranges are shipped to Chaatak.

**9. Latu (Sylhet) :—**Oranges are grown here on foothills. Better care of orchards are taken here than in Khasi hills. The oranges are not so sweet as those grown in the Khasi hills. The extreme drought during the winter season causes the trees to die here and there, when they are 8 to 10 years old. This is also one of the causes of orange drop.

Oranges grow to a certain extent at Kamrup and Goalpara. The industry seems to be promising. Besides oranges have recently been introduced in Cachar Hills where the soil is well-suited to oranges.

(c) **Manipur** :—Oranges are grown in orchards with other fruit-trees. The production is mostly locally consumed. Some new plantations are in progress.

Some oranges are grown in a scattered way in Bengal of which Kalimpong in Darjeeling and Kalahari (southern Bengal) are mentionable. In the former the oranges are sent to Duars, Tarai Bazaar, Calcutta and Darjeeling, while in the latter oranges are grown only in the irrigated lands and are sent to local markets.

(d) **Burma** :—In Burma oranges are grown mainly in the Shan States and to a certain extent in the Chin hills. In the Northern Shan States the orange flourishes in many parts of the country, especially along the Salween river and some of its tributaries and also along the Namma in Hsipaw. Besides Hsipaw Sawha possesses excellent orange plantations on the banks of the Namtu. In Southern Shan States oranges are one of the principal garden-crops under irrigation from the canal or the river.

In Amherst district the oranges are grown, especially in the gardens of the district mainly on the banks of the Ataran river. The gardens are in many places irrigated as the fruit does not



get sweet unless irrigation-water is applied before two months or at least a month and a half of the harvesting season.

In Mongnai the gardens contain scattered orange-trees in common with other cultivated fruit-trees.

In Lawksawk oranges are grown on hillsides and are mostly irrigated with great difficulty from wells.

In Chin Hills (border lying between Assam and Burma) the oranges are found to grow scattered on the foothills at an elevation of about 1500 feet above the sea-level. They are grown mostly in a semi-wild stage. The Seville oranges are found all over the country to grow wild.

In fact, citrus fruits grow luxuriantly almost in every part of India, Ceylon and Burma. The soil and the climate of India are well-suited to the cultivation of oranges, lemons, limes, pomeloes, citrons etc. The commercial centres can only be developed provided scientific methods are adapted to improve the cultivation as well as the manufacturing of by-products of various sorts.

In order to make the people realise the possibility of the future commercial success

in our citrus industry I shall try in this publication to give an account of the citrus-by-products so far as they have been improved from the Italians who are the oldest by-product manufacturers in Europe, up to the present well-developed scientific practices of Europe and America.

#### IV. OILS AND PERFUMES FROM CITRUS FRUITS.

Oils and perfumes of various kinds are extracted from citrus fruits in Europe and elsewhere. The chief centre is in Southern Europe, specially Italy, Southern France and Spain. There are various processes of extracting oils and perfumes from the fruits of which the following are more or less successful :—

1. Italian Method (Hand operation).
2. Solvent Process.
3. Flootation Process.
4. Centrifugal Process.
5. Heavy Pressure Process (Expression).
6. Distillation Process.

The above processes may be applied to extract the oil from Oranges, lemons and limes.

## 1. Lemon Oil.

The Lemon oil is chiefly manufactured in Sicily, at Raggio in Calabria and at Mentone and Nice in France. Small and green fruits are used to a large extent, as they contain more oil than those which are fully ripe. Different methods are employed to extract the oil. A brief description is given below :—

### (a) Italian Method.

In Italy two methods are employed in preparing the fruits for the extraction of the oil as follows :—

1. Two-piece method : In this method the lemons are cut in halves and the pulp is removed by a cup-shaped knife.

2. Three-piece method : In this method the peel of the lemons is pared off in three longitudinal sections or strips.

The workman after cutting the lemons, separates the pulp from the rind and keep them in different vessels. The pulp is taken for crushing to get the juice to prepare citrate of lime and the peels are dipped in cold water so as to make them plump for oil extraction.

The process by which the Italians extract the lemon oil is known as the "Sponge process"; because they use small pieces of sponges to work on the lemons which may be briefly stated as follows :—

Sponge process : The workman sits on a low stool with an earthen bowl before him. A stick is put cross-wise on top of the bowl on which the sponges are kept. For those fruits which are cut crosswise a flat sponge is surmounted by a small concave one, the half-lemon is put inside it with the upper part of the peel in contact with the sponge. It is then pressed by the palms of the hands. In the case of the three-piece method a large heavy sponge is used which rests on the flat one and the pieces are pressed with the coloured side down into it. This is done mostly where the rind is pared off from the fruit.

In pressing the lemons both palms and fingers are used. It is repeated for three or four times, so as to get all the oil out of the rind. The juice with the oil is received on the bowl. This bowl is made up of glazed earthenware. Another small bowl of the same material is fitted to it. The sponges, after the pressing is

complete, are squeezed by hand. The oil, being of less specific gravity than the juice, comes up on the surface of the bowl and slides down the big vessel on to the small one. In order to hasten the work the man violently blows his breath on the surface of the liquid till the oil goes down to the lower vessel. The oil is then separated from the bowl when it is full. The oil thus obtained is not quite pure, as there is some juice and pulp mixed with it. The operation of separating the oil is done by tilting and blowing repeatedly. The depression in the bowl catches the residue and the juice and the oil is drawn out. The oil obtained is not bottled at once, but is allowed to settle in a copper container for twenty four hours. It is then filtered and stored for a time in copper vessels with covers on. The oil is then bottled.

The residue left, after the oil is separated in the bowl is allowed to pass through a conical cloth filter in an earthenware bowl and the oil and water are thus separated in the two-piece method of extraction.

In the case of the three-piece method the same operation is carried on except that the residue thus left is distilled in a crude still and

the oil obtained gives a very poor product. By the above processes 9-15 ounces of oil can be obtained from 400-500 lemons or rather 2-3 lbs. of oil per ton which is the general yield in Italy.

In Mentone and Nice (France), the method adopted is as follows :—The lemons are placed in a shallow basin of pewter about  $8\frac{1}{2}$  inches in diameter having a lip for pouring on one side and a closed tube at the bottom. A number of brass pins stand up about one half inch from the bottom of the vessel. The man working on the lemons, rubs them, each at a time, over the pins very slowly and the oil comes out and goes down the pins, and is collected in the tube. The tube is emptied from time to time into another vessel. The oil is then filtered carefully and the clear oil is known as “essence de citron an zeste” or essence of lemon.

There is another oil called “essence de citron distillee” which is obtained in a somewhat different way by distillation. In this process the lemons are rubbed on the surface of a coarse grater and the grated peels are distilled on a modern still. The oil obtained by this process is colourless and is of rather inferior fragrance, while the old process oil has a yellow colour and

a very fine odor. In fact, there is a great loss in the percentage of oil in the old process and it is at the same time very laborious, while the new method eliminates these two at the cost of flavour which is seriously objectionable for its operation.

At present, the machine-made Italian essential oil is obtained as follows:—The machine consists of a stand supporting two upright arms united together strongly by iron beam at the top. On one of these two arms, a large cogged wooden fly-wheel is hung, which gears against a cylinder, the sides of which are upright spokes fitting into the cogs of the fly-wheel. On the under side of the cylinder is bolted a corrugated disc which revolve at the bottom of the machine. The disc can be lowered or raised by an arm which is fastened to the cylinder. This arm is weighted to regulate the pressure on the fruits which are placed between the upper and lower discs. When the arm is lowered the upper disc is raised and uniform sized lemons are placed within. Unless the lemons are uniform they do not work well. The lever is then raised lowering the disc upon the fruits and the outside fly-wheel is turned by hand. About two minutes are needed for the oil to come out. After this

the pressure is stopped, the disc is fitted and the fruits are removed. At this time each lemon is carefully wiped by a sponge so as to take up the oil that adheres on the outside of the fruits. The oil is received in large pan and after filtering, the residue is hand-pressed for the juice to manufacture citrate of lime and citric acid. The oil thus obtained is high in flavour and greenish yellow in colour.

### (b) Solvent Process.

A number of chemicals may be used as 86° Beaume gasolene, benzol, ether, alcohol, trichlor-ethylene etc. to extract the oil. The process may be briefly stated as follows :—

The lemons are grated in a machine grater. The grated peels are ground and solvent is poured in a cylindrical vessel "A" with an agitator "B" at the centre, as shown in fig. 1. The liquid is then decanted to a still "C" having a vacuum pump attached to it. The solvent is condensed by the condenser "D" and received at "E" the receiver. Thus, the same solvent may be used repeatedly. The oil obtained in this way contains to a slight extent the odor of the solvent which cannot be altogether removed. So,



the oil is rather to certain extent poor in flavour. The yield of oil in this case is the highest of all the methods, which is found to be from 6-12 lbs. per ton, depending largely on the nature and variety of fruits. Besides, the oil is high in aromatic resins and colour.

### (c) Floatation Process.

In extracting the oil by floatation, the lemons are ground into a paste and agitated under a column of water in a large cylindrical vessel. The oil being lighter than water comes to the surface. The oil thus obtained as an emulsion of oil and water which is then separated. The emulsion is very difficult to separate which is done by a cream separator. The yield in such cases is very low, being about 5 lbs. per ton ; but the oil obtained is rich in flavour and aroma.

### (d) Centrifugal Process.

In the centrifugal process the whole fruit is ground into a paste by a roller machine which is then run in a large continuous centrifuge. The oil comes out on the surface as an emulsion. A great difficulty is met with in breaking up the

emulsion. A De Laval Cream separator is used to separate the oil. The yield is not very high, being about 5-6 lbs. per ton. The oil thus obtained is rich in aroma and flavour.

### (e) Pressure Method.

The fruits are ordinarily grated in a machine grater and the grated peel is then run under a hydrolic press, having a pressure of 400 lbs. per sq. in or more. The oil in this case also comes out in the form of an emulsion. The oil obtained is very heavy, but rich in flavor and aroma. The yield is about 5 lbs. per ton.

### (f) Distillation Process.

The oil can be easily extracted from the fruit by distillation. In such a case a steam still should be used, because direct heat on the oil spoils the flavor altogether. The oil may be distilled satisfactorily at a temperature of 180° F. Above this temperature it impairs the flavor of the oil. The apparatus for this purpose consists of a still with a steam jacket attached to it at the bottom. It is connected with a condenser and a receiver. The yield is about the same as

the solvent process. The flavor of the oil is lost to a large extent and is not as permanent as in oils prepared in other ways.

In United States trials have been made to manufacture terpeneless oil. This terpeneless oil is made by distilling off 9/10 of the essential oil or by dissolving oil in 50 p. c. alcohol in which the terpenes are insoluble. But thus far, it has not come to a commercial success.

## 2. Orange Oil.

The oil of orange, known as "the oil of Bergamot" or "Bergamot oil" is obtained in Italy and Southern France from wild oranges. These oranges are just the same as the Saville oranges in India. The trees like those of ours grow wild all over the Southern Europe, especially in Italy, Southern France, and Spain. They are cultivated to a certain extent in Calabria, Italy, which is the centre of the production of "Bergamot oil". At present, the oil is mostly extracted by machines very similar to those of lemons, as already described. The oil is a limpid greenish yellow fluid with a pleasant odor. The chief use of the oil is in perfumery.

The well-developed scientific methods, as already stated in the case of lemons, hold good with all kinds of oranges to extract the oil. But, being heavier than lemon oil due to the presence of enough gums and resinous materials the orange oil is very hard to handle in breaking up the emulsion of oil and water.

In fact, even at present the extraction of oil from the fruit by scientific methods has not yet been a definite success from commercial point of view. But so far as the commercial possibility is concerned, the solvent and centrifugal methods seem to be promising.

### **3. Orange Flower Oil.**

The present development in science has brought the method of distillation and other processes to a high degree of perfection and it is for this reason various kinds of oils and perfumes (aromatics) are being extracted from the flowers and leaves of plants such as orange, lemon etc. without any difficulty.

The best quality of oil known as the so-called "Neroli oil" in the market is obtained from the flowers of the wild or bitter oranges as

already stated. The leaves of the same are also used to manufacture a lower grade of oil known as the "oil of petit grain".

There are a number of oil plants at Grasse and the neighbouring districts in France. When the orange-trees are in full bloom in May, the flowers are gathered and ordinary stills are used for distillation. The products of distillation pass through a receiver from which the water is drawn off by a bent tube (syphon) In this way one kilogram of orange flower yields two grams of neroli oil at the cost of 500—1000 Francs per kilo worth £9—£19 per pound. The orange-flower water is also sold at 25 centimes per litre. The leaves of the orange-trees yield in the same way by distillation about 16 grammes per kilo and worth about 1/10 of the neroli.

In general, the aroma of plants is not due only to volatile oils, but other odor bearing substances which are not of oily character. As for example, in lemons and oranges there are some resinous substances which carry the odor. Of these, some are acted upon by acids, while others are acted upon by bases. Some of the aromatic substances as, the Vanilla bean of commerce, is really an oily substance.

The volatile oil of plants, though scattered all over the plants, yet is localised in particular parts as the leaves, flowers, fruits, and seeds. In order to give a general outlook of such an industry to the reader, I shall here briefly describe the present methods of extracting the aroma from plants, especially leaves, and flowers, adopted in some parts of Europe and to a certain extent in America as follows :—

In the process of extracting the aroma from flowers two commercial methods are found to be adopted.

#### A. SOLVEN PROCESS.

The solvent process is mostly used in the case of flowers, as they are very tender and are liable to be smashed to a paste even by a slight pressure. In this process of solution there are three ways which may be adopted to advantage as follows :—

##### (a) Volatile solvents.

The method of extraction by the use of volatile solvents such as ether, chloroform,

benzol, petroleum ether, acetene etc., are adoptible only to flowers. The process is known as the "continuous extraction". By this the solvent carries with it in solution the odorous contents of the flowers which are treated in a container. It is then heated in a vessel by regulating the temperature. The vapour is condensed and utilised further for extracting any remaining odor. The figure No. 2 indicates the process involved in the operation which may be stated as follows :—

In this apparatus "B" serves the purpose of a percolator. A circular wire screen (brass) is put at the bottom of it. The flowers are put in the percolator over the screen and the cover "F" is attached by means of clamps on opposite sides. A piece of asbestos is placed between the cover and the percolator so as to make it airtight. The receiving vessel "A" is attached to the bottom of the percolator "B" and also the hot water bath "D" with screw unions. The condenser "C" has a glass tube "K" at the end passing through the rubber cork attached to the cover "F". The glass tube has rubber stoppers by which it is connected with "C", the condenser.

The condenser consists of a large tube filled with cold water. The tube from the cover "B" runs through the condenser to the receiver "D", where there is a spigot to extract the oil that floats on top of the liquid. It is taken out from time to time as the operation goes on. It is always preferable to have a copper receiver.

In treating the flowers with the solvent it is poured through the condenser into the percolator. The water bath "D" is heated at the same time. The steam which is generated readily as the solution is heated to 35° to 45° C., passes from "A", goes through "G" and then to the condenser, as is shown by the arrow marks in the figure. The solvent thus percolating through "B" to "A", then passing as steam through the tube "G", goes to "C" again where it is condensed and is dropped down the percolator. Such a continuous process goes on for a time and it may be run with the minimum amount of solvent.

For the final recovery of the solvent from "A" with the odor in it, the apparatus is cooled down and is disconnected at the union "H" between "A" and "B". The tube "G" is also



disconnected at "E", as shown in the figure, with the condenser in proper position and heat is applied to "D". The excess of solvent is recovered completely in this way.

The oil or perfume is drawn off by the opening of the stop-cork at "J". The oil thus obtained is rather crude, as it comes in contact with other substances. So, it is necessary to distill it by a steam still and the colorless oil is decanted in the receiver of the still. In this way pure perfume or oil can be extracted from orange flowers.

### (b) Liquid fats.

In the extraction of oil by liquid fats a number of fats or fatty oils may be used, as olive oil, lard etc. The oil is first placed in a procelain lined vat and is heated to 40°—60° C. The flowers may be put in either by bagging in cheese cloth and suspended over the fat or may be put directly over the fat and left for 6—12 hours. The vat should be kept covered tight.

After this the heat is removed and the mixture is then drained or the bags are removed and expressed, and a fresh charge of flowers is

made. In this way, after several charges, the oil or fat is perfumed from which the perfume is extracted by shaking out the oil with strong 95 p. c. alcohol in which the odor is soluble, while the fat is insoluble. The alcohol is then distilled off to get a pure perfume. This method of macerating in liquid fats is done to a certain extent in the Southern France.

In such an operation the temperature should be regulated by a water-bath and the oil will fill only a small part at the bottom of the vat being about  $1\frac{1}{2}$  to 2 inches in depth. The number of charges depends on the kind of flowers used. All the fragrant flowers as roses, jessamines etc. may easily be treated in this way.

### (c) Solid fats.

In the extraction of aroma, the process of absorption of perfumes in color by the solid fats, known as the *Enfleurage* process, has long been in practice. It was originally carried out by spreading freshly picked flowers upon thin layers of lard until they are exhausted and fresh charge made on it. In this way a perfumed pomade was made which contained the fresh natural odor of flowers.

The pomade thus made was agitated in alcohol. The alcohol dissolved the odor which was then carried to vacuum, where it was evaporated, and a concentrated oil or perfume was left. This crude process has been modified at present which is used to a large extent for the extraction of the aroma.

The present modified method adapted for the extraction of the perfume may be stated as shown in figure 3, consists of a tall box "H" being about 2 feet square in breadth and about 6 feet in length. The box is perfectly air-tight all round. It is provided with a number of glass-plates, which are shown in the figure, from 1—18. The bottom of the apparatus is perforated and consists of a layer of sponges on the tray, "G". This gives a free access of air into the apparatus. Each of the flower trays from A—F has a screen-bottom. The sides, front and back of the apparatus may be of wood or iron. The trays and glass-plates can be easily put in or taken out as need be.

The lard or solid fat is put in glass-plates about one half inch thick. The front of the apparatus has an air-tight door, which is closed after the charge is made. A small suction pump

is attached at the top of the apparatus. The air-current is allowed to pass through the sponges at the bottom. A circulation of air is produced inside the apparatus, the course of which is indicated by the arrow marks. In order to hasten the work a blower may be placed at the bottom of the apparatus to advantage. The sponges are moistened before they are put in. The air drawn through being moisture-laden by the sponges produces the best yield of perfume from the flowers. This is continued by charging fresh flowers from time to time.

The lard charged with the odor is then taken out and agitated with 95 p. c. alcohol. After shaking thoroughly for a time, the alcohol extract is distilled to get a pure perfume or oil as before.

## B. DISTILLATION PROCESS.

The separation of perfume by distillation with a still has been in use for a very long time. Even in the 18th. century, the apparatus used in Europe consisted of a simple still body with a condenser and a receiver connected with it. The process involved in this are (1) distilling,

(2) condensing of vapour and (3) collecting of oil.

A modern apparatus used for this purpose consists of a still "A", a still head "B" serving as a cover for the still body and a receiver "D" as shown in the fig. 4. "E" is the steam-pipe made up of galvanized iron of about  $\frac{3}{4}$  inch in diameter. "F" is the spigot. "G" is the tripod on which the condenser "C" is placed. "H" is the screen on which the materials to be distilled are poured on. It is then put in at about 3 inches from the bottom of the still. The cover is then closed air-tight by clamps. The running tube from the cover to the condenser has a joint which may be easily separated. The condenser itself consists of a large cylindrical vessel filled with cold water through which the tube in connection with the still runs to the receiver. In the receiver "D" there is a spigot to extract the oil that floats on top of water in it. The oil is taken out from time to time. The receiver may be of copper or glass.

The process of operation may be stated as follows : At first the screen bottom is placed in the still which stands on cleats inside and is tied by asbestos strings, so that it can be easily

put in and taken out. The materials (orange flowers etc) to be treated are put in and the cover is tied fast with the clamps. Steam is passed through a generator, as will be explained later, through the tube "E". In the condenser "C" cold water is allowed to enter through a tube at the same time in a continuous flow, passing through another opening with a tube attached to it. The oil in the receiver being lighter floats and is separated from time to time by opening the stop cock at the upper part of "D", the receiver. A syphon is attached to "D" to prevent over-flowing. It requires  $1\frac{1}{2}$ — $2\frac{1}{2}$  hours to complete the action. The oil thus obtained is not pure as it contains some impure substances which come out in distillation with the oil. To obtain pure oil it is advisable to distil it again. The oil is then filtered to remove any solid matter in it. It is then dried by shaking in a bottle with some anhydrous substance as calcium chloride, sodium sulphate etc. After this the oil is filtered again through cotton and finally the clear transparent liquid is bottled and stored.

In order to generate steam, a steam generator is needed which may be fixed as follows :

The generator consists of a boiler "A" and a cover "B," as shown in the figure 5. There is a steam gauze "C" on the side of the boiler to show the strength of the steam. "D" is the prop-valve which properly regulates the steam. "E" is the water gauze attached to the boiler showing the quantity of water left in the boiler. "F" is the steam outlet by which the steam passes to the apparatus.

## V. CITRATE OF LIME AND CITRIC ACID.

### 1. Citrate of Lime.

Most of the citrate of lime that is imported in this country or elsewhere comes from Italy. To prepare this lime compound it does not involve a great deal of apparatus. In order to do that no special device is adopted in Italy. After the pulp is scooped out from the rind, it is then crushed in a hand press or hydrolic is allowed to flow in a juice tank. At first the crushed pulp is shoveled into large circular straw mats used for filtering. After they are filled they are put one above the other and pressed. The juice is pumped from the juice tank to another tank

on an oven. The acidity of the juice is counteracted by adding lime water (milk of lime). Litmus paper is used to test the neutrality of the juice. After heating the juice for several hours, it is then run to a filtering tank while still hot. There is a cloth bottom at the tank by which the waste water runs off and the citrate of lime is deposited. The deposit is put in filtering bags and pressed by a hydrolic press or hand press. It is then removed as cakes to iron pans and put in drying oven for 6 48 hours. These dried cakes contain more than 60 p. c. of citric acid. These cakes are later on broken and put in hogs-heads for shipment.

According to the present developed method citrate of lime may be made as follows :—

1. Press out the juice.
2. Strain it by a cheese cloth or any other device.
3. Clarify with spanish clay. (5 grammes per litre).
4. Determine the acidity (Total acid).
5. Make a milk of lime mixture.
6. Heat the juice to boiling and add the milk of lime slowly till neutral to limits.



7. Filter off the citrate of lime and wash the precipitate with hot water.

8. Dry the precipitated material in an oven at 100° C. for 6 to 12 hours.

## 2. Citric Acid.

Citric acid is manufactured from citrate of lime. It is the acidium citricum or oxytricarballistic acid, a tetra hydroxytribasic ( $C_6 H_8 O_7$ ), first obtained by Karl Wilhelm Scheele in 1784 from the juice of lemons. It is present in lemons, oranges, citrons, currants, gooseberries and many other fruits. It is made on a large commercial scale mainly from the juice of limes and lemons. It may be obtained by fermentation of glucose under the influence of *Cytromycetes Pfefferianus*, *Citromycetes glabber* and other ferments.

Citric acid has an agreeable taste. It is soluble in three fourth of its own weight of water (cold). It is largely used in calico printing and also in the preparation of effervescing draughts. It is known as an antidote for scurvy for a long time. It is also used in pharmacy in many ways.

The processes involved in its preparation may be stated as follow :--

1. Citrate of lime is ground and water is added to make a milk.

2. Dilute sulphuric acid ( $H_2SO_4$ —20 p.c.) is used enough to liberate the calcium to give calcium citrate.

3. The mixture is boiled for 10-15 min., on a slow fire which precipitates the calcium sulphate ( $CaSO_4$ ).

4. It is then filtered to remove the calcium sulphate.

5. The liquid is then evaporated in a vacuum chamber till it crystallizes. It is these crystalized in a vat.

6. Hot water is added to dissolve the crystals. The solution is rather dark red in color, which is decolorized by bone black and filtered.

7. The clear liquid is then evaporated which gives pure white crystals of citric acid.

## VI CANNING AND PRESERVING OF CITRUS FRUITS.

### 1. Fundamental principles of preserving,

The citrus fruits can be canned and preserved in various ways. The chief processes involved therein are as follow :

1. Preservation by heat or cold.
2. Preservation by drying.
3. Preservation by the exclusion of air.
4. Preservation by the use of various preservatives as brine, syrup, vinegar, and alcoholic liquids etc.

The abstraction of heat, storage in a cold cellar, ice houses or freezing chambers keep the fruits in a good condition, as in those circumstances the fruits become unfavorable for the growth of bacteria and fungi. Heating to a temperature of 65° C and upwards kills all the ferments that cause decay in fruits and vegetables. Also, the use of some antiseptics as carbolic acid, salicylic acid, potassium metabisulfite etc. serve the same purpose, but they are objectionable to use. Besides, the exclusion of air and pickling

in suitable liquids preserve the fruits very satisfactorily.

It is found that lemons can be kept for a long time in charcoal powder or in slaked lime in alternate layers. The same is the case with oranges. Besides, paraffin may be used as a coat to prevent the fruits from decay and thus preserve them for a long time.

In preserving the fruits in sugar syrup, the strength of the syrup should be measured in degrees for which ærometers and densimeters of various kinds have been invented, of which the Brix Spindle, Balling Saccharometer and the Beaume are universally used.

#### (a) Hydrometers and their use.

In the determination of the percentage of sugar the ærometer known as the Brix and the Balling Saccharometer may be used. In such a spindle each degree corresponds to one per cent. of sugar at  $17.5^{\circ}$  C. That is, at  $17.5^{\circ}$  C. a syrup marking  $10^{\circ}$  of strength would contain 10 parts of sugar and 90 parts of water.

The Beaume ærometer is regulated by the density of the distilled water at  $15^{\circ}$  C., which

marks 0° Beaume (each degree marking 1 p. c. of salt.) That is, if put in water the ærometer marks 10°, then it means that the liquid contains 10 parts of salt and 90 parts of water. For salt water the ærometer is correct, but for sugar solution Brix and the Balling Saccharometer ought to be used. The following table shows the solubility of sugar in water from 0°—50° C or from 32°—122° F (after Pacrette) :—

Temperature		Percentage of sugar containing in a saturated solution.
Cent.	Fahr.	
0	32	65
5	50	65.2
10	50	65.6
15	59	66.1
20	68	67.0
25	77	68.2
30	86	69.8
35	95	72.4
40	104	75.8
45	113	79.2
50	112	82.7

The following is a comparative table of Brix and Balling degrees with the corresponding density in Beaume hydrometer (after Pacrette).

Brix or Balling.	Beaume.	Density.	p.c. of sugar.	p.c. of water.	Total.
0	0	1		100	100
2	1.11	1.0078	2	98	"
6	3.34	1.0237	6	94	"
10	5.56	1.0401	10	90	100
14	7.77	1.0570	14	86	"
20	11.07	1.0733	20	80	"
24	13.06	1.1015	24	76	"
28	15.46	1.1201	28	71	"
34	18.69	1.1419	34	66	"
45	24.56	1.2056	45	55	"
50	27.19	1.2328	50	50	"
60	32.36	1.2899	40	40	"
70	37.40	1.3509	30	30	"
80	42.29	1.4159	20	20	"
90	47.02	1.4849	10	10	"
1000	51.26	1.5578	...	...	"

### (b) Preparation of Syrup.

Plain syrups are merely a solution of sugar or glucose in boiling water made strong enough so as not to ferment. A syrup will keep the fruits in a good condition in summer and in winter, if made from 25°—28° Beaume and

30°—32° Beaume respectively. To make a syrup of 25° B., add

sugar ... .. 2 lbs.  
 water ... .. 2 qrts. (commercial)

Boil on a slow fire for 5 minutes.

To make a syrup of 30° B., add

sugar ... .. 17 lbs.  
 water ... .. 6 qrts. (commercial)

Boil slowly and skim to get a clear syrup.

In general, fruits can be preserved in sugar syrup easily. For this purpose a syrup made up of water and sugar and boiled for a time to dissolve the sugar completely will do well. The fruit is heated in water in the jar in a water-bath for a time. When the fruit is softened, water is drawn off and concentrated syrup (55 p. c.—65 p. c. sugar) is poured in. This will kill the fermentive organisms and cover the fruit with a protective coating. The jar is then sealed air-tight. Thus treated, the fruits will keep for a long time.

The process involved in preserving fruits in syrup may be stated as follows :

1. Glass jars scalded in hot water.
2. Fruits washed and then put in jars.
3. Glass jars stand on water-bath at 40°—60° C.

4. Concentrated syrup of about the same temperature is poured in.

5. The water in the bath is heated up to boiling.

6. Heating in boiling water is continued from 15—60 minutes according to the size of the jars.

7. The jars are capped while hot.

## 2. Canning Oranges.

In canning oranges care must be taken to select ripe and sound ones. The following method may be adopted to advantage for ordinary canning.

1. Wash in hot water and peel.

2. Cut in thin slices, if the fruit has inseparable carpels; otherwise, separate each carpel (section).

3. Put in 16 oz. enamel-lined tin cans or glass jars, as desired.

4. Boil a sugar syrup of 10°—20° Beaume (20 p. c. —40 p. c. sugar syrup).

5. Pour the syrup in the tin cans.

6. Cap the cans with solder iron.

7. Sterilize in boiling water for 10 minutes.



8. Label the cans and store in a cellar.

For commercial purpose, where machinery is used, the same treatment is needed except that the cans are syrugged, capped and sterilized automatically in machines on a large scale.

## VII. CITRUS FRUIT JUICE.

The juice of oranges and lemons may be treated in various ways to manufacture different articles of commerce. There are two methods of marketing the juice.

### 1. Unfermented Juice.

The unfermented juice is the plain fresh juice bottled and sterilized. Such a juice may be easily used for jelly-making or a cold drink, while the fermented or alcoholic juice is the juice allowed to undergo some change through the action of some micro-organism. Such a juice may be used for syrup, vinegar or wine-making purpose. In fact, unfermented juice, when boiled with sugar, will give a jelly, provided there is enough pectin in it, while fermented juice, if boiled with sugar, will give syrup of the fruit.

**(a) Unfermented Orange juice.**

To extract the juice from oranges and manufacture plain juice for drinking purpose, the following methods may be adopted :

1. Peel the fruits and cut them in pieces.
2. Extract the juice by a screw-press, as shown in figure 6. On a large scale a hydrolic press may be used to advantage.
3. Add a little potassium metabisulphite ( $K_2S_2O_5$ ) (150 mlgms. per litre).
4. Clarify the juice with spanish clay (1000 grms. per hecto litre). Fullers earth may be used.
5. Filter the juice.
6. Bottle the juice, for which ordinary pint and quart bottles may be used.
7. Cap. A cheap capping machine may be used.
8. Sterilize at  $65^\circ$  C. for 10 minutes.

The juice bottled in this way is not satisfactory, as it develops a limy flavour after a time. So, in order to get juice with fresh orange flavour it is better to bottle cloudy juice without clarification. The juice after pressing can be strained in cheese cloth and then bottled and

pasteurised at the same temperature as above. This cloudy orange juice will keep well without any loss of flavour.

### (b) Unfermented lemon juice.

The method is just the same as that of the orange except that the fruits are sliced and crushed to obtain the juice without peeling. It does not lose flavour. In the same way lime and pomelo juice can be made. In dealing with all the juices potassium metabisulphite should be added. It not only checks the bitterness of the juice, but at the same time keeps up the flavour and also acts as a preservative.

### (c) Concentrated orange juice.

The orange juice is sweetened with sugar and acidified with a small amount of lemon juice. The juice is made to about 45° Balling. It is then bottled and pasteurised at 65° C for 10—20 minutes. This concentrated juice should be diluted with water before using. (3 times dilution seems satisfactory, 15° Balling).

### (d) Concentrated lemon juice for soda fountain.

The lemon juice is concentrated with sugar in the same way as orange juice. It is used in making lemon soda. Generally, lemon soda is made by sugared water and citric acid. The water is carbonated before being bottled.

### (e) Concentrated lime juice.

There is a demand in the market, especially for the sailing vessels for concentrated lime juice. For this purpose both diluted and concentrated lime juice may be used. The preparation of the juice is just the same as orange except that it needs less care to pasteurize it.

## 2. Fermented orange juice.

Fermented orange juice may be used in three ways :—

- I. Vinegar-making.
- II. Syrup-making.
- III. Wine-making.

## (I) Vinegar-making.

In Western countries the oranges separated from the sizing machines, as unfit for packing, are used with advantage in making Vinegar. This practice utilizes the culls and those which are to be thrown out as waste. It is to economise the production of the farmers that practical methods have been developed to carry on such a useful industry. Perhaps, without doubt such a method may use the culls and waste oranges in different sections of India, provided our growers and manufacturers know thoroughly well how to dispose them of.

There are two ways that may be followed to make vinegar from the cull oranges as follows :—

1. Alcoholic fermentation and direct acetification as is done in apple and grape vinegar.

2. Alcoholic fermentation, separation of alcohol by distillation and acetification of diluted alcohol.

It is generally found that to convert any juice to vinegar two fermentations are necessary of which the one changes the sugar in the fruit-

juice to alcohol and carbon dioxide by yeasts as agents and the other is the transformation of the above-mentioned alcohol to Acetic acid by the vinegar bacteria as agent which means the addition of oxygen from the air to the alcohol, already formed, to form acetic acid.

The cull oranges contain the same amount of sugar, as the sound ones. This fruit sugar, (mixed form) when allowed to ferment, makes one-half its amount of alcohol *i. e.*, 2 p. c. of sugar make 1 p. c. of alcohol. The percentage of alcohol, when it is changed to acetic acid, is just the same, *i. e.*, 1 p. c. of alcohol gives 1 p. c. of acetic acid under the influence of fermentation.

#### Pressing out the juice :

In pressing out the juice the manipulation is just the same, as already mentioned. The oranges can be cut in pieces and the juice can be pressed out by a hand-machine or screw-press on a small scale. But on a large scale a hydrolic press may be used to advantage.

After the juice is extracted, it is always liable to turn bitter which lowers the grade of the vinegar produced by a bitter taste. To avoid this the following methods may be followed :

Add  $H_2SO_3$  in the form of Potassium metabisulphite solution ( $K_2S_2O_5$ ) immediately after the extraction of the juice. This treatment prevents the juice from fermenting for 24 to 72 hours. It clears the solution by a precipitation at the bottom of the bottle. It prevents bitter flavour and fermentation for a time. The amount used is 8 ounces to 200 gallons of juice on a commercial scale. For ordinary use a 10 p.c. solution should be made from which .2 CC. may be used per litre (150 mgms. per litre).

After the juice is treated with  $SO_2$ , it is allowed to stand for a time (24 hours). This gives a clear liquid on top and a heavy precipitation at the bottom. The clear juice is to be decanted for which a syphon can easily be used. The mud is to be filtered. To manufacture on a large commercial scale filter-bags are used to clear out the mud. The liquid, after it is defecated, is ready for the yeast fermentation. It is always better to inoculate the juice with pure yeast (2 gallons of pure yeast to 100 gallons of juice).

The process of fermentation goes on in the tanks on a commercial scale. The liquid is tested from time to time. When no sugar is left *i. e.*,

when all has been changed to alcohol, as is found by the balling test, the fermented liquid is to be drawn off free from the sediment of yeast and is then ready for the vinegar fermentation.

The fermented juice is inoculated with vinegar bacteria. The process of vinegar fermentation may be adopted in two ways :

### 1. Slow process.

In the slow process large barrels are used which have a capacity to hold 50 gallons of the juice. The barrels are filled three fourth with the fermented juice and starter is added. This starter is already made by adding sterilized orange juice to vinegar.

Generally fermentation is started with  $\frac{1}{3}$ th vinegar and  $\frac{1}{3}$ th orange juice. Every four to six weeks  $\frac{1}{3}$ th of the liquid is drawn off from the barrel and new orange juice is added. It takes about a year to make the vinegar. Holes are made in the barrels for the access of air on the upper part (above the liquid) on top of the barrels and they are covered with cheese cloth. This helps oxidation which is needed for vinefication.



The liquid is tested from time to time by the Twitchell or Leo acetometer to test the acidity and when no increase is found in the liquid, it is then drawn off. After this the liquid is filtered and clarified with isinglass (fish gelatine). It may be filtered through wood pulp which is also satisfactory. One to one and a half ounces of isinglass may be used to 100 gallons of vinegar. This clarified juice is then ready for bottling and marketing.

## 2. Rapid method or generator process.

In generator process the fermented liquid is put in a revolving generator or upright generator, as the case may be. The liquid is run through beech shavings in the generator with vinegar mother added to it. A generator can run from 25—50 gallons of vinegar per day (24 hours). This vinegar is then clarified and bottled. According to the U. S. Food and Drug Laws vinegar should contain 4 p.c. acid as acetic acid, which is the standard of United States of America.

**(b) Orange wine :**

In the manufacture of orange-wine the following process may be adopted :

Orange juice      ...      ...      1 part.

Water      ....      ....      1 part.

Add 3 lbs. of sugar per gallon of the mixture (glucose may be used). The mixed material should be put in a cask and let it remain open for spontaneous fermentation. It is better to keep one gallon of juice outside and fill up every day. Thus the natural fermentation will go on for 10—20 days and then it will cease. At this time the bung should be kept covered for a few days.

After it is allowed to stand for two months more, the liquid should be transferred to a new cask. It is to be filtered, if found cloudy. This clear liquid should be left in the cask for months more. This liquid is then bottled and sealed. The wine continues to improve with age.

Instead of spontaneous fermentation inoculation with pure yeast gives satisfactory result. The method is just the same as the alcoholic fermentation explained in the manufacture of vinegar.

Attempts have been made in America to manufacture denatured alcohol and sugar from orange juice, but so far they have not yet been successful commercially.

### VIII. CITRUS FRUIT SYRUPS.

The juice of oranges and lemons may be used to make syrups, as is done with other fruit-juices, as apples, plums etc. The method may be stated as follows :

1. Peel the fruits and cut in pieces.
2. Press out the juice by a hand-press.
3. Clarify the juice with spanish clay (1000 grammes per hectolitre) or albumin water as described before.
4. Bottle, warm and seal before cold.
5. Take one part of juice (plain or fermented) by weight and one part of sugar and boil out till 30°B.
6. If fresh fruits are used, they may be treated as follows :—
  1. Crush and press out the juice.
  2. Bring to boil and then strain.
  3. Take one part juice and one-half times sugar. More sugar should be added, if the juice is very sour.

## 1. Orange and Lemon Syrup.

In preparing orange and lemon syrup, the following method may be applied :

1. Crush the fruits.
2. Strain the juice.
3. Evaporate to a syrup.
4. Make a sugar syrup about 22° B.
5. Add the two syrups.

This gives an orange or lemon syrup, as the case may be or a mixed syrup of orange and lemon as desired. In the case of lemons more sugar is to be added.

The orange and lemon syrups may also be made according to the following method :—

1. Take the pulp from the 1st press.
2. Mix with adequate quantity of sugar.
3. Press out the juice and strain.

The result is a golden coloured juice with orange flavour which is a very fine syrup for table purpose

On a commercial scale orange syrup may be made by concentrating the juice in vacuo to 65° Balling or it may be made by freezing in a mixture of salt and ice. When crystals of ice are formed, it is to be strained. The freezing

process may go on till it reaches to 65° Balling. The juice is then mixed with sugar syrup about 75 p. c. strong. It is better to grind two or three oranges, as fine as possible, and mix with the syrup and let it stand for 48 hours. It is then pressed and strained. The syrup must be 65° Balling. Extra sugar may be added, if necessary.

At present the bulk of the syrup, made in Italy and United States, is manufactured according to the well-known freezing method, the Monti Process (Patented in Italy and U. S. A.) which gives the best result.

Lemon syrup may also be made in the same way as the orange syrup, described above. In this case 70 p. c. syrup does well. Besides, lime-syrup may be made in the same way, as lemon. The lemon-syrup is mostly used in the soda fountain to make lemonade.

## **2. Orange flower syrup.**

To prepare orange flower syrup, it is first necessary to prepare orange flower water. In France they use the orange flower water that comes out as refuse in the preparation of essential oil. This water may be used satisfactorily.

Formula :—Orange flower water ...1 quart.  
 Water ... ..2 quarts.

Dissolve sugar in cold orange extract or orange flower water and then place it on a slow fire, adding more sugar till 30° Beaume is reached.

**(c) Citrus fruit syrup by orange or lemon extract.**

Lemon extract or orange extract... 1 part  
 Syrup at 30° Beaume ... ..50 parts.

After the sugar is brought to a boil, the extract is added and the syrup is then ready to be bottled.

**(d) Limes preserved in syrup.**

With the abundant production of limes in India, especially in the North Western part of Bengal, and elsewhere it seems that they may be preserved on a commercial scale, as is done in Europe. For this purpose both green and yellow limes can be used. The method of treatment is as follows :

1. Wash the fruits and if salted (preserved in brine), wash in running water for 2 hours.

2. Boil them till soft and prick with copper needles.

3. Put in jars and cover with a hot syrup at 18° Beaume.

4. Drain and reboil the syrup every day increasing its strength two degrees each time till 24° Beaume—26° Beaume is reached.

5. Put in cans or jars and cover with hot syrup of the same strength.

6. Seal the jars and process is as follows :—

Quart cans ... 20 min. in boiling water.

Pint ... 10. " " " "

Quart jars ... 10 " " " "

Pint ... 5 " " " "

Both the oranges and lemons may be preserved in the same way, but there is little or no demand for them and are not preserved in this way.

## IX. CITRUS FRUIT EXTRACTS AND SPIRITS.

### 1. Lemon or orange spirit.

In making the spirit of lemon or orange the following methods may be used :—

(a) Wash the oranges or lemons (fresh fruit gives the best result).

(b) Grate the rind either with hand or machine grater.

(c) Treat with double proof alcohol (95%).

Formula :—

Grated peel	...	...	20 grammes
Double proof alcohol	...	...	80 „

(d) Shake and filter.

(e) Bottle and seal.

## 2. Lemon Extract.

The method of making lemon extract involves in the preparation of lemon spirit as explained above,

Formula :—

Lemon spirits	...	...	20 quarts
Fermented lemon juice	...	...	20 quarts
Citric acid	...	...	15 lbs.

This may be agitated for a time and then filtered and bottled.

## 3. Orange syrup extract.

The orange syrup extract may be prepared in the same way. The recipe is as follows :

Fermented orange juice	...	...	5 quarts
Orange peel infusion	...	...	5 „



Orange spirit	...	...	15 quarts
Citric acid	...	...	6 lbs.
Tartaric acid	...	...	4 „

Thoroughly agitate the whole mixture and then filter and bottle.

#### 4. Orange and lemon infusors.

The orange and lemon infusors are the products of alcoholic infusions. They may be prepared as follows :—

Formula :—

Rind	...	...	...	1 lb.
Double proof alcohol (95%)	...	...	...	1 quart

Infuse the materials for about a month and then drain and filter. They are then ready to be put in bottles.

These infusors are largely used in confectionery in flavoring mince pies and other pastries.

#### 5. Orange lemon liquor.

The method of preparation of orange lemon liquor is as follows :—

Formula :—

Orange peels	...	...	2 lbs.
Lemon „	...	...	2 „

Cinnamon peels	...	...	1 lb.
Cayenne pepper	...	...	8 oz.
Double proof alcohol (95%)	...	...	10 quarts

All these materials are allowed to infuse for 10 days and then distilled. The distilled material is added to 9 lbs. of sugar dissolved in water. It is then filtered to remove the foreign matter. An orange yellow liquid is obtained which is then ready to be bottled and sealed.

## 6. Creme de Fleur d' Oranges.

There are a number of by-products manufactured in France of which the 'Creme de Fleur d' orange is very popular. It is made, in the following methods :—

Formula 1. (commercial).

Orange flower water	...	...	4 quarts
Double proof alcohol (95%)	...	...	20 „
Sugar (cane sugar)	...	...	20 lbs.
Water	...	...	9 quarts

The mixture is then bottled, and sealed.

Formula No. II. (commercial).

Neroli essence	...	...	3-8 oz.
Orange flower water	...	...	1 quart
Water	...	...	6-8 quarts

Sugar	...	...	...	15-20 lbs.
Double proof alcohol (95%)				15-20 quarts

Bottle and seal the mixture.

In order to prepare the orange flower water the following method may be adapted :—

Formula (commercial)

Orange flowers	...	...	10 lbs.
Water	...	...	40 quarts
Salt	...	...	1 lb.

Distil the whole material which will give 10 quarts of orange flower water. If it is cloudy, add some magnesia and filter it. The clear liquid is then ready to be bottled and sealed.

## 7. Orange Cordials.

Some of the finer products are made out of oranges in Europe, especially in France, of which the cordials are common. These are alcoholic preparations with various spices to give a characteristic flavor. The cordial from oranges may be prepared as follows :—

Formula :—

1. Take the rind of 20 oranges.
2. Cinnamon ... .. 1-3 ounces
3. Mace ... .. 1-6 „
4. Double proof alcohol (95%) 7 quarts

5. Crystallised sugar . . . . . 6 lbs.

Mix the materials and allow to infuse for 8 days. Then distil and add sugar dissolved in water to make it sweet.

## 8. Lemon Cordials.

The method of preparation of lemon cordials is about the same as the orange cordials except in the method of treatment which may be stated as follows :—

Take the rind of 30 lemons and 10 quarts of double proof spirit (95%). Infuse them for 3 days and distil to obtain 6 quarts. Add 2 quarts of water to this distillate and redistil to get 4 qts. of fine lemon spirit. To this add 10 lb. of sugar dissolved in 2 quarts of water. Coloring matter may be used at this time. Turmeric serves the purpose to take the juice yellow. After filtration the yellow liquid may be bottled and sealed.

## X. CANDIED PREPARATIONS.

### 1. Candied Oranges.

Candied oranges are sold a special delicacy, which may be very easily made on a satisfactory profit as follows :—

1. Peel the oranges and separate the carpels. (If the carpels are attached as is found in many varieties, slice the fruits about  $\frac{1}{4}$  inch thick).

2. Put in an earthenware jar.

3. Fill the jar with 20° Balling sugar syrup (11° Beaumé).

4. Every 3rd and 4th day drain the syrup, boil it and increase 3° Beaumé each time till the syrup reaches to 35° Beaumé. (It is better to add  $\frac{1}{3}$  glucose and  $\frac{2}{3}$  cane sugar).

5. Take the fruits off from the jar and allow them to dry each section being put separately. For this purpose small racks provided with a screen bottom may be used to dry the fruits. In this way the syrup is not wasted but collected on a wooden tray below the rack. Special wooden tray with wire gauge top may be made for this purpose.

For commercial purpose the following methods may be adopted :—

1. Peel the fruits and put them in stone jars, as shown in Fig 7.

2. Put hot syrup of 14°—20° Beaumé.

3. Drain off after a day and boil the syrup again adding more sugar, about 3° Beaumé each time.

4. Repeat the process of draining and boiling with additional amount of sugar every 3rd or 4th day till the syrup has concentrated up to 33° Beaumé. The fruit by this time becomes candied.

In candying oranges, the concentration of the syrup should be increased at least up to 32° Beaumé beginning from 14° Beaumé, increasing 2°—3° Beaumé each time.

A stone jar may be made with a draining stop-cock at the bottom and a cover on top, as is shown in figure. Such a jar may preferably hold  $\frac{3}{5}$  gallons of syrup. Any other fruit can be candied in the same way. The work is better done in a cool place. In commercial candy making  $\frac{1}{3}$  glucose and  $\frac{2}{3}$  cane sugar should be used.

## 2. Crystallized oranges.

Crystallized oranges may be made about the same way as candied fruits which may be stated as follows :—

1. Peel the fruits and separate the carpels.
2. Make up a syrup of water and sugar of about 14° Beaumé.
3. Pour over the peeled fruits.

4. Drain off after 4 days and reboil it to 25° Beaumé.

5. After six days drain off the syrup and reboil it to 32° Beaumé.

6. After being left for a week, take the fruits out and dry in a warm room at 70°-80° F. The fruits should be thoroughly dried.

7. After being dried the fruits are put in a crystallization box which may be stated as follows:—

(a) Prepare small wooden boxes.

(b) Prepare crystals by making heavy syrup with good cane sugar. For this purpose 16 lbs. of sugar and 2 gallons of water will serve the purpose. Boil till it reaches 33° Beaumé.

(c) Put the dried fruits in the boxes.

(d) Cover with the syrup (cold) and keep it undisturbed for 10-12 hours. This will form crystals on the surface of the fruits.

(e) Drain the syrup off by inclining the boxes and let the fruits stand for 10-12 hours more, till they are fully dried up. They are then ready to be packed.

### 3. Glace Oranges.

The glacé fruits are just as good as candied fruits. In commercial preparation, the fruits instead of being crystallized that come out from the warm room, according to the process described above, they can be treated in a very heavy syrup to give a glassy appearance on the surface. This preparation is known as glacé fruits. The process may be described as follows :—

1. Make a heavy syrup of 33° Beaumé.
2. After the fruits are taken out of the warm room, as in the case of crystallized fruits, dip them one by one in the hot syrup.
3. Dry them on racks in a warm room till they are fully dried up. This brightens the color of the fruits.

### 4. Candied peels.

The peels of lemons, oranges, pomelos, citrons and limes can be easily candied. The process is as follows :

1. Cut the fruits in halves and scoop out the pulp with a spoon.
2. Blanch in boiling water on a slow fire till they are soft.



3. Put in a jar and cover with a syrup of 18° Beaumé. It is better to use 150 mgs. of  $\text{SO}_2$  per litre in the form of  $\text{K}_2\text{S}_2\text{O}_8$ , so that the peels do not ferment. ( $\text{K}_2\text{S}_2\text{O}_8$  is 50  $\text{g}^\circ \text{SO}_2$ ).

4. Drain every day and boil till syrup increases 1° Beaumé each day till 24° Beaumé is reached.

5. Then every 10 days drain and boil till it increases 33° to 35° Beaumé being increased 3° Beaumé each time.

6. Drain and allow to dry. They are then ready to be packed.

### Rapid process :

Fruits can be candied very rapidly, even in four days. The following is a description of the rapid process ;

1. Cut the fruits in halves and scoop out the pulp with a spoon.

2. Blanch the peels till very soft.

3. Drain off the water and then boil slowly at 100°C in a sugar solution of about 16° Beaumé.

4. Allow the peels to stay in this boiling syrup for about 4 days.

Add additional syrup of the same strength. In four days the syrup will be concentrated and

reach up to 33° Beaumé. The sugar will penetrate evenly all throughout the peels.

5. Take out the peels and drain them. Allow them to dry slowly. This will form a white sugar coat on the surface of the peels. In candying the peels coloring matters may be used as emerald green, orange aniline etc.

### 5. Citrus fruit paste.

After the oil cells of the rind are removed by the grater to extract the oil and the pulp has been pressed juice, the pressed cake can be boiled with water and then pressed to get the pectin, the last pressed cake may be used to prepare to get the pectin, the last pressed cake may be used to prepare a kind of fruit paste. The process may be adopted as follows ;

1. Boil the paste with a little water in a vessel.

2. Boil a syrup of 33° Beaumé in another vessel.

3. Mix equal amount of sugar syrup and pulp (boiled).

4. Cook for a while and stir so that they may be mixed very well.

5. Color the material with an aniline dye and then pour in a plate sheet, having thickness of one inch and a half.

6. Dry the material for a time till it is hardened and then cut in the form of squared discs, stars etc. and put in crystallization box. After the sugar has been crystallized on the surface just as is done in candied oranges, they are to be taken out and dried well. They are then ready to be packed.

Kumquats, small mandarines, limes and citrons may be candied whole. In such a case the fruits should be pricked with copper or alluminum needles ; so as to allow the juice to penetrate.

## 6. Dried peels.

Citrus peels are ordinarily dried (in halves). They are used for the manufacture of orange and lemon extracts and are also used to a certain extent in pharmaceutical preparations. Fruits may be dried in an oven with racks, as shown in fig. 8. In our country the peels can be easily dried in the sun.

## 7. Peels in brine.

Citrus peels may be put in brine. A salt

solution of 10 ‰ serves the purpose of preserving them very well. The peels may be preserved in  $K_2S_2O_8$  adding 150 mgs. per litre of water from a 10 ‰ solution. These peels are used in making candied peels as already has been stated.

## XI. CITRUS FRUITS PRESERVES.

### 1. Jelly-making.

The fundamental principle in jelly-making lies in the fact that the juice must contain a sufficient amount of pectin which is the material causing the jelly to set. Besides, it should contain a certain amount of solid matter as sugar and not less than 5 ‰ acid.

Pure sugared fruit-jellies may be made by merely boiling the juice with sugar in the proportion as follows :

2 lbs. of sugar

1 lb. of juice

Boil for a time. Skim and continue boiling till the material drops to a jelly from the spoon. Such a jelly should mark not less than 32° Beaumé.

In the case of citrus fruits the rind has a gummy substance which is called the pectin. It is

this pectin body in the juice that form the gelatinous mass. This substance comes out in the juice when the fruits are boiled and pressed.

### (a) Orange jelly.

The process :

1. Slice the oranges with rind and boil with a little water for half an hour.

2. Press hot by a screw-press.

3. Add one and one half times of sugar to the juice.

4. Boil on a slow fire till the liquid forms a jelly when allowed to drip from a big spoon.

5. Pour in glasses or jars.

6. Dissolve some paraffin in a small dish and pour that on the containers when, they are cooled.

7. Store away the jelly in a cool place, specially in a cellar.

This is the ordinary way of preparing orange jelly.

Lemon jelly may be made in the same way.

### (b) Orange lemon jelly.

On a commercial scale a mixture of oranges

and lemons suits the purpose very well. The process may be stated as follows :

### 1. Process of extracting the juice.

(a) Slice the oranges with a few lemons (8 : 2 ratio by weight).

(b) Crush by a hand machine (screw-press) to get the juice. Bottle and sterilize the juice.

(c) Boil the pulp and rind together after crushing with a little water for 1—1½ hours.

(d) Press out the juice which will bring out the pectin.

(e) The pectin solution may be put in bottles and sterilized, and allowed to settle.

(f) The clear pectin solution may be drawn off later on, when it is desired to make jelly.

In preparing the jelly proceed as follows :

(a) Add sugar to the juice and pectin mixed in the following proportions :

100 CC ... .. Juice and pectin solution.

125-150 grms. ... .. Sugar.

(b) Warm the mixture till the sugar dissolves. Test the percentage of sugar by a saccharameter which should be near to 60° Balling or 32° Beaume'.

(c) Boil the mixture till it reaches 105° C. At this temperature the liquid will drop from the spoon in a jelly.

(d) Strain the material in a cheese-cloth. This will give a clear jelly.

(e) Pour into glasses or jars.

(f) Paraffin the glasses when they are somewhat cooled. The paraffin should be melted in a dish and poured on the top of the glasses. A thin layer of paraffin will serve the purpose of keeping the jelly from outside impurities.

In order to serve the commercial purpose a cheap jelly may be made by adding gelatine in place of pectin, which is not always found to be sufficient for jelly making. In such a case the following methods may be adopted :

1. Take two kettles and make a syrup in the first kettle as follows :

65 lbs, . . . . . Sugar.

15.5 lbs. . . . . Glucose.

Boil this with an adequate amount of water on a slow fire till it reaches 33° Beame.

2. Soak 2/3 lbs. of Japanese gelatin (fish gelatine) in the other kettle in cold water for 6-12 hours. When dissolved, add 45 lbs. of glucose. Boil and skim the syrup.

3. Add the materials of the first and second kettle.

4. Take 45 quarts of juice in the empty kettle and bring to a boil and then add this to the gelatine mixture of the other kettle.

5. Add  $1\frac{1}{2}$  lbs. of Tartaric acid dissolved in hot water, if the juice is not acid. This will give a tart taste.

The above process will give about 450 lbs. of jelly.

In commercial preparation jellies are colored with cochineal extract, cut-bear and a few other coloring materials which are harmless.

## 2. Orange Marmalade making.

The fundamental principle of marmalade-making is just the same as jelly-making except that the rind is used in it more or less. It is the pectin in the rind that caused the jelling effect in the marmalade as in jelly. The acidity of marmalade should be between 5% to 1%. In case of the lack of acidity citric acid may be used to get the required acidity.

In ordinary marmalade-making the following process may be adopted :



1. Wash the oranges in a basin of hot water.

2. Slice them very thin with rind on.

3. Boil for 1—1½ hours till the rind is very tender.

4. Add 1½ times sugar to the juice and rind mixed.

5. Continue to boil till the liquid reaches to 105° C. At this point the liquid will drop down to a jelly from the spoon.

A very fine marmalade which may be made as follows :

1. Peel the oranges.

2. Cut the rind in thin chips and boil them till they are very soft.

3. Press out the juice from the pulp.

4. Add one and one half times of sugar to the juice.

5. Boil and add the chips.

6. Continue boiling till the liquid drops to a jelly.

7. Pour in glasses and paraffin them.

This kind of marmalade is imported from England to a large extent in almost all the markets in India.

In European countries orange marmalade is generally made from bitter oranges, Seville oranges, which give comparatively a bitter product. In America, ripe sweet oranges are mostly used.

In India, both sweet and bitter oranges may be used to advantage for this purpose.

The characteristic bitterness of the sweet oranges marmalade is not due to the white portions of the rind, as is generally believed, but to the immaturity of the fruit itself. Marmalade from well-ripened fruit is little or not bitter at all. In case the fruits are under-ripe, the chipped rind may be soaked in water for 24 hours which seems to remove the bitterness to a large extent. It may be the fact that soaking in water dissolves the glucosides which are the main cause of bitterness.

## XII. PASTRY PREPARATIONS.

Citrus fruits may satisfactorily be used in the preparation of various kinds of pastry. In order that a house-wife may find it convenient to make some delicious preparations for the table, a few recipes are briefly described as follows :

## 1. Orange Custard.

Orange custard may be easily made in the usual way by the use of the juice of one or two oranges to each pint of milk. It gives a fine orange flavor to the custard.

## 2. Orange Cake.

Add juice and grated rind of one or two oranges to other ingredients used in the preparation of cakes. In layer cakes beat eggs and sugar together as for frosting and add the juice and grated rind of the orange. Spread it between the layers. This will give an excellent flavor to the cake.

## 3. Orange Icing.

Take two or three eggs. Add sugar to make it sufficiently sweet. Add also juice and grated rind of one or two oranges. Beat the material to frosting which may be used on the top of the cakes.

#### 4. Orange Pudding.

Take four to six oranges. Peel and cut in pieces. Add one cup of sugar and let it stand for a time. Take one cup of warm milk and stir into it four table spoonfuls of corn starch mixed with a little water and yolks of 4 eggs. When done, let it cool and then mix with the orange.

Use the white of the 4 eggs, already mentioned, with one cup of sugar for frosting. Spread it on the top and place it in the oven until brown.

#### 5. Orangade.

Generally, orangade is made from concentrated orange syrup, as already been stated. The syrup is diluted before using up to 15° Balling. It may be made as follows :

1. Dip the rind of a dozen of oranges in a quart of boiling water in a kettle and cover the kettle tight for 6 hours.
2. Make a syrup of one pound of sugar and three pints of water.
3. Mix the infusion and syrup together.
4. Press the pulp of the oranges used and mix the juice with the infusion and syrup.

5. Stir thoroughly and then filter in a jelly-bag.

6. Bottle the filtrate.

Besides, orangade can be made artificially by making a syrup of 65° Balling and adding to it. 5 p. c. citric acid, and orange oil with a little aniline dye to give an attractive color. This is diluted to 15° Balling, when bottled.

## 6. Orange suffle.

Make a soft custard of one pint of milk and the yolk of five eggs. Take two large oranges. Grate the rind of one of them. Beat the white of the egg stiff and sweeten and flavor with vanilla. Put this on top of the custard. Brown in an oven on a hot water pan.

## 7. Lemon cake.

1. Take one cup of butter, 3 cups of sugar and rub to a cream.

2. Beat the yolk of 3 eggs and mix with cream.

3. Add one cup of sweet milk, one table spoonful of soda, the juice and grated peel of a

lemon, the white of 5 eggs, 4 cups of sifted flower and one tea-spoonful of cream of tarter.

4. Stir the whole material so as to mix them well.

5. Bake in a round or square pan in an oven.

### 8. Lemon pie.

1. Take one cup of boiling water and two table spoonfuls of corn starch.

2. Cook them until a thick paste.

3. Add one cup of sugar and a little butter and set it to cool.

4. Stir together the yolks of two eggs and the grated rind and juice of one lemon.

5. Mix all together.

6. Bake quickly.

7. Frost when done.

### 9. Lemonade.

Lemonade is ordinarily made from plain lemon juice and water with enough sugar to make it sweet. Concentrated lemon syrup may be used as is done with orangade.

### XIII. CONFECTIONARY PREPARATION.

#### 1. Lemon biscuits.

1. Take one and one half cups of sugar, one cup of butter and 4 well-beaten eggs, Mix them well.
2. Add to it flour sifted with two table spoonfuls of baking powder.
3. Flour the board and roll out the dough about one fourth of an inch thick.
4. Cut out and lay on a greased tin plate.
5. Wash over with milk and lay a thin slice of citron on each.
6. Bake in a hot oven for 10 minutes.

#### 2. Lemon creams.

1. Peel two lemons thin, pour over one half pint of boiling water and let it stand over night.
2. Squeeze the juice of the lemons on one half pound of sugar.
3. Beat 3 eggs.
4. Take out the peel and mix the water in which the peel was soaked with other ingredients.

5. Strain through a sieve and boil.
6. Stir frequently till it is thick as cream.
7. Pour hot in glasses.

### 3. Lemon drop.

1. Dissolve one half pound of sugar in lemon juice and boil to a thin syrup.
2. Drop on plates.
3. Harden in a warm place.

### 4. Lemon bonbons.

1. Use a few drops of lemon spirit to a pound of sugar.
2. Acidify the sugar with Tartaric acid (.5 to 1 gramme).
3. Dye with turmeric yellow.
4. Add 100 mgms. of potassium metabisulfite per 100 grs. of the material.
5. Boil the mixture for a while.
6. Cool it and cast in wooden mold. When dried, it is ready to be put in jars. Orange bonbons may be made in the same way.

### 5. Orange blossom bonbons.

1. Make a heavy syrup of 80 % sugar which may be used in casting readily.



2. Mix with orange flower-water.
3. Shape into bonbons in the cast.

#### XIV. MISCELLANEOUS USE OF CITRUS FRUITS.

##### 1. Facial creams.

Facial cream is a newly manufactured by-product. It is made up of lemons sliced and ground into a paste. The paste is then strained by a fine 150 mesh sieve. Some perfume is added to it. The finished product is put in the market in small tin tubes well-sealed and labelled. This cream seems to soften the skin satisfactorily.

##### 2. Fertilizers.

The peels of oranges and pressed cakes which are the waste materials in a by-product plant may be used to advantage as fertilizers to supply organic matter to the soil. The material may be treated with lime in a tank and inoculated with nitrifying bacteria to help the action of decomposition.

## XV. CONCLUSIONS.

The main object of manufacturing by-products is to utilize best the surplus production of fruits and especially those of poor quality. It is always found that all the fruits in an orchard cannot possibly be sound and free from blemishes. Besides, during the full season, it is not always possible to sell all the fruits at a reasonably satisfactory price. So the problem presents itself to the grower of disposing his poor or rather unsaleable fruits, so as to give a marginal profit. This can only be successful, provided there are by-product industries to turn out waste and surplus materials to a finished commodity. In fact, it is on the basis of by-product manufacturing that such an industry, as the growing of oranges and lemons might be improved on a commercial scale.

Generally, the citrus fruits have a number of very useful ingredients in its composition which may be utilized best to serve our economic purpose. The rind of the fruit has an essential oil on the upper side and pectin, both of which can be extracted to manufacture essential oils and preserves of various kinds. The juice has a

large amount of total solid (12 % sugar on average) as in oranges and 6 % acid as in lemons and limes, the latter of which are important in manufacturing citrate of lime and citric acid. The juice also may be used in manufacturing preserves as jellies, marmalade etc. and bottled for use as a soft cold drink. Besides, various kinds of candied and other preparations can be made out of the pulp and the rind of which a brief account has already been given.

In starting a commercial plant a combination of several by-products should be taken into consideration with one or two staple article of commerce. This will not only give efficiency in marketing the products, but at the same time it will utilize all parts of the fruit in different ways. As for example, the manufacture of oil, citrate of lime and citric acid with lemons and manufacture of oil, orangeade and pectin and jelly stock with oranges may be taken up very satisfactorily. There is a great demand for marmalade and jelly in India. The fruit can be profitably used to prepare these two commodities on a large commercial scale. Besides, due to the long continued summer month, it seems there is a great chance for marketing orange, lemon and lime juice, for

which purpose concentrated juice may be bottled. This juice should be diluted before use as already been stated.

Perhaps, it has come to the notice of many of our observers that in the localities where oranges are grown on a commercial scale, about 30 p.c. to 40 p.c. of the fruits are found to be lost due to insect-attack, rough handling, wind fall etc. All these waste oranges can easily be utilized in making vinegar and wine, with a large margin of profit.

At present, there is not a single by-product plant in India on a commercial scale, although the fruit can be easily obtained in any locality where they are grown commercially during the season without much cost. From the present status of the citrus enterprise and its need and demand in the market, it seems that the establishment of a by-product plant in each citrus growing section on individual ownership or a co-operative basis would bring a commercial success with satisfactory profit.

The main object of such a by-product plant should be to utilize all the parts of the fruit in connection with some staple by-product as already been stated.

In conclusion, I have this much to say that our educated men should turn to business and thus organize the industrial side of our agriculture. This may easily be done, provided the work is begun on a co-operative basis. Certainly the time is now ripe enough for industrial organisation in agriculture which seems to be the essential need to further the cause of our farmers and farming in India.

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## XVII APPENDIX.

For cottage industry purpose simple machineries can be brought from the following companies :—

1. Sprague Canning Machinery Company,  
Chicago, Illinois.  
U. S. A.
2. Berger and Carter Company,  
San Francisco,  
California.  
U. S. A.
3. Eroom and Company,  
Dhurrumtola Street,  
Calcutta.
4. North Western Steel and Iron Works,  
Eau claire, Wisconsin.  
U. S. A.

THE END.