

# Chemistry of Butter and Butter Making

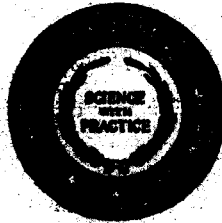
## IV. The Relationships Among the Cream Acidity, the Churning Loss and the Churning Time

BY E. W. BIRD, D. F. BREAZEALE AND E. R. BARTLE

AGRICULTURAL EXPERIMENT STATION  
IOWA STATE COLLEGE OF AGRICULTURE  
AND MECHANIC ARTS

R. E. BUCHANAN, Director

DAIRY INDUSTRY SECTION



A311:73:E.7375  
G7  
047299

CH BULLETIN 227

NOVEMBER, 1937

AMES, IOWA

November, 1937

Research Bulletin 227

# Chemistry of Butter and Butter Making

## IV. The Relationships Among the Cream Acidity, the Churning Loss and the Churning Time

BY E. W. BIRD, D. F. BREAZEALE AND E. R. BARTLE

AGRICULTURAL EXPERIMENT STATION  
IOWA STATE COLLEGE OF AGRICULTURE  
AND MECHANIC ARTS

R. E. BUCHANAN, Director

DAIRY INDUSTRY SECTION

Dhananjayrao Gadgil Library



GIPE-PUNE-047299

AMES, IOWA

	Page
Summary and conclusions . . . . .	175
Introduction . . . . .	177
Literature review . . . . .	178
Sweet vs. sour cream losses . . . . .	178
Pasteurization of sweet vs. sour cream . . . . .	180
Churning time and loss as functions of pH . . . . .	181
Experimental . . . . .	182
Methods . . . . .	182
Processing cream . . . . .	182
Analytical methods . . . . .	184
Check on experimental methods . . . . .	185
Results of churning experiments . . . . .	187
Relationship between the Mojonnier test and the buttermilk pH . . . . .	187
Relationship between the percentage of the total fat churned that is lost in the buttermilk and the buttermilk pH . . . . .	187
Relationship between the churning time and the buttermilk pH . . . . .	189
Discussion of results . . . . .	189
Practical considerations . . . . .	189
Theoretical considerations . . . . .	192
Isoelectric points of casein, milk fat globules and molecular state of casein . . . . .	192
Electrokinetic potential and the churning loss . . . . .	196
Protective materials associated with the milk fat globule . . . . .	199
Literature cited . . . . .	214

## LITERATURE CITED

- ( 1 ) Abderhalden, E., and Völtz, W. Beiträge zur Kenntnis der Zusammensetzung und der Natur der Hüllen der Milchkügelchen. *Z. physiol. Chem.* 50:13-18. 1909.
- ( 2 ) Adametz, L., and Wilkens, M. Milchwirtschaftliche Untersuchungen des thierphysiologischen Instituts der k.k. Hochschule für Bodencultur in Wien. *Landw. Jahrb.* 21:131-148. 1892.
- ( 3 ) Anthony, E. L. A study of the manufacture of dairy butter; Methods of making farm butter. *Pa. Agr. Exp. Sta. Bul.* 135, 30 pp. 1915.
- ( 4 ) Assoc. Official Agr. Chem. Official and tentative methods of analysis, p. 226. Method 1. 3rd ed. 1930. Washington, D. C.
- ( 5 ) Babcock, S. M. Churning tests. *Wis. Agr. Exp. Sta. Ann. Rept.* 5:111-121. 1888. (See also *Milch-Ztg.* 18:7-8. 1889.)
- ( 6 ) Bauer, H. Untersuchungen über Oberflächenspannungsverhältnisse in der Milch und über die Natur der Hüllen der Milchkügelchen. *Biochem. Z.* 32:362-379. 1911.
- ( 7 ) Bird, E. W., Breazeale, D. F., and Sands, G. C. Chemistry of butter and buttermaking. II. The nature of the fatty materials in buttermilk and the significance of certain buttermilk testing methods. *Iowa Agr. Exp. Sta. Res. Bul.* 175. 1935.
- ( 8 ) Bird, E. W., and Derby, H. A. Chemistry of butter and buttermaking. III. The relationships between (1) the percentage fat and (2) the protein percentages of cream and the churning loss. *Iowa Agr. Exp. Sta. Res. Bul.* 214. 1937.
- ( 9 ) Bouska, F. W. Buttermaking practices. *N. Y. Prod. Rev.* 63:692-693. 1927.
- ( 10 ) Bouska, F. W. Observations on losses of fat in buttermilk. *World's Butter Rev.* 1; No. 9; 9. 1927.
- ( 11 ) Bredenberg. Beiträge zur Kenntnis der Hüllen der Milchkügelchen. *Abhandl. Agrikulturwissenschaftl. Ges. Finnland. Helsingfors.* 1912. (From German abstract. *Zentr. Biochem. Biophys.* 13:584. 1912.)
- ( 12 ) Buchanan, J. H., and Peterson, E. E. Buffers of milk and buffer value. *Jour. Dairy Sci.* 10:224-231. 1927.
- ( 13 ) Burr, A. Studien über Buttermilch. *Milch-Ztg.* 38:13-16. 1909.
- ( 14 ) Button, F. C. A study of the effect of butter as a source of fat on the whipping ability of ice cream mix. *N. J. Agr. Exp. Sta. Biennial Rpt.* 1:32-33. 1933.
- ( 15 ) Button, F. C., and Levowitz, D. A study of the effects of certain triglycerides and fatty acids on the processing of ice cream, churning of butter and whipping of cream. *N. J. Agr. Exp. Sta. Biennial Rept.* 1:33-34. 1933.

- ( 16 ) Combs, W. B. Butter fat losses in buttermilk. N. Y. Prod. Rev. and Amer. Creamery. 66; No. 3; 138-141. 1928.
- ( 17 ) Combs, W. B. Fat losses in buttermilk. World's Butter Rev. 2: No. 3; 9, 10, 20. 1928.
- ( 18 ) Combs, W. B. Fat losses in buttermilk. Am. Creamery Poultry Prod. Rev. 71; No. 2; 72-75. 1930.
- ( 19 ) Combs, W. B., and Coulter, S. T. Fat losses in buttermilk. Minn. Agr. Exp. Sta. Bul. 273: 30 pp. 1930.
- ( 20 ) Clayton, W. The theory of emulsions and their technical treatment. pp. 120-136. 2nd ed. 1928. Churchill, London.
- ( 21 ) Csonka, F. A., Murphy, J. C., and Jones, D. B. The iso-electric points of various proteins. Jour. Am. Chem. Soc. 48:763-768. 1926.
- ( 22 ) Dam, W. van, and Holwerda, B. J. De beteekenis van de gesuspendeerde de kaastof bij het verkarnen van zuren room. Verslag. landb. Onderzoek. Rijkslandbouwproefsta. 32:223-233. 1927.
- ( 23 ) Dam, W. van, and Holwerda, B. J. Over den invloed van hooge zuurheidsgraden van den room op het vetgehalte der karnemelk en op den karnduur. Verslag. landb. Onderzoek. Rijkslandbouwproefsta. 32:406-410. 1927.
- ( 24 ) Dean, H. H. Report of the professor of dairying. Ontario Agr. Col. Exptl. Farm, Ann. Rpt. 18; part VIII; 221. 1892.
- ( 25 ) Dean, H. H. Report of the professor of dairying. Experiments in buttermaking. *ibid.* 30:81-85. 1904.
- ( 26 ) Dean, H. H. Report of the professor of dairying. Experiments in buttermaking. *ibid.* 31:107-115. 1905.
- ( 27 ) Dean, H. H. Report of the professor of dairying. Experimental work. *ibid.* 35:101-106. 1910.
- ( 28 ) Dean, H. H. Report of the professor of dairying. Butter experiments. *ibid.* 36:130-131. 1911.
- ( 29 ) Dean, H. H. Report of the professor of dairying. Butter. *ibid.* 43:2. 1919.
- ( 30 ) Degli Atti, M. Ricerche fisico-chimiche sulla costituzione dell'inquero dei globuli grassi del latte. Ann. scuola super. agr. Portici. Ser. II; 19:1-23. 1924. (From abs. in Internat. Rev. Sci. Prac. Agr. New Series 4:449-450. 1926.)
- ( 31 ) Douglas, H. H. A study of the causes of variation in fat content of buttermilk. Creamery Jour. 23; No. 10:1, 2; No. 11:1, 2, 23, 24; No. 12: 1, 2, 4, 6; No. 13:1-3. 1912. (From Exp. Sta. Rec. 28:277. 1913.)
- ( 32 ) Gilchrist, D. A. Effects of variations in the ripening and churning of cream upon the butter produced. Reading Col. Agr. Dept. Rept. pp. 47-50. 1901. (From Exp. Sta. Rec. 14:184. 1902-1903.)

- ( 33 ) Guthrie, E. S., and Sharp, P. F. The effect of the hydrogen ion concentration on the churning time of cream. *Jour. Dairy Sci.* 14:1-13. 1931.
- ( 34 ) Harkins, W. D., Brown, F. E., and Davies, E. C. H. The structure of the surfaces of liquids, and solubility as related to the work done by the attraction of two liquid surfaces as they approach each other. (Surface tension. V.) *Jour. Am. Chem. Soc.* 39:354-364. 1917.
- ( 35 ) Harkins, W. D., Davies, E. C. H., and Clark, G. L. The orientation of molecules in the surfaces of liquids, the energy relations at surfaces, solubility, adsorption, emulsification, molecular association, and the effect of acids and bases on interfacial tension. (Surface energy VI.) *Jour. Am. Chem. Soc.* 39:541-596. 1917.
- ( 36 ) Hattori, K. Ueber die Hüllen substanz der Milchfettkügelchen. *Jour. Pharm. Soc., Japan.* No. 516, February, 1925. (From German abs. by Hattori on abs. pages 7-9.)
- ( 37 ) Hattori, K. Beiträge zur Untersuchung über die Hüllensubstanz der Milchfettkügelchen. *ibid* 49:332-336. 1925. (From German abs. by Hattori on abs. pages 54-56.)
- ( 38 ) Hattori, K., and Ogimura, Y. Beitrage zur Untersuchung der Hüllensubstanz der Milchfettkügelchen (II. Mitteilung) *ibid.* 49:1147-1149. 1929. (From German abs. by Hattori and Ogimura on abs. pages 171-173.)
- ( 39 ) Hesselberg, O. The churning of sweet cream and acid cream: Investigations in Sweden. *Nordsk. Mejeri-Tidning* 33; No. 13:267-269. 1918. (From Intern. Inst. Agr., *Bul. Agr. Intelligence.* 9:1251-1252. 1918.)
- ( 40 ) Hills, J. L. Dairying V. Churning experiments. *Vt. Agr. Exp. Sta. Ann. Rpt.* 7:100-106. 1893.
- ( 41 ) Jack, E. L., and Dahle, C. D. Some observations on the electrokinetic potential of milk fat. *Jour. Dairy Sci.* 19:476-478. 1936.
- ( 42 ) Joël, E. Das Kolloide Gold in Biologie und Medizin. (pp. 72, 76-78.) Akademische Verlagsgesellschaft M.B.H. Leisig. 1925.
- ( 43 ) Jones, W. F. Canadian creamery buttermilk. Loss of fat in buttermilk. *Dominion Can. Dept. Agr. Bul. (New Series),* 70:20-22. 1926.
- ( 44 ) Josephson, D. V., and Dahle, C. D. The importance of the fat globule membrane in the freezing of ice cream. *Proc. 36th Ann. Convention Intern. Assoc. Ice Cream Manufacturers,* 2:100-116. 1936.
- ( 45 ) Kondo, K., and Hayashi, T. Studies on proteins. V. On the point of optimum flocculation of rice-glutelin. *Mem. Col. Agr. Kyoto Imp. Univ.* No. 2; article 2: 55-69. November, 1926.

- (46) Kondo, K., Hayashi, T., and Matsushita, T. Studies on proteins. VI. The influence of salts on the point of optimum flocculation of rice-glutelin. *ibid.* No. 2, article 3: 71-81. November, 1926.
- (47) Kondo, K., and Tomiyama, S. Proteins XVI. Behavior of the protein in the isoelectric solution. Jour. Chem. Soc. Japan 53:954-963. 1932. (From Chem. Abs. 27:740. 1933.)
- (48) Ladd, E. F. Report of the chemist. Dairy notes. N. Y. (Geneva) Agr. Exp. Sta. Ann. Rpt. 8:206-207. 1889.
- (49) Langmuir, I. The constitution and fundamental properties of solids and liquids. Part 1. Solids. Jour. Am. Chem. Soc. 38:2221-2295. 1916.
- (50) Langmuir, I. The constitution of liquids with especial reference to surface tension phenomena. Chem. & Met. Eng. 15:468-470. 1916.
- (51) Langmuir, I. The constitution and fundamental properties of solids and liquids. II. Liquids. Jour. Am. Chem. Soc. 39: 1848-1906. 1917.
- (52) La Rotonda, C. Sul fenomeno della coagulazione presamica. Influenza degli ioni-H sulla separazione della caseina per azione degli elettroliti. Ann. Chim. applicata. 19:310-328. 1929.
- (53) Lebermann, F. Über die Caseinfällung im isoelektrischen Punkte. Biochem. Z. 206:56-59. 1929.
- (54) Linderstrøm-Lang, K. Studies on Casein III. On the fractionation of casein. Compt.-rend. trav. lab., Carlsberg. 17; No. 9. 116 p. 1927-1929.
- (55) Macheboeuf, M. A., and Sandor, G. Recherches sur la nature et la stabilité des liaisons proteids-lipides du sérum sanguin. Etude de l'extraction des lipides par l'éther en présence d'alcohol. Bul. soc. chim. biol. 14:1168-1190. 1932.
- (56) McKay, G. L. Fat loss in churning. N. Y. Prod. Rev. 52:949-952. 1921.
- (57) Michaelis, L., and Pechstein, H. Der isoelektrische Punkt des Caseins. Biochem. Z. 47:260-268. 1912.
- (58) Mitchell, J. W. Churning losses. Chicago Dairy Prod. 28; No. 31: 16-19. 1921.
- (59) Mohr, W., and Brockman, C. Oberflächenspannungsmessungen an Milch. Milchwirtschaft. Forsch. 10:72-95. 1930.
- (60) Mohr, W., and Brockman, C. Kataphorese von Kuhmilch. Milchwirtschaft. Forsch. 11:211-217. 1930.
- (61) Mohr, W., and Moos, J. Oberflächenspannung und Grenzflächenspannung in ihrer beziehung zu Milch und Milchprodukten. Molkerei Ztg. (Hildesheim) 46; No. 130: 2302-2304; No. 131: 2318-2320. 1932.
- (62) Moir, G. M. The determination of the milk proteins. I. The chemistry of the separation of casein. Analyst 56:2-9. 1931.

- ( 63 ) Moir, G. M. The determination of the milk proteins. II. The identity of the casein precipitate. *Analyst* 56:73-78. 1931.
- ( 64 ) Mommsen, H. Über die Kataphorese von Kuhmilch und Frauenmilch. *Monatsschr. Kinderheilk.* 42:361-372. 1929.
- ( 65 ) Mortensen, M., Gaessler, W. G., and Cooper, W. H. Pasteurization of cream for buttermaking. *Iowa Agr. Exp. Sta. Bul. Part I.* 156:3-26. 1914. (See also *N. Y. Prod. Rev.* 47:956-958. 1919.)
- ( 66 ) Müller, A. Chemische Untersuchungen auf dem Gebiete der Milchwirtschaft. *Landw. Vers.-Sta.* 9:364-396. 1867.
- ( 67 ) Myers, J. A. Six months' experience in running a creamery. Improved process of handling cream and churning. *W. Va. Agr. Exp. Sta. Bul.* 6:142-152. 1889.
- ( 68 ) North, G. C., and Sommer, H. H. Electrokinetics in relation to dairy phenomena. I. Theory and method. *Jour. Dairy Sci.* 18:21-43. 1935.
- ( 69 ) Nugent, R. L. The application of the Mudd interfacial technique in the study of protective protein films in oil-in-water emulsions. *Jour. Phys. Chem.* 36:449-466. 1932.
- ( 70 ) Palmer, L. S. The chemistry of milk and dairy products from a colloidal standpoint. *Proc. World's Dairy Cong.* 1923. 2:1157-1168. 1923.
- ( 71 ) Palmer, L. S., and Samuelson, E. The nature of the substance adsorbed on the surface of the fat globules in cow's milk. *Proc. Soc. Exptl. Biol. Med.* 21:537-539. 1923-24.
- ( 72 ) Palmer, L. S., and Tarassuk, N. P. The effect of the adsorption "membrane" around the fat globules on the curd tension of cow's milk. *Jour. Dairy Sci.* 19:323-335. 1936.
- ( 73 ) Palmer, L. S., and Wiese, H. F. Substances adsorbed on the fat globules in cream and their relation to churning. II. The isolation and identification of adsorbed substances. *Jour. Dairy Sci.* 16:41-57. 1933.
- ( 74 ) Patrick, G. E. Sweet cream butter. *Iowa Agr. Exp. Sta. Bul.* 8:317-320. 1890.
- ( 75 ) Patrick, G. E. Creamery and dairy notes. IV. Loss of fat in buttermilk. *Iowa Agr. Exp. Sta. Bul.* 11:487-489. 1890.
- ( 76 ) Patrick, G. E., Leighton, F. A., and Bisbee, D. B. Sweet versus sour cream butter. *Iowa Agr. Exp. Sta. Bul.* 18:478-487. 1892.
- ( 77 ) Patrick, G. E., Leighton, F. A., and Heileman, W. H. Sweet versus ripened cream butter. *Iowa Agr. Exp. Sta. Bul.* 21:788-791. 1893.
- ( 78 ) Pedersen, K. O. Ultracentrifugal and electrophoretic studies on milk proteins. 1. Introduction and preliminary results with fractions from skimmilk. *Biochem. Jour.* 30:948-960. 1936.
- ( 79 ) Penny, C. L. Report of the chemist. Creameries as a business. *Del. Col. Agr. Exp. Sta. Bul.* 9:12-32. 1890. (See also *Del. Col. Agr. Exp. Sta. Ann. Rpt.* 3:129-149. 1890.)



- (80) Prieger, I. Über die Hüllen der Milchfettkügelchen. 1. Biochem. Z. 217:331-336. 1930.
- (81) Rahn, O. Die Bedeutung der Oberflächenspannungserscheinungen für den Molkereibetrieb. Kolloid Z. 30:341-346. 1922.
- (82) Rahn, O. Die Entstehung der Butter. Proc. World's Dairy Cong. 2:1008-1012. 1923.
- (83) Rimpila, C. E., and Palmer, L. S. Substances adsorbed on the fat globules in cream and their relation to churning. IV. Factors influencing the composition of the adsorption "membrane." Jour. Dairy Sci., 18:827-839. 1935.
- (84) Robertson, J. W. Report of the agriculturist. Part III. Experimental dairy work. Experiments in the churning of cream. Can. Exptl. Farms Rpts. pp. 96-101. 1891.
- (85) Robertson, J. W. Experimental dairy work. Can. Exptl. Farms. Rept. pp. 100-101. 1891. (From Exp. Sta. Rec. 4:444-447. 1892-1893.)
- (86) Ruehe, H. A., and Stiritz, B. A. Some studies in reducing the stability of butter fat emulsions. Jour. Dairy Sci. 8:330-343. 1925.
- (87) Schmöger, M. Ueber das Verbuttern von süßem und saurem Rahm. Biedermann's Zentr. 10:703-704. 1881.
- (88) Schollenberger, C. J. An improved calomel electrode. Jour. Ind. Eng. Chem. 17:649. 1925.
- (89) Sebelien, J. Mitteilungen aus dem Laboratorium des Milchwirtschaft. Instituts zu Ultuna, Schweden. II. Über die Abhängigkeit der Butterausbeute von dem Säuerungsgrade des Rahmes. Landw. Vers. Sta. 34:93-108. 1887.
- (90) Sharp, P. F., and McInerney, T. J. Effect of salts on the solubility of casein and paracasein. Jour. Dairy Sci. 19:573-579. 1936.
- (91) Shutt, F. T., and Charron, A. T. Sweet-cream butter. Dept. of Agr., Branch, Dairy and Cold Storage Commissioner, Ottawa, Canada. Bul. 13. 1907.
- (92) Sjögren, B., and Svedberg, T. The molecular weight of lactalbumin. Jour. Am. Chem. Soc. 52:3650-3654. 1930.
- (93) Sommer, H. H., and North, G. C. The electrokinetic potential and its relation to churning. Mimeographed material, 28th Ann. meeting Am. Dairy Sci. Assoc., U. of Ill., June, 1933.
- (94) Sørensen, S. P. L., and Sladek, I. On Wo. Ostwald's "Bodenkörperregel" and the solubility of casein in sodium hydroxide. Compt.-rend. trav. lab., Carlsberg, 17; No. 14; 35 pp. 1927-1929. (See also Kolloid Z. 49:16-35. 1929.)
- (95) Sproule, W. H., and Grimes, M. Partial neutralization of acidity of cream before pasteurization as a factor in buttermaking. Ontario Dept. Agr. Circ. 38:12. 1921. (See also N. Y. Prod. Rev. Am. Creamery 53:417-422 and 465-469. 1921-1922.)
- (96) St. Johnston, J. H. The surface tension of protein solutions. Part III. Biochem. Jour. 21:1314-1328. 1927.

- (97) Storch, V. On the structure of the "Fat Globules" in cow's milk. *Analyst*. **22**:197-207. 1897.
- (98) Storch, V. Ueber den Bau der Milchkügelchen. *Jahresber. Fortschr. Tier-Chem.* **27**:273-275. 1897. (An abstract by Hammarsten from 36th Beretning fra den Kgl. Veterinar-og Landbohøjskoles Laboratorium for landøkonomiske Forsøg. Kjöbenhavn, 1897, of an article entitled "Konsistensfejl hos Smörret.")
- (99) Svedberg, T., Carpenter, L. M., and Carpenter, D. C. The molecular weight of casein. I. *Jour. Am. Chem. Soc.* **52**:241-252. 1930.
- (100) Svedberg, T., Carpenter, L. M., and Carpenter, D. C. The molecular weight of casein. II. *Jour. Am. Chem. Soc.* **52**:701-710. 1930.
- (101) Tapernoux, A and Vuillaume, R. Viscosité du laite de vache. *Lait*. **14**:449-456. 1934.
- (102) Thomsen, L. C. Buttermilk testing and losses. *N. Y. Prod. Rev.* **68**:546. 1929.
- (103) Tiemann, H. Versuche mit einem Hansa-Butterfass "Nr. 1" Melkerei-Ztg. (Hildesheim) **19**:711-712. 1905.
- (104) Titus, R. W., Sommer, H. H., and Hart, E. B. The nature of the protein surrounding the fat globules in milk. *Jour. Biol. Chem.* **76**:237-250. 1928.
- (105) Van Slyke, L. L., and Bosworth, A. W. Condition of casein and salts in milk. *Jour. Biol. Chem.* **20**:135-152. 1915.
- (106) Vonk, H. J. Quellungsminimum und isoelektrischer Punkt des Fibrins. *Z. physiol. Chem.* **198**:201-218. 1931.
- (107) Völtz, W. Untersuchungen über die Serenhüllen der Milchkügelchen. *Arch. ges. Physiol. (Pfüger's)* **102**:373-414. 1904.
- (108) Wallace, H. C. A study in churning. *Iowa Agr. Exp. Sta. Bul.* **22**:819-832. 1893.
- (109) Wiegner, G. Ueber die Aenderung einiger physikalischer Eigenschaften der Kuhmilch mit der Zerteilung ihrer dispersen Phasen. *Kolloid. Z.* **15**:105-123. 1914.
- (110) Wiese, H. F., and Palmer, L. S. Substances adsorbed on the fat globules in cream and their relation to churning. 1. The churnability of artificial emulsions prepared with the known emulsifying agents of cream. *Jour. Dairy Sci.* **15**:371-381. 1932.
- (111) Wiese, H. F., and Palmer, L. S. Substances adsorbed on the fat globules in cream and their relation to churning. III. Analysis of the adsorbed protein. *Jour. Dairy Sci.* **17**:29-32. 1934.
- (112) Zsigmondy, R., and Spear, E. B. *Chemistry of colloids.* p. 264-265. 1st ed. Wiley. 1917.
- (113) Zsigmondy, R., and Thiessen, P. A. *Das kolloide Gold.* (p. 185-186.) Akademische Verlagsgesellschaft. M.B.H. Leipsig, 1925.