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FAT SEPARATION IN EVAPORATED MILK
II. AGE-THINNING OF CONCENTRATED, STERILIZED MILK [1]

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During the process of sterilization of evaporated milk there is a gradual increase in the viscosity, or the body of the product. However, there is a reduction in the viscosity especially during the early phase of storage. This loss in viscosity, referred to as age-thinning, continues for a number of months.

The extent of age-thinning is of considerable importance, because a low viscosity allows more rapid fat separation and a general detraction from the salability of the product. Mojonnier and Troy *(4)* and Deysher, Webb, and Holm *(1)* have shown that age-thinning proceeds most rapidly immediately after sterilization. The latter group concluded that the rate of age-thinning decreases until the milk reaches a basic viscosity, which means the milk has ceased to undergo rapid age-thinning, or that age-thickening has set in. Age-thickening is an increase in viscosity that takes place on extended storage. Webb, Deysher, and Hufnagel *(6)* reached the following conclusion: "The viscosity of all evaporated milks dropped to a basic level during storage. The relationship between the time required for a milk to thin to such a level (to a basic viscosity) and the storage temperature was logarithmic with respect to time." It is not clear whether the viscosities of all evaporated milks decline to the same level, or that all evaporated milks exhibit this decline in viscosity, each to its own characteristic level. More recently Webb, Deysher, and Potter *(7)* showed that each sample of evaporated milk will tend to reach its own minimum viscosity before age-thickening commences. In addition, they showed that the temperature of storage is directly related to the logarithm of the reciprocal of the time required for a sample to lose a definite viscosity value.

The loss in viscosity is a critical factor in the consideration of fat separation. Therefore, to determine the effectiveness of viscosity in retarding fat separation, it is necessary to know the average or representative viscosity value that is active throughout the storage period. The following work was undertaken primarily to develop a technique whereby this value could be determined.

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EXPERIMENTAL

Evaporated milk was prepared according to a normal commercial process *(3)*. One can was used for each viscosity measurement at 100° F. with a modified Gardner mobilometer *(2)*. The remainder of the cans were stored under quiescent conditions at 100° F., except for a single gentle inversion each day to prevent fat separation.

The greatest loss in viscosity occurred during the first few days with a progressively smaller loss for each succeeding day. When these data were plotted with the viscosity as the ordinate and the logarithm of the time of storage as the abscissa, the points formed a straight line (Figure 1). This relationship makes possible the calculation of the average viscosity during the early phases of quiescent storage.

The temporary viscosity formed during sterilization can be dissipated by simple agitation. For example, cans of evaporated milk were placed on a reciprocating agitator for one hour and the viscosity was reduced to approximately one-half the original value. The effectiveness of agitation in the cans apparently is limited by the foaming or whipping of the air of the headspace into the product. Thus, the effectiveness of the concussion is reduced.

An Osterizer can be used to obtain violent agitation and avoid whipping air into the product. This device consists of propeller blades that are constructed in an assembly for closing the container on which it is to be used. Since the assembly is designed to fit a standard glass jar, it is possible to utilize a container that can be filled completely with liquid.

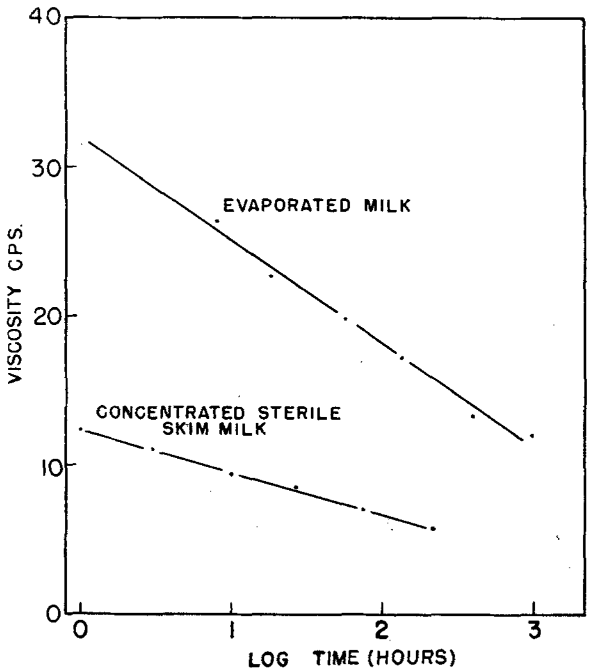

FIG. 1. The pattern of age-thinning during quiescent storage at 100° F.

When samples of sterilized evaporated milk were agitated for 30 seconds in the Osterizer, the viscosity was reduced to near that of the original unsterilized milk. The viscosity, after treatment with the Osterizer, was slightly higher for samples that had been given a longer sterilization treatment. For example, when the time of sterilization was 14, 15, and 20 minutes, the viscosity was 7.2, 7.4, and 7.8 cps., respectively. The viscosity of the concentrated milk prior to sterilization was 5.2 cps. The values are what might be expected as the basic viscosity reached through age-thinning.

Since the viscosity formed during sterilization could be reduced quickly by mechanical agitation and since any consideration of fat separation in evaporated milk during storage would include a consideration of the state of dispersion of the butterfat, it seemed logical to determine the effect of butterfat on the pattern of age-thinning.

Mixed skimmilk from the University creamery was forewarmed at 150° F. for 30 minutes and then condensed to slightly less than half the original volume. A Mojonnier test for total solids was performed on the concentrated product, and sufficient distilled water was added so that the resulting product contained 19.7% total solids—the percentage of solids-not-fat in the aqueous phase of evaporated milk. The remainder of the procedure was the same as for the concentrated whole milk.

From a representative set of the data given in Figure 1, it is apparent that concentrated, sterilized skimmilk showed the same pattern of age-thinning as evaporated milk. That is, there was an inverse relation between the viscosity and the logarithm of the storage time. One may conclude, therefore, that the pattern of age-thinning is completely independent of the butterfat. Thus, the proteins undoubtedly constitute the structures that account for the apparent viscosity.

It may be of interest to note that Shahani and Sommer *(5)* found an increase in the nonprotein nitrogen of evaporated milk during storage.

CALCULATIONS

As was pointed out in the previous section, the viscosity during storage was inversely related to the logarithm of the storage time. Thus, a straight line was formed and the average viscosity was the average height of the line; this average height was calculated.

The method of calculation can best be exemplified by a sample problem: Assume the viscosity after 1 hour was 30 cps. and after 7 days it was 20 cps. The general equation for a straight line passing through the above points would be $V = m \log t + b$. Where V is viscosity, m is the slope of the curve, t is time of storage, and b is a constant determining the intercept of the line. Substituting the specific values into the above equation, it becomes $V = -4.494 \log t + 30$.

The average height *(h)* is obtained by determining the area *(A)* under the curve and dividing the time *(t)* involved in the test. The area between 0 time and 168 hours is determined as follows:

$$
\begin{aligned}
A &= \int_{t_1}^{t_2} V dt \\
&= \int (-4.494 \log t + 30)\ dt \\
&= -4.494 \int \log t dt + 30t \\
&= -4.494\ (t \log t - 0.4343t) + 30t \\
&= -4.494\ t \log t + 31.95t
\end{aligned}
$$

Substituting into the above equation for a time *(t)* of 1 hour the equation becomes:

$$
\begin{aligned}
A_1 &= -4.494 \log 1 + 31.95 \\
&= 31.95
\end{aligned}
$$

To determine the area to time 168, the equation becomes:

$$
\begin{aligned}
A_2 &= (-4.494 \times 168 \log 168) + (31.95 \times 168) \\
&= 3{,}687.5
\end{aligned}
$$

The area between time 168 and time 1 is $A_2 - A_1$ or 3,687.5.

The average height *(h)* is:

$$
h = \frac{A_2 - A_1}{t_2 - t_1} = \frac{3{,}687.5 - 31.95}{168 - 1} = 21.9
$$

Thus, the average height of the line is 21.9, which is the average viscosity of the sample chosen in the above example.

DISCUSSION

The pattern of age-thinning of evaporated milk can be subjected completely to definitive mathematical relationships. The rate of age-thinning (the slope of the age-thinning curve) is inversely related to the storage temperature, the intercept of the line being directly related to the initial viscosity. In addition, the viscosity of a sample of evaporated milk is inversely related to the logarithm of the storage time, the slope being determined by the initial viscosity and the storage temperature. For example, during the first 3 days the viscosity loss will be the same as for the subsequent 27 days.

The above generalizations are based on age-thinning under quiescent storage conditions. Intermittent agitation would disrupt the original pattern, but only the rate of age-thinning would be altered. The fundamental relationship should hold for any given period of quiescent storage.

The rate of age-thinning or the slope of the curve as given in Figure 1 and the final viscosity are the most important considerations. These values have practical significance in so far as the slope is directly related to storage temperature, and the final value, or the value obtained during extended storage periods, indicates the viscosity that will be operative in preventing fat separation during delayed marketing conditions.

The above considerations have theoretical significance in that a method exists for studying the mechanism of the age-thinning phenomenon. Furthermore, the above relationship permits calculation of the average viscosity for consideration in the problem of fat separation.

SUMMARY

Data are presented to characterize further the phenomenon of age-thinning of evaporated milk. The loss of viscosity is inversely related to the logarithm of the storage time, and the slope of the curve for age-thinning is directly related to the storage temperature. These relationships can be expressed in mathematical terms. A method is presented for the utilization of the above relationships in the calculation of the average viscosity during the early stage of quiescent storage. In addition, a method is described whereby it is possible to dissipate quickly the temporary viscosity formed during sterilization.

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REFERENCES

(1) DEYSHER, E. F., WEBB, B. H., AND HOLM, G. E. The Viscosity of Evaporated Milks of Different Solids Concentration. *J. Dairy Sci.*, **27**: 345. 1944.

(2) MAXCY, R. B., AND SOMMER, H. H. Fat Separation in Evaporated Milk. I. Homogenization, Separation, and Viscosity Tests. *J. Dairy Sci.*, **37**: 60. 1954.

(3) MAXCY, R. B., AND SOMMER, H. H. Fat Separation in Evaporated Milk. III. Gravity Separation and Heat Stability. *J. Dairy Sci.* (In press).

(4) MOJONNIER, T., AND TROY, H. C. *The Technical Control of Dairy Products.* 2nd ed., p. 781. Mojonnier Brothers Co., Chicago. 1925.

(5) SHAHANI, K. M., AND SOMMER, H. H. The Protein and Non-Protein Nitrogen Fractions in Milk. III. The Effect of Heat Treatment and Homogenization. *J. Dairy Sci.*, **34**: 1035. 1951.

(6) WEBB, B. H., DEYSHER, E. F., AND HUFNAGEL, C. F. A Study of the Physical Changes Which Affect the Storage Life of Evaporated Milk. *J. Dairy Sci.*, **29**: 499. (Abs.) 1946.

(7) WEBB, B. H., DEYSHER, E. F., AND POTTER, F. E. Effects of Storage Temperature on Properties of Evaporated Milk. *J. Dairy Sci.*, **34**: 1111. 1951.