

Effect of storage temperature on the keeping quality of commercially pasteurized milk

M. ZAHAR¹✧, S.R. TATINI², A. HAMAMA³ & S. FOUSSHI¹

(Reçu le 3/07/1995 ; Accepté le 24/11/1995)

تأثير درجة حرارة الخزن على الاحتفاظ بالحليب المبستر

أجري هذا البحث قصد دراسة تأثير درجة حرارة الخزن على مدة الاحتفاظ بجودة الحليب المبستر واستعملت لهذا الغرض عينات من الحليب المبستر جلبت من معملين صناعيين لبسترة الحليب. احتفظ بقسم من هذه العينات في البرودة 7 درجة و القسم الآخر في درجة حرارة 25 درجة. بالنسبة للحليب المبرد 7 درجة بلغت مدة الجودة 5 إلى 6 أيام بينما لم تبلغ هذه المدة سوى 20 إلى 24 ساعة بالنسبة للحليب الغير المبرد 25 درجة كما بلغ عدد الميكروبات الإجمالية عند تعفن الحليب أكثر من 10^7 وحدة في مل بينما كان هذا العدد في اليوم الأول بعد بسترة الحليب 10^3 وحدة في مل فقط. وكانت علامة التعفن متشابهة في عينات الحليب القادمة من كلا المعملين فبالنسبة للحليب المبرد لوحظ وجود علامات : تعفن، مرارة، فاكهة، وتضمن بينما لوحظ في الحليب الغير المبرد علامات : حموضة، مرارة، وتضمن. كما لوحظ تخثر الحليب عند غليانه ساعتين قبل ظهور علامات التعفن بالنسبة للحليب المحتفظ به في 25 درجة، وفي نفس اليوم لظهور علامات التعفن بالنسبة للحليب المحتفظ به في البرودة.

الكلمات المفتاحية : الحليب المبستر - درجة حرارة الخزن - مدة الاحتفاظ بالجودة.

Effet de la température de stockage sur la conservation du lait pasteurisé

Pour étudier l'effet de la température sur la durée de conservation du lait pasteurisé, du lait fraîchement pasteurisé et non homogénéisé provenant de deux laiteries industrielles, a été conservé à 7 et à 25°C. L'évolution du pH, des caractéristiques sensorielles, et de la flore totale du lait a été étudiée durant la période de conservation. L'altération du lait dont le taux microbien initial était de 10^3 UFC/ml a été observée entre le 5^{ème} et 6^{ème} jour de conservation à 7°C. A 25°C, cette durée n'a été que de 20 à 24 heures. Au début de l'altération, le taux microbien a dépassé 10^7 UFC/ml. Les deux laits ont montré les mêmes signes d'altération à savoir la putréfaction, l'amertume, le caractère fruité, et la rancidité à 7°C; tandis qu'à 25°C, les défauts détectés étaient l'acidité, le surissement, et la rancidité. Les échantillons de lait ont montré également le signe de coagulation après ébullition, 2 heures avant l'altération à 25°C alors qu'à 7°C la coagulation du lait a eu lieu le même jour du début de l'altération.

Mots clés: Lait pasteurisé - Température de conservation - Durée de conservation

Effect of storage temperature on the keeping quality of commercially pasteurized milk

To study the effect of temperature on the shelf-life, freshly pasteurized and unhomogenized whole milk from two dairy plants was stored at 7 and 25°C. Microbial, sensory, and pH changes were monitored during storage. Milk of 10^3 CFU/ml, as initial microbial count, showed evidence of spoilage between 5th and 6th day of storage at 7°C. When stored at 25°C, the shelf-life was only 20 to 24 hours. The microbial count at the time of spoilage exceeded 10^7 CFU/ml. Both brands of milk showed similar spoilage characteristics of putrid, bitter, fruity and rancid at 7°C and acid, sour, and rancid defects at 25°C. Milk samples showed clotting on boiling 2 hours before evidence of spoilage at 25°C and simultaneously with spoilage at 7°C.

Key words: Pasteurized milk - Storage temperature - Shelf-life

¹ Département de Technologie Alimentaire, Institut Agronomique et Vétérinaire Hassan II Hassan II. B.P. 6202-Instituts, 10101-Rabat, Maroc

² Department of Food Science & Nutrition, University of Minnesota, St. Paul, MN 55108, USA

³ Département de HIDAOA, Institut Agronomique et Vétérinaire Hassan II, B.P. 6202-Instituts, 10101-Rabat, Maroc

✧ Corresponding author

INTRODUCTION

Pasteurized milk represents more than 80% of the milk processed by the Moroccan dairy plants (Anonymous, 1993). Beside a low bacteriological quality of raw milk, the dairy industry must face a dispersed retail market where handling practices are not always adequate. Available marketed retail packages for pasteurized milk are of half-liter capacity, and consequently, are expected to be used within 1 to 2 days after processing.

However, there have been sometimes evidence of flavor spoilage or clotting upon boiling before use even within this period of 1 to 2 days. This is mainly due to the fact that some store retailers and/or consumers are not aware of the importance of refrigeration on the keeping quality of pasteurized milk. This problem of storage at room temperature is very critical during the hot season where ambient temperature reach 30 to 40°C in most parts of the country.

Shelf-life of pasteurized milk is affected by the number of days held raw (Jansen *et al.*, 1982a), pasteurization, and storage conditions (Finley *et al.*, 1969). In addition, microbial activity is closely related to pasteurized milk spoilage (Jansen *et al.*, 1982b; Hankin *et al.*, 1977; Bishop *et al.*, 1984), and the nature of its microflora is dependent on the storage temperature (Griffiths & Phillips, 1988). Storage temperatures below 7°C are one of the key factors to extend the shelf-life of pasteurized milk (Bernard, 1974).

According to Bernard (1974) and Jansen *et al.* (1982a), every 2.77°C (5°F) rise in temperature cuts shelf-life in half. Hankin *et al.* (1977) reported that the keeping quality of commercially filled cartons stored at 1.7, 5.6, and 10°C remained organoleptically acceptable on the average 17.5, 12.1, and 6.9 days, respectively. Shipe *et al.* (1981) reported a quality keeping period of 13 days for commercial milk at 7°C.

Up to now, there is no information available on the relationship between storage temperature and the keeping quality of pasteurized milk produced in Morocco. Therefore, the purpose of this study was to evaluate the effect of storage temperature on the shelf-life of Moroccan pasteurized milk.

MATERIAL AND METHODS

1. Milk Samples

Two pasteurized milk brands (3.5% fat, unhomogenized) in half liter containers commercially available in the city of Rabat, were used. For one milk brand (brand A) samples were obtained immediately after pasteurization at the processing plant and kept in coolers until arrival at the laboratory, approximately 90 min. after collection. For the other milk brand (brand B), samples were taken from a supermarket immediately after truck delivery and kept cool until arrival at the laboratory in approximately 30 min. Milk samples were obtained in sufficient quantities to allow for separate triplicate packages to be used at different stages of analysis. Half of the samples from each brand were kept in a refrigerator at $7 \pm 1^\circ\text{C}$, and the other half in an incubator at $25 \pm 1^\circ\text{C}$. At different time intervals up to 24-30 hours for samples at 25°C and 6-7 days for refrigerated samples, three units of each brand were randomly drawn for analysis. The experiment was performed twice during a two months period of study.

2. Microbial Enumeration

• Total Aerobic Flora

Petrifilm SM plates (3M) were inoculated. Plates were incubated in a horizontal position with the clear side up in stacks not exceeding 10 units at 32°C for 48 hours (Speck, 1976).

• Coliforms

Petrifilm VRB plates were used for coliforms enumeration. Plates were incubated at 32°C for 24 hours. Coliform colonies appeared red and associated with entrapped gas (Speck, 1976).

3. pH determination

The pH of milk samples was determined using a combination electrode (Orion 91-05) attached to a pH-meter, model 301 (Orion Research).

4. Clotting on boiling (Boiling test)

Test tubes containing 2 ml of milk were placed in a boiling water bath for 5 min. Tubes were then checked for signs of coagulation (Alais, 1985).

5. Sensory evaluation

The sensory evaluation was conducted using a pre-trained panel which consisted of ten milk drinkers among students and laboratory staff. Samples for tasting were coded and served at room temperature. For this purpose, samples kept at 7°C were withdrawn from storage and allowed to equilibrate at room temperature 1 hour before serving. The panelists were asked to rate the acceptability of milk samples on a scale of 1 to 10 (10 = no criticism). They were also invited to comment on the off-flavors of milk samples graded "5" or below.

RESULTS AND DISCUSSION

Figures 1 and 2 show the microbial increase in pasteurized milk samples stored at 7 and 25°C, respectively.

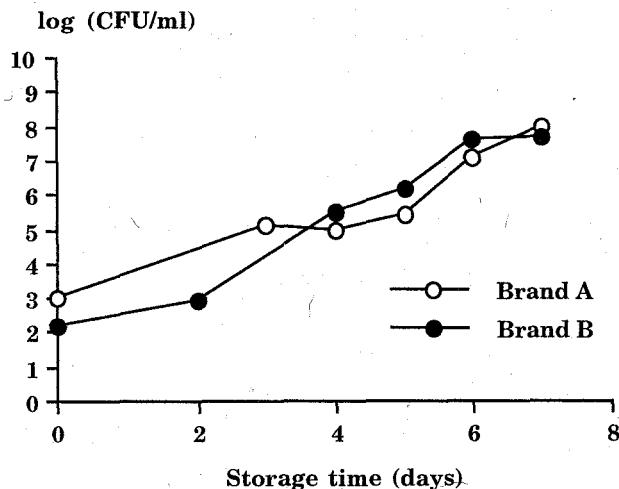


Figure 1. Changes in total aerobic flora counts in pasteurized milk during storage at 7°C

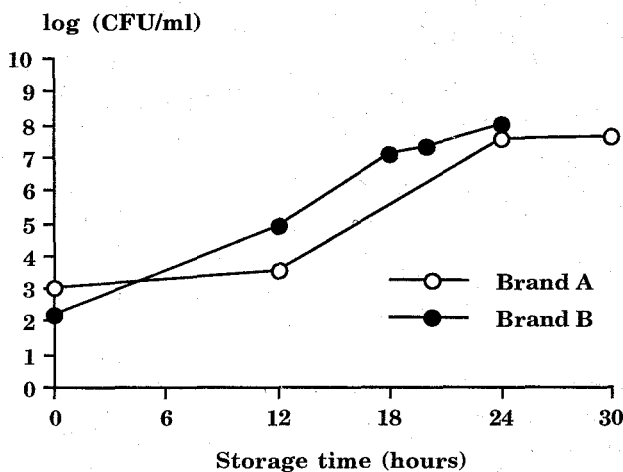


Figure 2. Changes in total aerobic flora counts in pasteurized milk during storage at 25°C

At 7°C, the microbial growth in pasteurized milk samples was very low. From 10^2 to 10^3 CFU/ml at day 0, the total aerobic flora reached 10^5 to 10^6 CFU/ml at day 5 of milk storage. At day 7, the microbial count was between 10^7 and 10^8 CFU/ml. When stored at 25°C, the milk samples supported a relatively rapid microbial growth. In fact, the microbial population reached 10^7 - 10^8 CFU/ml counts after a storage time of only 20-24 hours.

A similar microbial growth rate was seen for both brands of pasteurized milk either at 7°C or at 25°C. These results show the great influence of storage temperature on the relative growth of the microbial populations initially present in milk. Coliforms were undetectable (less than 10 CFU/ml) in both milk brands at day 0.

The pH values of milk sampled at different intervals during storage at 7 and 25°C are shown in Figure 3.

At 7°C, both brands showed only a slight change in pH after 7 days of storage. However, at 25°C the pH decrease was more pronounced for brand A milk samples than for brand B milk at time of spoilage. It seems that for brand B milk, even for storage at 25°C, the quality deterioration was related to a proteolytic activity in contrast to the quality deterioration of brand A milk which was related to a lactic bacteria activity.

The influence of storage time on the sensory scores obtained for milk samples stored at 7°C is illustrated in Figure 4.

The average acceptability scores decreased slightly during the early days of milk storage. However, after 5 days at 7°C, flavor deteriorated rapidly and milk samples were judged unacceptable after 5 and 6 days for brand B and A, respectively. Milk samples kept at 25°C were rejected by the panel after 20 to 24 hours. Milk defects described by judges included acid, sour, and rancid for samples kept at 25°C and bitter, rancid, and slight acid for samples at 7°C. Some brand B samples kept at 7°C were described as fruity and putrid at the time of spoilage. Cooked flavor and flat defects were also mentioned by some panelists at the early stage of storage, which may partially explain the downgrading of samples at that moment.

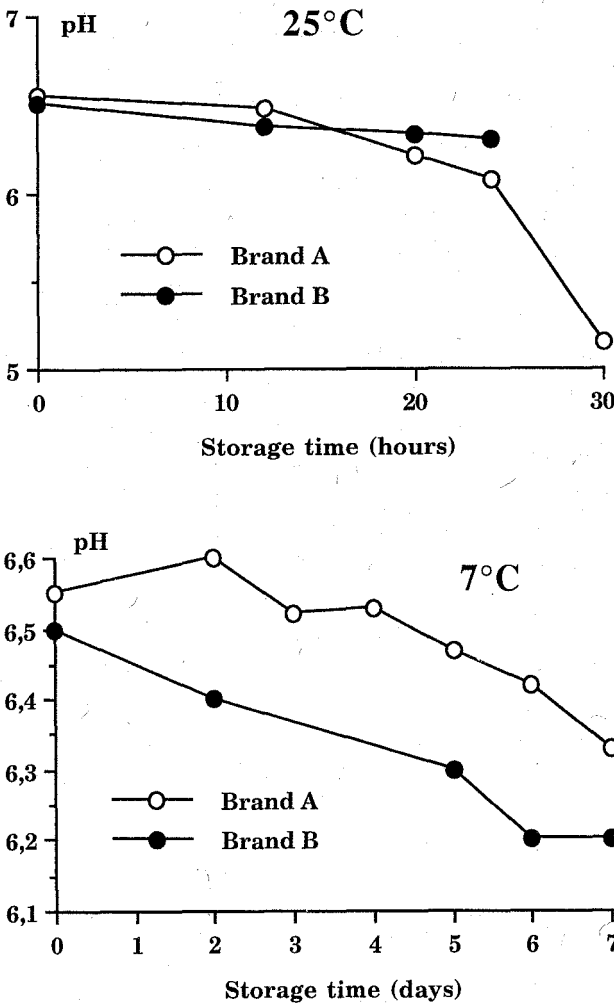


Figure 3. pH evolution in pasteurized milk samples during storage at 7 and 25°C

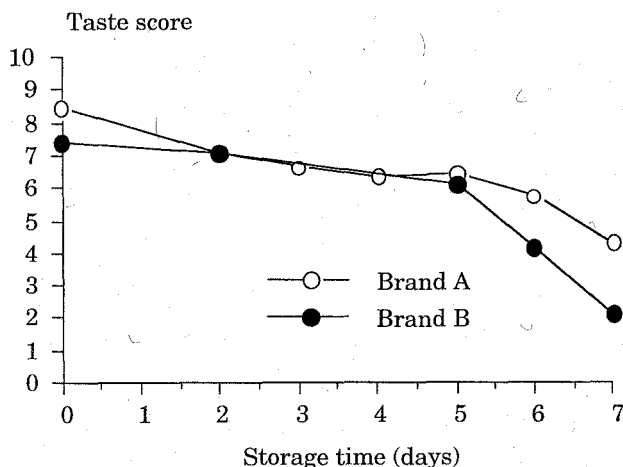


Figure 4. Effect of storage at 7°C on the flavor acceptability score of pasteurized milk

The observed differences in defects in milks stored at the two temperatures may be due to differences in the nature of the flora with storage temperature. Griffiths & Phillips (1988) found that at refrigeration temperatures spoilage was mainly due to the growth of *Pseudomonas* spp. while at storage temperatures above 10°C, *Enterobacteriaceae* and Gram-positive bacteria assumed greater importance in the spoilage of pasteurized milk.

The shelf-life values found at 7°C are shorter when compared to values reported in developed countries. For pasteurized milk stored at 7°C, Shipe *et al.* (1981) reported an average keeping quality of 13 days while Martins *et al.* (1982) reported 9, 12-13, and 15-17 days as values for a short, medium, and long shelf-life.

The relatively short shelf-life found at 7°C for Moroccan milk might be due to the poor bacteriological quality of raw milk delivered to dairy plants. It should be noted that the present study was done during the hot season (June-July) when the raw milk is characterized by high bacterial counts (Amhour, 1993).

Hamama & El Mouktafi (1990) reported average microbial counts of 6.10^6 and $3.3.10^7$ CFU/ml for the pooled raw milk received over a study period of 8 months by dairy plants A and B, respectively. This is probably the reason for using severe pasteurization conditions by Moroccan dairy plants in order to produce a pasteurized milk with lower counts.

However, such reduction of microbial population is not enough to have a product with good keeping quality. Gillis & Custer (1982) found that even repasteurization did not significantly extend the shelf-life beyond that of the same milk that was not repasteurized. Raw milk with counts of 10^6 to 5.10^6 CFU/ml developed objectionable flavors after its pasteurization and subsequent storage (Patel & Blankenagel, 1972; Muir *et al.*, 1986).

The relationship between total aerobic flora and acceptability scores for milk samples stored at 7°C is shown in Figure 5.

For both milk brands, rejection of samples by the panel occurred when microbial counts exceeded 10^7 CFU/ml. Similar results were obtained with samples kept at 25°C. These results support the

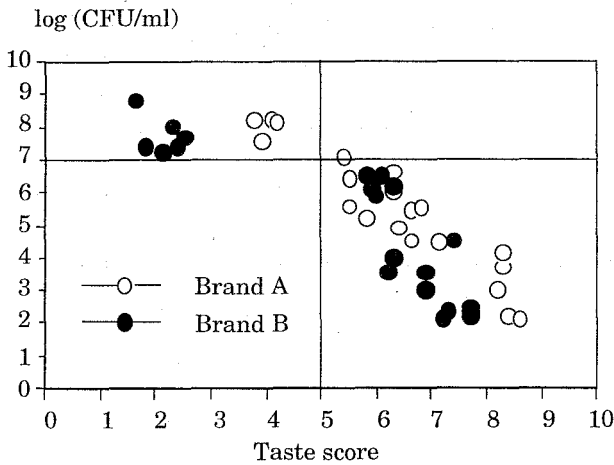


Figure 5. Relation between total aerobic flora count and flavor acceptability score for pasteurized milk samples stored at 7°C

use of the time taken for the bacterial count in the product to reach log 7.5 as a shelf-life of pasteurized milk (Griffiths & Phillips, 1988).

It appears also from Figure 5 that for similar microbial counts, samples of brand B were graded lower than brand A. This may be due to a difference in the nature of the flora and/or their biochemical activities, which can explain some differences in defects at spoilage between samples of the two brands at 7°C.

Some consumers boil pasteurized milk before use and it is discarded when clotted after heating. Milk samples stored in this study at 7°C clotted when using the boiling test on the same day of sample rejection by the panel. For samples kept at 25°C, clotting on boiling occurred 2 hours before sample rejection by the panelists.

In conclusion, shelf-life of unhomogenized pasteurized milk samples analyzed was 5 to 6 days at 7°C and only 20 to 24 hours at 25°C. This indicates the importance of storage at low temperature of pasteurized milk at the store level as well as at home on its keeping quality.

REFERENCES CITED

Alais C. (1985) Appréciation de la qualité du lait cru. Ch. 18. In Sciences du lait. Tome 2. 1ère Edition, Edition SEPAIC, Paris.

Amhourri F. (1993) Qualité bactériologique du lait cru: évaluation et stabilisation par le Système Lactoperoxydase/Thiocyanate/H₂O₂. Cas de la région d'Errachidia. Mémoire de Fin d'Etudes. Institut Agronomique et Vétérinaire Hassan II, Rabat, Morocco.

Anonymous (1993) Le secteur laitier au Maroc. *Développement Industriel* (33) : 28-33

Bernard S.E. (1974) Flavor and shelf-life of fluid milk. *J. Milk Food Technol.* 37 : 346-349

Bishop J.R., White C.H. & Firstenberg-Eden R. (1984) Rapid impedimetric method for determining the potential shelf-life of whole milk. *J. Food Prot.* 47(6) : 471-475.

Finley R.D., Warren H.B. & Hargrove R.E. (1969) Storage stability of commercial milk. *J. Milk Food Technol.* 32 : 382-387

Gillis W.T. & Custer E.W. (1982) Effect of repasteurization on shelf-life of fluid milk. *J. Dairy Sci.* 65 : 220 (Abstract)

Griffiths M.W. & Phillips J.D. (1988) Modelling the relation between bacterial growth and storage temperature in pasteurized milks of varying hygienic quality. *J. Society of Dairy Technol.* 41(4) : 96-102

Hamama A. & El Mouktafi M. (1990) Etude de la qualité hygiénique du lait cru produit au Maroc. *Maghreb Vet.* 5 : 17-19.

Hankin L., Dillman W.F. & Stephens G.R. (1977) Keeping quality of pasteurized milk for retail sale related to code date, storage temperature, and microbial counts. *J. Food Prot.* 40 : 848-853

Jansen J.J., Bishop J.R. & Bodine A.B. (1982) Relationship of protease activity to shelf-life of skim and whole milk. *J. Dairy Sci.* 65 : 2237-2240

Jansen J.J., Bishop J.R., Bodine A.B. & Caldwell C.A. (1982) Shelf-life of pasteurized milk as affected by age of raw milk. *J. Dairy Sci.* 65 : 2233-2236

Martins S.B., Hodapp S., Dufour S. W. & Kraeger S.J. (1982) Evaluation of a rapid impedimetric method for determining the keeping quality of milk. *J. Food Prot.* 45 : 1221-1226

Muir D.D., Griffiths M.W., Phillips J.D., Sweetsur A.W.M. & West I.G. (1986) Effect of bacterial quality of raw milk on the bacterial quality and some other properties of low-heat and high-heat dried milk. *J. Society of Dairy Technol.* 39 : 114-118

Patel G.B. & Blankenagel G. (1972) Bacterial counts of raw milk and flavor of the milk after pasteurization and storage. *J. Milk Food Technol.* 35 : 203-206

Shipe W.F., Senyk G.F., Ledford R.A., Bandler D.K. & Wolff E.T. (1981) Changes in flavor, acid degree value, tyrosine value, and pyruvate content of commercial milks during storage. *J. Dairy Sci.* 64 : 66 (Abstract)

Speck M.L. (Ed.) (1976) Compendium of methods for the microbiological examination of foods. American Public Health Association, Inc. Washington, DC.