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Influence of Pasteurization Before and After Separation of Cream on the Oxidative Stability of Ripened Cream Butter

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ABSTRACT

Ripened cream butter manufactured from cream separated from pasteurized milk (80 C for 15 sec) was more susceptible to oxidative changes than the corresponding butter manufactured from cream which was separated from milk at 50 C and the cream subsequently pasteurised (80 C for 15 sec). The propensity to oxidation is related to changes in copper distribution between the serum and fat globule phases and also to the relative ratio of serum to fat at the time of pasteurization.

The thermal treatment of cream for buttermaking differs in different regions of the world. On the European continent, milk is preheated for separation and the cream is then pasteurized and ripened for manufacture of butter. Most manufacturers of sweet cream butter in Ireland pasteurize milk at 80 C for 15 sec and then cool by regeneration for separation. In some instances cream is repasteurized at temperatures ranging from 80 to 95 C. In recent years the manufacture in Ireland of ripened cream butter for export has increased. The susceptibility of ripened cream butter to oxidative deterioration is well established.

In view of the studies by Samuelsson (*12*) and the more recent studies in this laboratory (*3*) on the changes in copper distribution between the serum and cream phases during heat treatment and the influence of the latter on oxidative changes in cream, it was decided to study the influence on lipid oxidation of pasteurization pre and post separation of cream for the manufacture of ripened cream butter.

MATERIALS AND METHODS

Cream treatment

Creams containing 35% fat for manufacture into ripened cream butter were obtained from bulk milk. The following treatments, designated A and B, were applied to the milk.

A. Part of the milk was pasteurized at 80 C for 15 sec in a plate heat exchanger and separated after regenerative cooling to 50 C. The cream was then cooled to 10 C in the cooling section of the plant.

B. The remainder of the milk was heated to 50 C for separation. The cream was pasteurized at 80 C for 15 sec and then cooled to 10 C in the cooling section of the plant.

Butter samples

Both creams were ripened with a lactic culture to a pH of 4.6 and were not neutralized before churning. After ripening they were cooled to 10 C, held overnight, and individually churned. The moisture and salt contents were controlled to 16.0 and 0.8%, respectively. After working, butters were printed into 1-lb rectilinear prints, wrapped in parchment, and placed in a store at −20 C. Three replications of the experiment were made.

Peroxide values of the samples were determined at 1 and 8 weeks after 0, 12, 24, and 36 h in a display cabinet at 5 C at a light intensity of 50 lumens/ft^2. Peroxide analyses were also made after 4, 6, 8, and 9 months storage at −20 C and after holding these samples for one week at 10 C.

Peroxide test

Peroxide analyses were made by the ferric thiocyanate method of Loftus Hills and Thiel (*10*) as modified by Holloway (*5*). Quantities of 0.5 ml or 0.1 ml of fat were used depending on the expected magnitude of the peroxide values which are expressed as m equiv of oxygen per kg of fat.

Determination of copper

A modification of the method of Mertens et al. (*11*) was used. A 50-g portion of butter was melted at 43-45 C in a 250-ml beaker. After gravity separation, the fat layer was decanted. Traces of curd remaining in the fat were washed free of fat with petroleum ether and the curd added to the serum. The serum was dried in an oven at 102 C and the residue ashed in a muffle furnace at 550 to 600 C for 10 to 12 h until a white colored ash was obtained. When cooled, the ash was dissolved in 15 ml of a nitric acid and 10 ml of perchloric acid. The acids were then boiled off for 20 min (using a glass reflux) until about 1 to 2 ml remained. After cooling, distilled water was added to give a final volume of 20 ml.

The copper concentration of this solution was determined with a Perkin-Elmer Atomic Absorption Spectrometer using the following instrument settings: wavelength, 3257A°; oxidant, air at 45 psig pressure and a flow rate of 26.5 1/min; fuel, acetylene gas at 8 psig pressure and a flow rate of 3.5 1/min; lamp current, 8 ma. Readings were made against a reagent blank of nitric acid and perchloric acid carried through the same procedure i.e. evaporating 1-2 ml by boiling and subsequent dilution with distilled water.

Glassware

All glassware, after washing with hot detergent solution, was steeped for 24 h in dilute nitric acid and then thoroughly rinsed with deionized water and dried.

RESULTS

When milk was heated to 50 C for spearation and the cream subsequently pasteurized at 80 C × 15 sec the cream had considerably lower peroxide values after holding under light than cream separated at 50 C from milk which had been previously pasteurized at 80 C (Fig. 1).

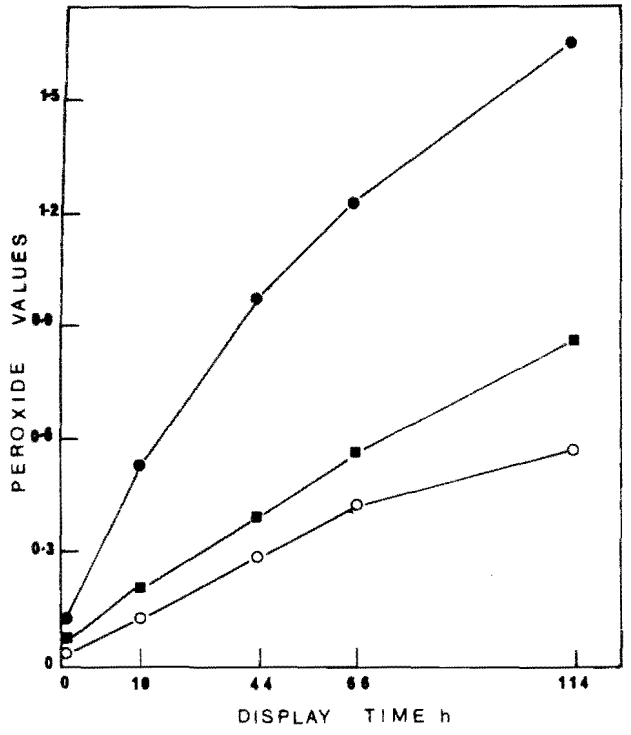

Figure 1. *The effect of pasteurization before and after separation on the peroxide values of cream before and after display of the cream under fluorescent light.* O—O *Control; milk preheated to 50 C, separated cream cooled to 5 C.* •—• *Milk pasteurized at 80 C for 15 sec, separated at 50 C, cream cooled at 5 C.* ■—■ *Milk preheated to 50 C, separated, cream pasteurized at 80 C for 15 sec, cooled to 5 C.*

An unpasteurized control sample separated from milk at 50 C gave lower peroxide values than either of the heat treated samples. The control sample, rather than becoming oxidized tended towards hydrolytic rancidity.

Figure 2 shows that butter B made from the cream which had received treatment B had lower peroxide values after 1 week at -20 C and after display under fluorescent light for up to 36 h than butter A made from the cream subjected to treatment A.

After 2 months at -20 C the peroxide values had increased considerably. (Fig. 3).

Butter B continued to have lower peroxide values before and after exposure to fluorescent light than butter A. At this stage, butter A had a peroxide value over 1 before display which is about the value at which an oxidized flavor becomes noticeable in sweet cream butter (*4*). The same definite trend was evident in the two other replications of the experiment.

Table 1 shows the peroxide values of butters A and B

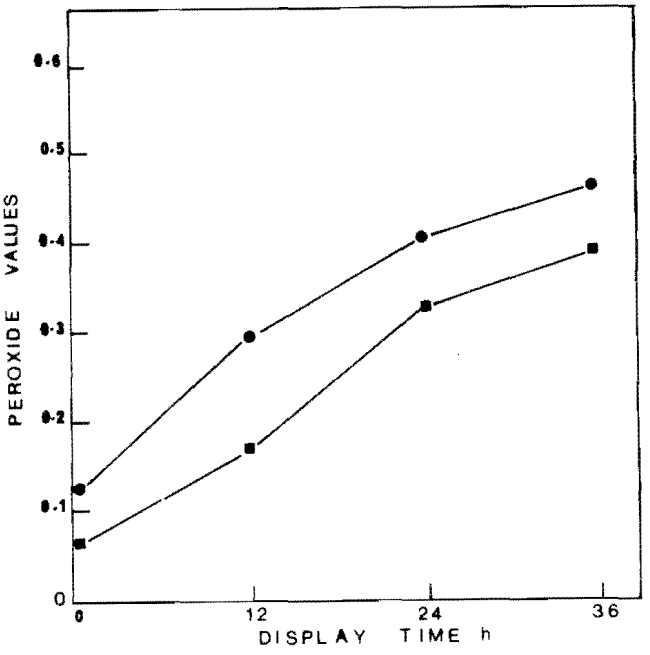

Figure 2. *The effect of pasteurization before and after separation on the peroxide values of ripened cream butter after 1 week of -20 C and after display under fluorescent light for up to 36 h.* •—• *Butter A-milk pasteurized at 80 C for 15 sec, separated at 50 C, cream ripened, cooled, and churned.* ■—■ *Butter B-milk preheated to 50 C, separated, cream pasteurized at 80 C x 15 sec, ripened, cooled, and churned.*

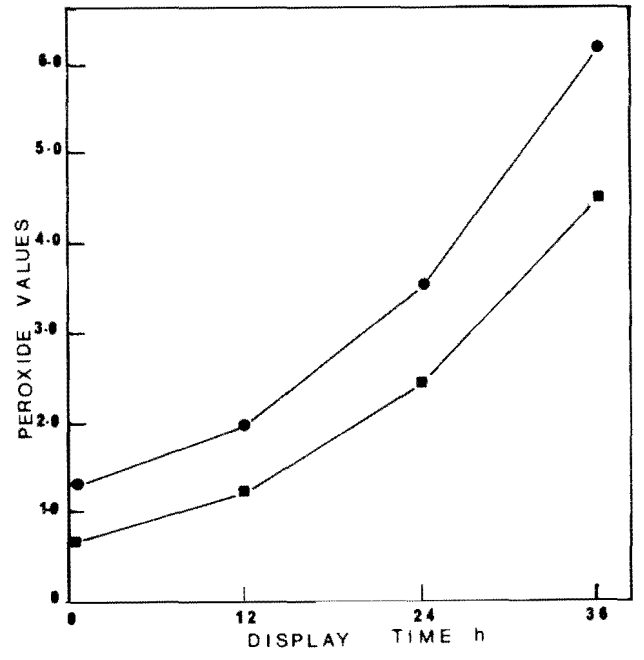

Figure 3. *The effect of pasteurization before and after separation on theperoxide values of ripened cream butter after 2 months at -20 C before and after display under fluorescent light for up to 36 h.* •—• *Butter A-Milk pasteurized at 80 C for 15 sec, separated at 50 C, cream ripened, cooled, and churned.* ■—■ *Butter B-Milk preheated to 50 C, separated, cream pasteurized at 80 C for 15 sec ripened, cooled, and churned.*

after cold storage at -20 C for 4,6,8 and 9 months and after holding these samples for 14 days at 10 C. The greater pro-oxidant tendencies of butter A is evident in all comparisons.

TABLE 1. *Peroxide values of butters A and B after extended storage at -20 C and after holding the stored butters at 10 C for 2 weeks*

Storage time (months)	Held at -20 C		Held at -20 C and 2 weeks at 10 C	
	(A)	(B)	(A)	(B)
4	1.04	0.70	1.37	1.13
6	1.20	0.94	1.41.	1.12
8	3.37	1.05	3.52	1.95
9	4.80	2.00	6.92	3.62

Table 2 gives the copper concentrations of butters A and B for the three replications of the experiment.

TABLE 2. *Copper concentrations (ppm) of ripened butters manufactured from differently treated creams (A and B)*

Trial	Copper concentration (ppm)	
	Butter A	Butter B
1	0.068	0.035
2	0.063	0.047
3	0.060	0.048

Concentrations of copper in series B are distinctly lower than those in series A. Evidently, the different cream treatments influenced the copper concentrations of the respective butters which in turn influenced their oxidative stability.

DISCUSSION

Ripened cream butter is manufactured in Ireland mainly for export to Germany and to certain areas of the United Kingdom where there is a preference for the ripened cream variety. It is more susceptible to flavor deterioration during storage than unripened butter. The level of copper is a critical factor in oxidative degradation of butterfat and the catalytic effect of copper is far greater in ripened than is sweet cream. Koops (*8*) showed that by lowering the pH of cream to 4.6 about 30 to 40% of added copper migrated from plasma proteins to the fat globule membrane.

He also showed that the phospholipid fraction, cephalin in particular, oxidized more rapidly when the pH was lowered. Oxidation of fatty acids occurred as oxidation proceeded (*9*). The serum of ripened cream butter, which is not washed during manufacture, is rich in phospholipids.

Factors other than processing may influence the level of copper in cream. Thus the copper content of milk varies with the stage of lactation (*6*). Cooling fresh milk to 6 C for 2 h reduces the copper content of cream (*2*). The milk used for this study was in the main held in refrigerated stainless steel bulk tanks on farms before delivery to the creamery and was unlikely to contain much contaminating copper. Both natural and contaminating copper have a catalytic effect on off-flavor development during cold storage of butter (*8*).

Foley et al. (*3*) noted that the oxidative stability of cream decreased progressively as the temperature treatment was increased from 60 to 95 C. They showed that the pro-oxidant influence was associated with migration of copper from the cream serum to the fat globule phase when cream was heated.

According to King et al. (*7*), Samuelsson (*12*), and Aulakh and Stine (*1*), the greater portion of copper in milk is in the serum phase and associated with the milk protein fraction. It is likely therefore that the ratio of serum to fat in a system would influence the extent of copper migration during heat treatment. Samuelsson (*12*) when studying the effect of heat treatment on distribution of added labelled copper, found that the serum to fat ratio influenced the amount of copper which migrated from the serum to the fat globules. Van Duin and Brons (*13*) showed that pasteurization of milk before centrifugation gave a relatively high copper content in the resultant cream.

When the ratio of serum to fat is high, as in milk, more copper associates with the fat during the heat treatment than happens when the ratio is lower in a product like cream. Thus the concentration of copper in butter A obtained from pasteurized milk (80 C) is higher than in butter B, the cream for which was pasteurized (80 C) post separation, when the serum to fat ratio was reduced from about 24:1 to approximately 2:1. The increased susceptibility of cream A to photocatalyzed oxidation is almost certainly due to its higher copper content (*3*). Likewise, butters made after treatment A had higher peroxide values after holding at -20 C and after exposure to light than butters from cream subjected to treatment B. The higher levels of copper in butters A explains their lower oxidative stability.

The study clearly shows that the practice of pasteurizing milk, before separation of cream, is not conducive to oxidative stability of ripened cream butter. Separation of milk preheated to 40 to 50 C and subsequent pasteurization of cream gives better results.

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