

Shelf-Life of Pasteurized Fluid Milk as Affected by Age of Raw Milk¹

J. J. JANZEN, J. R. BISHOP, A. B. BODINE, and C. A. CALDWELL

Dairy Science Department
Clemson University
Clemson, SC 29631

ABSTRACT

Increasing raw milk storage time prior to pasteurization may affect product shelf-life. Raw milk was stored at 4.5°C for 0, 2, 4, and 6 days prior to pasteurizing. Milk samples from each pasteurized lot were analyzed after continuous storage at 4.5°C for 0, 4, 8, 12, 16, and 20 days. Both raw and pasteurized samples were analyzed for coliforms, psychrotrophs, and total bacteria counts. Flavor scores were also determined. No correlations were significant between raw or pasteurized samples and total bacteria or coliform counts. Related were flavor score and days held raw, shelf-life of the resulting pasteurized product, and interaction of days held raw and shelf-life of the pasteurized product. Psychrotrophic counts and age of the raw milk were correlated. From correlations of flavor scores with shelf-life of the milk, a predictive equation was: Flavor score = $8.00 - .88 R - .11 P - .0015 P^2 - .009 R P$, where R is days held raw and P is shelf-life of the pasteurized product.

INTRODUCTION

There is continuing interest among processors to extend the shelf-life of milk and milk products by higher processing temperatures and preventing recontamination by psychrotrophic bacteria after pasteurization. However, quality of raw milk may be of even greater importance. It has been said that "you cannot make a better finished product than the original starting product." Controlling microorganisms in raw milk is of prime importance because this is the starting product.

The dairy industry has gone to great lengths to develop milk products with long shelf-lives. The American consumer expects pasteurized milk to retain satisfactory flavor for about 2 wk from purchase. Changes in on-farm procedures of milk harvesting, longer refrigerated storage of raw milk at the farm, plus additional storage periods in bulk silos prior to processing, may contribute to problems of shortened life of pasteurized milk.

Psychrotrophic bacteria are difficult to exclude from raw milk and may grow and produce proteolytic enzymes during refrigerated storage. Many of these protease enzymes are heat-stable and survive pasteurization temperatures (7). Hence, if sufficient heat-stable enzymes are in raw milk prior to pasteurization, defects may become more pronounced after pasteurization during refrigerated storage. Psychrotrophs isolated from raw milk produced proteases that survived 149°C for 10 s. Seventy to 90% of raw milks contained psychrotrophs capable of producing heat resistance proteases (1).

White and Marshall (8) reported significantly lower flavor scores for Cheddar and cottage cheese made from milk containing protease enzymes as compared to protease-free milk.

Janzen (6) suggested that shelf-life of pasteurized milk is influenced by somatic cell concentration in raw milk. High somatic cell concentrations are indicative of abnormalities that frequently involve increased microbial flora.

Zall (9) reported that when milk was heated at 74°C for 10 s at the farm and then stored in a refrigerated tank for 8 days, its quality was comparable to fresh milk. He suggested that the heat process destroys most psychrotrophs and inactivates proteases.

Because of the trend towards extended holding times for raw milk prior to pasteurization, this study was to determine the effect of age of raw milk on shelf-life of the pasteurized product.

Received October 5, 1981.

¹Technical Contribution No. 1984. Published with the approval of the Director, South Carolina Experiment Station.

MATERIALS AND METHODS

Raw milk was obtained from the Clemson University dairy herd and represented regular pick up every other day. The temperature of the farm tank milk at pick up was 2 to 3°C. The experiments were replicated three times using separate raw milk supplies. In the first phase of the experiment, raw milk was subdivided into four 2-liter lots, then stored at 4.5°C for 0, 2, 4, and 6 days prior to pasteurization.

Milk was laboratory pasteurized at 62.8°C for 30 min, cooled to 4.5°C, and packaged in six sanitized 235-ml glass milk bottles. Bottles were capped and hooded with aluminum foil. Each bottle served as a subsample with individual bottles used for each observation. The pasteurized product then was stored at 4.5°C. Examinations were after 0, 4, 8, 12, 16, and 20 days storage. All samples (raw and pasteurized) were evaluated for flavor score (ADSA), standard plate count (SPC), coliform count violet red bile (VRB), and psychrotrophic counts (7°C for 10 days) (2). All assays were in duplicate. Flavor evaluation samples were coded and evaluated by two experienced judges of dairy products.

A follow-up study was in the University milk

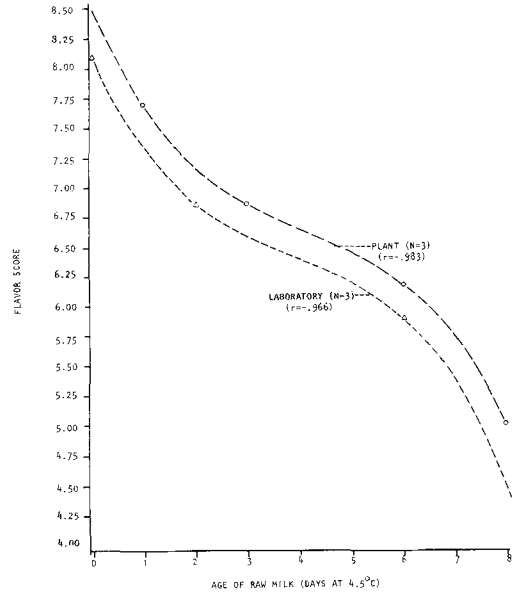


Figure 2. Flavor scores of raw milk.

processing plant. An adequate supply of raw milk was stored in refrigerated storage tanks at 4.5°C. At day 0, 1, 3, 6, and 8 days, sufficient milk was withdrawn and pasteurized at 72°C/16

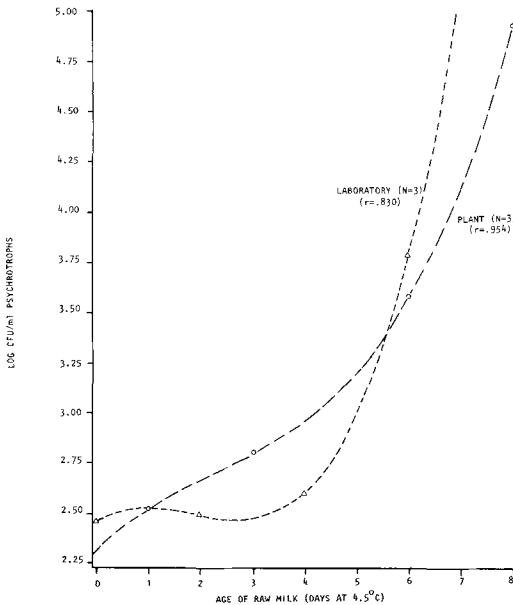


Figure 1. Psychrotrophic counts of stored raw milk.

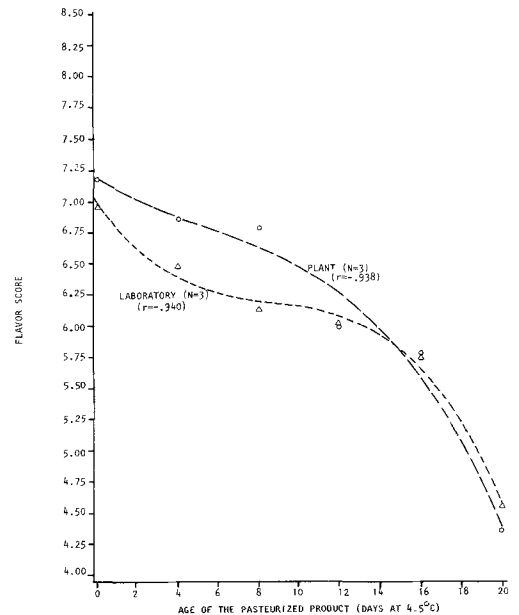


Figure 3. Flavor scores of pasteurized milk stored at 4.5°C.

s in a high temperature short time pasteurizer (HTST). Milk was packaged in 22.8 liter polyethylene bags and stored at 4.5°C. Samples were drawn from the 22.8 liter reservoir after 0, 4, 8, 12, 16, and 20 days storage. All samples were examined for characteristics listed previously with flavor scores used to test the validity and accuracy of the predictive equation formulated from results of the laboratory study.

Variances were analyzed from a randomized block design. Data were blocked across replicates with treatment being days held raw and storage days after pasteurization.

RESULTS AND DISCUSSION

Because total bacteria counts remained less than 1000/ml and coliform counts remained less than 100/ml, there were no significant relationships between these bacteria counts and age of raw milk or storage time of the pasteurized product. This agrees with Erhola et al. (4) who showed that extending storage time from 2 to 4 days did not affect markedly either bacteriological or chemical quality of farm stored milk. Psychrotrophic count and age of raw milk were correlated ($P < .01$) for both laboratory and plant pasteurization

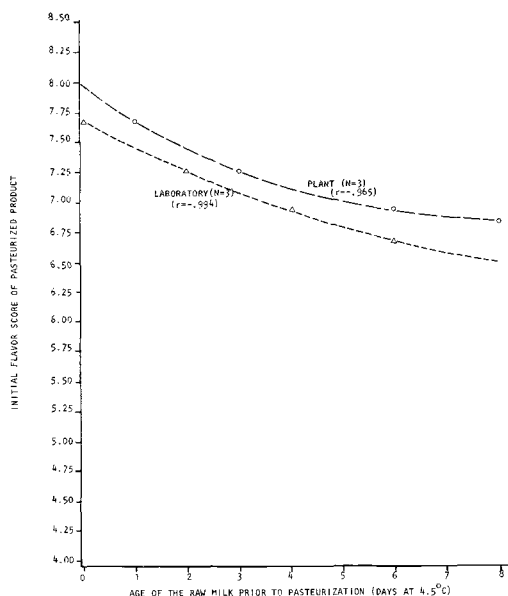


Figure 4. Initial flavor scores of pasteurized vs. age of stored raw milk.

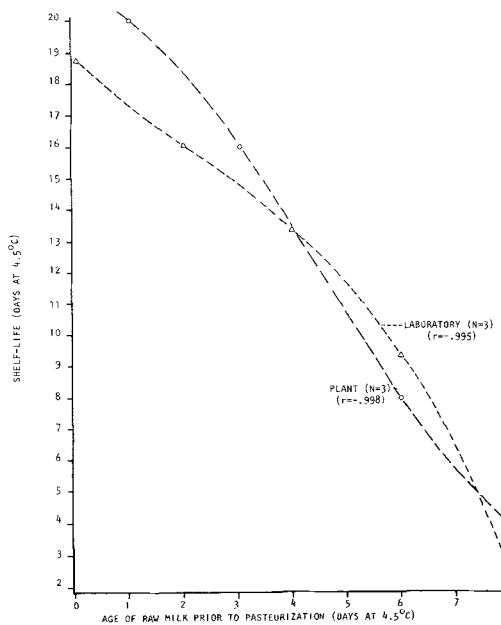


Figure 5. Shelf-life of the pasteurized product vs. days held raw.

(Figure 1). Flavor score decreased significantly when milk was held raw and then stored after pasteurization. Linear correlations were significant ($P < .01$) between flavor score of raw milk and age of raw milk (Figure 2), and flavor score of the pasteurized product and storage time of the pasteurized product (Figure 3). There was also a significant decrease ($P < .01$) in flavor score of the initial pasteurized product as a result of age (days) of raw milk (Figure 4).

Age of raw milk had a significant ($P < .01$) linear effect on shelf-life of the resulting pasteurized product when a cut-off flavor score of ≥ 6.0 was used (Figure 5). Also detected in Figure 5 was a significant difference ($P < .01$) between shelf-life of the pasteurized product and the storage time of the raw milk. Shelf-life of the pasteurized product compared favorably with that reported by Collins and Patrick (3), who found an average shelf-life of 20.2 days when fresh raw milk was pasteurized but disagreed with Hadland and Hoyle (5) who stated that average storage time for homogenized milk was 14 days.

From laboratory data, a predictive equation was formulated to determine the probable shelf life of pasteurized milk as a function of age of

raw milk prior to pasteurization: Flavor score = $8.00 - .088 R - .11 P - .0015 P^2 - .009 R P$, where R = days held raw (4.5°C) and P = days stored pasteurized (4.5°C).

A significant ($P < .01$) linear correlation of .913 was noted when comparing Actual flavor scores from the plant study were correlated .91 ($P < .01$) with calculated flavor scores by the predictive equation.

CONCLUSIONS

A predictive equation would be valuable to the dairy industry for determining shelf-life of pasteurized fluid milk based on the age of raw product stored at 4.5°C. By setting the minimum acceptable flavor score (usually 6.0), one can insert days held raw into the equation and solve for the predictive shelf-life of the pasteurized product. The 8.0 within the equation represents the initial flavor score of fresh raw milk. This would need adjusting depending on the flavor score of the raw milk in question.

REFERENCES

- 1 Adams, D. M., J. T. Barach, and M. L. Speck. 1975. Heat resistant proteases produced in milk by psychrotrophic bacteria of dairy origin. *J. Dairy Sci.* 58:828.
- 2 American Public Health Association. 1978. Standard methods for the examination of dairy products. 14th ed. Am. Publ. Health Assoc., Washington, DC.
- 3 Collins, J. A., and T. E. Patrick. 1972. Shelf-life of milk from retail outlets in northwest Arkansas. *J. Dairy Sci.* 55:666.
- 4 Erhola, A., P. Mykkanen, and O. Nykanen. 1970. Effect of lengthening the storage time on the quality of farm-stored milk. *Karjantuote* 53:314.
- 5 Hadland, G., and T. Hoye. 1974. Bacterial activity and lypolysis in raw bulk milk during storage, as related to the keeping quality of the pasteurized milk. Pages 368 in XIX Int. Dairy Congr.
- 6 Janzen, J. J. 1972. The effect of somatic cell concentration in the raw milk on the shelf-life of the processed product. *J. Milk Food Technol.* 35:112.
- 7 Mayerhofer, H. J., R. T. Marshall, C. H. White, and Lu Margaret. 1973. Characteristics of heat stable protease *Pseudomonas fluorescens* P26. *Appl. Microbiol.* 25:44.
- 8 White, C. H., and R. T. Marshall. 1973. Reduction of shelf-life of dairy products by a heat stable protease from *Pseudomonas fluorescens* P26. *J. Dairy Sci.* 56:849.
- 9 Zall, R. 1981. Blanching milk to extend shelf-life. *Dairy Field* 164:51, 55.