1955

Improving Curd-Forming Properties of Homogenized Milk

R. B. Maxcy
University of Nebraska-Lincoln

W. V. Price
University of Wisconsin, Madison

D. M. Irvine
University of Wisconsin, Madison

Published in JOURNAL OF DAIRY SCIENCE 38 (1955), pp. 80-86.

IMPROVING CURD-FORMING PROPERTIES OF HOMOGENIZED MILK[1]

R. B. MAXCY,[2] W. V. PRICE, AND D. M. IRVINE
Department of Dairy and Food Industries, University of Wisconsin, Madison

Homogenizing milk for cheese reduces fat losses in the whey *(6, 9, 12)* and decreases leakage of fat from cheese stored at high temperatures *(6, 11)*. Homogenization of milk influences its curd-forming properties with rennet. Trout *(10)* has reviewed this subject thoroughly. Gel strength is reduced and rate of coagulation is increased. Reduction in gel strength is directly related to the effectiveness of homogenizing.

Apparently no single explanation of the mechanism responsible for the lowering of gel strength by homogenization of the milk has been commonly accepted. One possibility is the adsorption of proteins on the newly created fat surfaces. Another suggestion is that fat disrupts the continuity of gel structure and that increasing the number of fat globules therefore increases the number of weak points.

Wilson and Johnson *(11)* and Nichols *(6)* studied the making of Cheddar cheese from homogenized milk as a means of decreasing leakage of fat from cheese exposed to above-normal temperatures. The difficulties encountered in curd making and handling they tried to minimize by homogenizing cream and then standardizing it with skimmilk to the percentage of fat desired. Their procedures are not used commercially for Cheddar cheese. The practice is used in making blue-mold cheese but for reasons other than conservation of fat.

Homogenizing cream does not give maximum dispersion of fat globules *(5)*. Nichols *(6)* observed that fat leakage from cheese made from homogenized cream mixed with skimmilk tended to increase with the extent of fat clumping. He added disodium phosphate or, preferably, sodium citrate to the cream before homogenization in order to obtain better emulsification.

If Cheddar cheese is to be made from homogenized milk, the success of the operation depends in part upon improving the gel strength obtained by rennet. This investigation indicates the possibility of achieving this objective by increasing the concentration of solids-not-fat in the milk after homogenizing.

EXPERIMENTAL METHODS

The mixed milk for this work came from the 25,000-lb. supply received daily at the manufacturing laboratory of Babcock Hall. It was homogenized at 60° C. and 2,500 lb. pressure in a Manton-Gaulin homogenizer just prior to its final heat treatment at 74° C. for 16 seconds in an HTST pasteurizer.

Coagulation measurements and tests for curd tension were made on this milk within 6 hours after pasteurizing. The milk was tempered to 30° C. for 30 min-

Received for publication August 18, 1954.

[1] Approved for publication by the Director of the Wisconsin Agricultural Experiment Station.

[2] Present address: Diversey Corporation, Chicago.

utes before testing. It was coagulated with liquid commercial rennet which had been freshly diluted with distilled water so that 1 ml. of the solution added to each 50 ml. of milk in the tests gave the equivalent of 6 oz. of extract in 1,000 lb. of milk.

Rate of rennet coagulation was determined by the rolling bottle technique *(8)*. The time for coagulation was recorded in revolutions, each of which approximated 4 seconds. Firmness of curd was measured by an apparatus, shown in Figure 1, that combined the techniques of Alleman and Schmid *(1)* and Hill *(3)*.

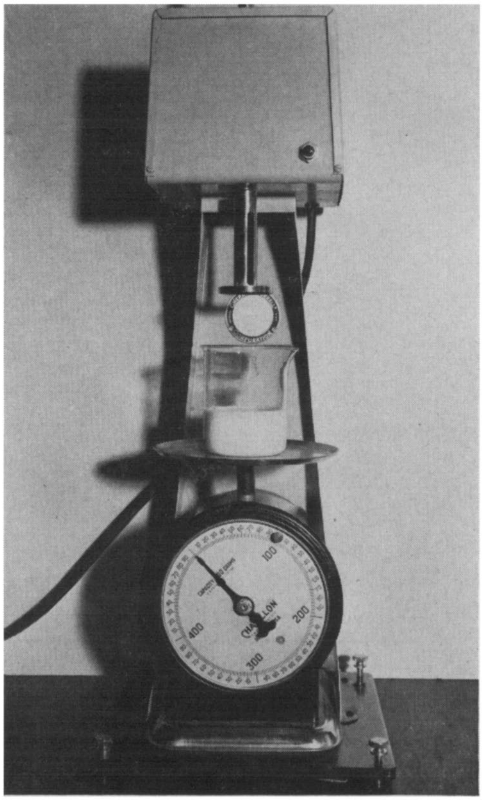

FIG. 1. The curd tension meter.

Cutting knife and driving mechanism were designed to meet the specifications of the Doan committee on curd tension *(2)*. Downward movement of the knife was 1 in. in 7 to 8 seconds, and time from adding rennet to curd tension measurement was 30 minutes.

RESULTS

The soft-curd properties of homogenized milk are well known *(10)*. During rennet coagulation this milk reacts to added calcium chloride and disodium phosphate as does nonhomogenized milk. Calcium chloride reduces the time of coagulation, and the first increments added produce the greatest reductions. Disodium phosphate increases the time of coagulation in direct proportion to the amounts added to the homogenized milk. Typical measurements made in this laboratory are illustrated in Figure 2.

Homogenized milk, however, does not react as does the nonhomogenized product in developing gel strength. In normal milk, curd tension can be increased by adding calcium chloride; by increasing temperature of coagulation, amount of rennet, and time for rennet action; and by increasing the acidity of the milk at the time of adding rennet.

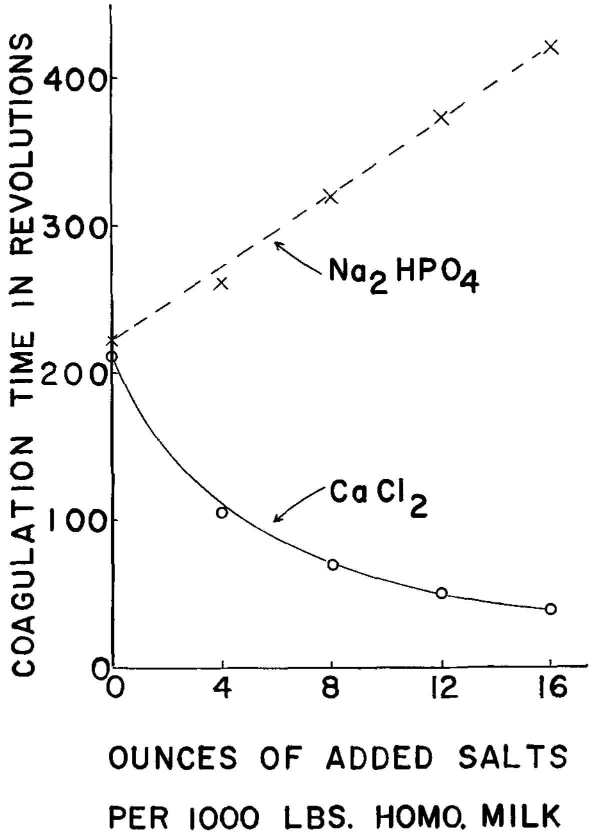

FIG. 2. The effect of added calcium chloride and disodium phosphate on the rate of coagulation of homogenized milk.

In these experiments calcium chloride did not restore the curd tension values lost by homogenizing even when added at more than double the rate permitted by federal standards for cheesemaking. In one typical trial the addition of 0, 2, 4, 6, and 8 oz. of this salt per 1,000 lb. of homogenized milk gave curd tension values of 8, 9, 11, 12, and 14 g., respectively. The curd tension of untreated, nonhomogenized milk taken from the identical milk supply approximated 25 to 30 g. during the period of these experiments.

Increasing the temperature of rennet action from the usual 30° C. to 40° C. produced curd tensions of only 7 or 8 g. in the homogenized milk curd. These values were not increased by tripling the amount of rennet or by a threefold increase in time allowed for coagulation.

The acidity of coagulation was increased by adding dilute hydrochloric acid to the homogenized milk. When the pH values of the adjusted samples were 6.71, 6.61, 6.43, 6.30, and 6.14, the curd tension measurements were: 7, 8, 10, 12, and 12 g., respectively.

These common methods of increasing curd tension all failed to produce in homogenized milk sufficient gel strength for normal curd-making operations. The lack of response to these methods suggested the possibility of either a lack of available casein for curd formation or a mechanical interference with curd formation by increased numbers of fat globules in homogenized milk. Concentration of homogenized milk for gel strength tests seemed to be necessary to study these reactions.

Pasteurized, homogenized milk was concentrated at 57° to 60° C. in 1 hour to increase the solids-not-fat (SNF) content from 8.5 to 16.0% (1.88 to 1). Fat content was increased from 3.5 to 6.6%. The concentrate was cooled and tested immediately for curd tension. Six dilutions of the concentrate were made with distilled water so that SNF of the dilutions ranged downward to that of the original milk. The resulting curd tension measurements are shown in Figure 3.

Increasing the SNF of the homogenized milk by concentrating 1.88 to 1 increased the curd tension fivefold. In a similar trial in which concentration was 2.3 to 1 the increase in curd tension was tenfold. This value can be predicted by extrapolating the curve shown in Figure 3. Increases of SNF from 8.5 to 10.5% were less effective than increases beyond that zone of concentration. When the SNF of homogenized milk was increased by concentration, the rate of rennet coagulation remained practically unchanged. This is a surprising fact in view of the well known relation *(1)* between rate of coagulation and curd tension.

The results with milk concentration shown in Figure 3 suggested that the addition of low-heat, nonfat dry milk solids (NFDMS) to homogenized milk might produce similar improvement in gel strength. This was tried, and the results are plotted in Figure 3 for comparison with the data obtained by concentration. The addition of NFDMS to homogenized milk to increase curd tension was slightly more effective than milk concentration up to approximately the 13% level of SNF; beyond that zone, addition of NFDMS was slightly less effective than milk concentration.

Further observations showed that as the curd tension of homogenized milk was increased by concentrating the milk or adding NFDMS, there was a tendency for the milk to respond in gel strength like nonhomogenized milk to such factors as the addition of calcium chloride and duration of rennet action. The rate of coagulation remained unchanged at 171 to 163 revolutions (684 to 652 seconds) when SNF of homogenized milk was increased as much as 8% by adding NFDMS; curd tension values, however, increased fourfold from 11 g. for nonfortified homogenized milk to 43 g. for the same milk fortified with NFDMS.

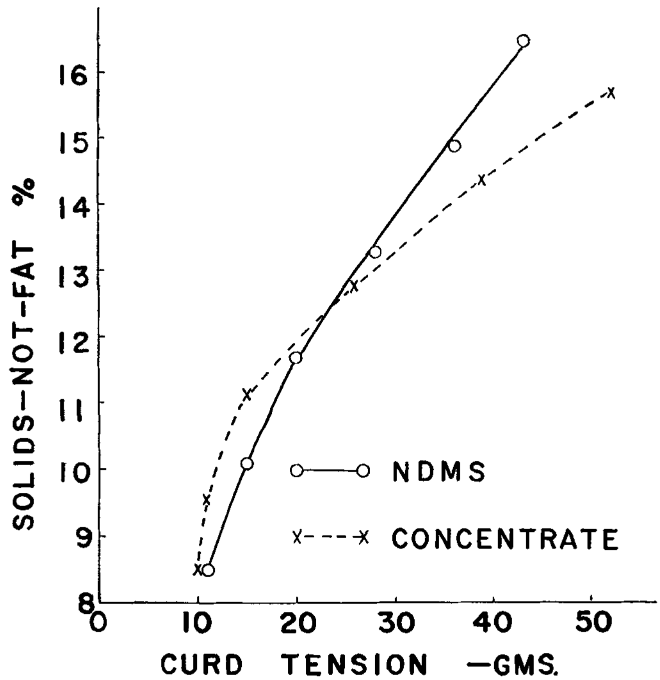

FIG. 3. The effects on curd tension of homogenized milk of increasing percentage of solids-not-fat by concentration of the milk and by adding nonfat dry milk solids.

A number of small vat lots of Cheddar, a soft-ripened cheese, and a cheese of the Pasta Filata type were made from concentrated homogenized milk and from homogenized milk fortified with small amounts of NFDMS or concentrated skimmilk. Gel formation was extremely rapid and firm. If allowed to become hard, the curd tended to fracture more than normally in cutting. Fat losses in the whey were 0.02-0.07%, or 10 to 20% of the normal values as measured by the Babcock test with the butyl alcohol modification. The curd lost moisture readily during the making operation at a rate comparable to that of the non-homogenized milk. The finished Cheddar cheese was very firm, yet higher in moisture (approximately 40%) than might have been expected from its body characteristics. Cut pieces of these cheese showed no visible leakage of fat when held on filter paper for 7 days at room temperature. Organoleptic observations of the 3-month-old Cheddar and Pasta Filata types of cheese showed that curing proceeded in the characteristic manner of low-moisture cheese made from pasteurized milk.

DISCUSSION

Homogenization decreases the time required for coagulation of milk by rennet. This effect might be explained by an increased adsorption of anions (citrates and phosphates) leaving calcium and magnesium to stimulate rate of coagulation. This explanation is also suggested by the decreased heat stability *(4)* and alcohol stability *(7)* of homogenized milk.

The lowering of curd tension caused by homogenization of the milk indicates that coagulation rate and gel formation are not completely dependent upon the same factors. It is probable that this lowering of curd tension is caused by adsorption of casein on the newly formed fat surfaces. The increase of curd tension obtained by concentrating the homogenized milk suggests that the curd structure is strengthened by bringing closer together the casein particles still available for forming gel structure. Increasing curd tension by adding low-heat NFDMS to homogenized milk provides a greater concentration of gel-forming casein in the serum. The same effect was obtained by adding low-heat concentrated skimmilk to homogenized milk.

Restoration of curd-forming properties of homogenized milk opens new possibilities and, perhaps, economies in cheesemaking. It suggests new ways of reclaiming excess supplies of homogenized milk. Fat losses in the whey of normal making operations can be reduced. Losses of fat from hot curd during the molding of Pasta Filata types of Italian cheese can be minimized. Control of leakage of fat from cheese held at abnormally high temperatures seems to be feasible. It is possible that the use of cheese made from homogenized milk may affect the dispersion of fat in cheese-processing operations. Studies of these possibilities will be continued.

SUMMARY

The factors which alter the rate of rennet action and curd tension of nonhomogenized milk have a similar action on rate of coagulation but very little or no effect on the curd tension obtained by rennet action on homogenized milk.

Practically normal curd-making properties were restored to homogenized milk by concentrating it or by adding to it low-heat, nonfat dry milk solids or low-heat concentrated skimmilk. The treatments may have practical commercial applications.

These data suggest that reduction of curd tension by homogenizing may be caused by adsorption of casein on the newly created surfaces of fat.

REFERENCES

(1) ALLEMAN, O., AND SCHMID, H. Uber die Festigkeit des durch Lab erzeugten Milchkoagulums. *Landwirtsch Jahrb. Schweiz.*, **30**: 355. 1916.

(2) DOAN, F. J., BABCOCK, C. J., CHAMBERS, L. A., FLORA, C. C., HULL, M. E., MUELLER, W. S., SOMMER, H. H., AND STORRS, A. B. Final Report of Committee on Methods of Determining the Curd Tension of Milk. *J. Dairy Sci.*, **24**: 825. 1941.

(3) HILL, R. L. A Test for Determining the Character of the Curd from Cows' Milk and Its Application as an Index to the Food Value of Milk for Infants. *J. Dairy Sci.*, **6**: 509. 1923.

(4) HUNZIKER, O. F. *Condensed Milk and Milk Powder.* 6th ed. Published by the author, LaGrange, Ill. 1946.

(5) MAXCY, R. B., AND SOMMER, H. H. Fat Separation in Evaporated Milk. III. *J. Dairy Sci.*, **37**: 1061. 1954.

(6) Nichols, L. E. The Manufacture of Nonfat-Leaking Cheddar Cheese from Reconstituted Milk. *Queensland J. Agr. Sci.*, **5**: 39. 1948.
(7) Sommer, H. H., and Binney, T. H. A Study of the Factors that Influence the Coagulation of Milk in the Alcohol Test. *J. Dairy Sci.*, **6**: 176. 1923.
(8) Sommer, H. H., and Matsen, Helene. The Relation of Mastitis to Rennet Coagulability and Curd Strength of Milk. *J. Dairy Sci.*, **18**: 741. 1935.
(9) Stevenson, A. F. (assignor to Borden Co.) Manufacture of Cheese from Homogenized Milk. U. S. Patent 1,868,547. July 26, 1932.
(10) Trout, G. M. *Homogenized Milk.* p. 30. Michigan State College Press, East Lansing. 1950.
(11) Wilson, H. L., and Johnson, W. T. (to the free use of the people of the United States) Process to Prevent the Oiling Off or Leakage of Butterfat in Cheese. U. S. Patent No. 2,127,453. August 16, 1938.
(12) Zollikofer, E. Der Einfluss der Homogenisation auf die Labfähigkeit der Milch und den Fettgehalt der Käsemolke. *Proc. 12th Intern. Dairy Congr.*, **3**: 129. 1949.