

STUDIES ON FROZEN MILK

By

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B.Sc.Agric.Sc. (Dairy Science and Technology), Ain Shams University, 2003

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ABSTRACT

Mohammed Yousef Mohammed Abo El-Naga: Studies on Frozen Milk. Unpublished M. Sc. Thesis, Department of Food Science, Faculty of Agriculture, Ain Shams University, 2010.

One of the major obstacles to the successful marketing of frozen milk product has been the instability of milk proteins during frozen storage. Destabilization of proteins in milk during frozen storage is known to involve mainly the casein fractions and depend on a number of factors including time and temperature of storage, and degree of milk concentration.

Fresh buffaloes' milk cooled to 4°C was transported to the laboratory within 1h in isothermal containers. Raw milk was skimmed using laboratory milk separator (at 40 °C). Raw and skim milk was pasteurized at 75 °C for 15 sec. followed by cooling to 4°C. The milk was packaged into special plastic pages (300 ml each), four types of milk samples were obtained i- Raw whole milk samples, ii- pasteurized whole milk samples, iii-Raw skim milk samples and iv- pasteurized skim milk samples. All of these samples were stored in deep freezer at - 22± 2°C for 12 weeks

During storage the pH decreased to a minimum during the first 2 to 4 weeks of storage and increased gradually thereafter. Total nitrogen contents and non protein nitrogen contents (NPN) of fresh and frozen milk were nearly similar. Total bacterial count in buffalo frozen milk decreased during frozen storage. The obtained data revealed more total viable counts, yeasts and moulds and Psychrophilic bacterial counts in raw whole milk samples than the other kinds of pasteurized whole milk, raw skim milk, and pasteurized skim milk examined. In raw whole milk the lightness (L-values), were decreased, while redness (a-values) were increased during storage period.

Rheological properties of raw and pasteurized whole and skim milk during frozen storage period of 12 weeks at $-22\text{ }^{\circ}\text{C} \pm 2$ were also measured. Differences between shear stress values of ascending and descending curves were negligible so, no remarkable hysteresis was observed. Obtained shear stress values were found to be dependent on type, treatment and fat content of the milk. Flow curves of raw skim milk showed almost linear relationship between shear stress and shear rate values, which in turn express a Newtonian behaviour. Increasing fat in milk did not greatly influence the obtained shear stress values as well as the linear characteristic of the obtained flow curves. Storage of pasteurized milk either whole or skim at $-22\text{ }^{\circ}\text{C} \pm 2$ gave the highest viscosity values, compared to that of tested raw milk samples. The average surface tension of skim milk was higher about 2 mN/m than that of raw whole milk.

The second part of study was carried out to evaluate the effect of freezing conditions on concentrated milk either in whole or skim form. Retentate was adjusted to obtain concentration factor 2X and 3X in both forms. Retentate treatments of (whole and skimmed) were packaged into PVC cups (300 ml) and frozen at $-22\pm 2^{\circ}\text{C}$ for 12 weeks. The samples were tested for chemical, physical, and microbiological properties when fresh and followed up weekly till the end of storage period (3 months). Concentration of the milk by Ultrafiltration decreased the pH slightly with increase in concentration. During storage at $-22\text{ }^{\circ}\text{C}$. for all samples the ethanol stability and heat stability decreased to a minimum during the first 3 weeks of storage and increased gradually thereafter. Concentrated skim milk 3X had higher specific gravity than 2X milk samples. The total nitrogen contents and non protein nitrogen (NPN) contents of concentrated frozen milk when fresh and during storage at $-22\text{ }^{\circ}\text{C}$ were nearly similar. Frozen storage of milk samples resulted in a remarkable decrease in the surface tension values. The curd syneresis

decreased in all treatments by increasing storage period. The decrease in curd syneresis during storage could be correlated to the differences in chemical composition of concentrated milk.

Key words:

Frozen buffalo milk, chemical composition, microbiology, rheological properties, surface tension, technological properties.

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1. INTRODUCTION

During World War II, frozen homogenized milk was used to supply fresh milk to patients on hospital ships. Usually this milk was very acceptable when thawed after having been stored under a frozen condition for 3 months and frequent reports indicated that its acceptability was good after 6 to 9 months of storage. Instances occurred, however, where the milk was unacceptable when thawed after storage for less than 3 months. In these instances either a separation of the caseinate system had occurred or the milk had developed an oxidized flavor.

When milk is frozen, water converts to ice; the freezing point is decreased because of greater concentration of milk solids in smaller amount of unfrozen water. Milk should be frozen quickly to yield small ice crystals. Slow freezing can yield larger ice crystals and these can rupture fat globules yielding fat separation. Most market milk is homogenized so the effect of fat separation is minimized. If however, unhomogenised milk is frozen, there is greater possibility of fat separation. It is good to remember that smaller containers with larger surface area to volume ratio will freeze faster than larger containers. The container should not be full when liquid milk frozen as the milk volume increases during freezing and this may be ruptures the container. In plastic bags, with a little extra space milk should be okay. Thawing is best done slowly by leaving frozen milk in the fridge overnight or for long periods. During the thawing process, thawed milk may appear inconsistent or may show separation of components. Some of these effects disappear after gentle mixing of thawed milk.

Freezing has no significant effect on the proteins of milk. Defects cannot be detected after thawing, even though the product

may have been solidly frozen. On frozen storage, however, the calcium caseinate-phosphate complex is affected. With time it loses its stability and on thawing appears as a precipitate. One of the very important effects of freezing milk and cream is the destruction of the fat emulsion. The inadvertent partial freezing of milk or cream may lead to an oily layer of fat on the surface. Demulsification and coalescence of the fat are caused by the internal pressures set up in the freezing milk by ice crystals, and the degree is closely related to the extent of freezing. Even mild freezing, as it sometimes occurs on the tubes of a surface cooler during the cooling process has an effect on the normal fat emulsion of milk, in as much as the subsequent creaming ability of such milk is reduced. Homogenization prior to freezing almost entirely overcomes the demulsification of the milk fat apparently the smaller fat globules produced by homogenization are less easily deformed and the newly adsorbed surface layer are less prone to rupture by expanding ice crystals. Very rapid freezing minimizes the destructive effects on the fat emulsion. The calcium caseinate-phosphate complex flocculated during frozen storage of milk has been found to be similar to but not identical with that existing in normal milk. It is associated with more calcium phosphate, and electrophoresis patterns indicate that both the precipitated protein and serum protein fractions are somewhat altered by frozen storage. Flocculated casein contains less β -casein than normal acid casein, and has been shown to have characteristics similar to casein salted out of milk by saturation with NaCl. Several workers have suggested that the unfrozen solution, highly concentrated in salts, exerts such an effect in destabilization of casein.

The possibility of preserving milk by freezing has been of interest to food. One of the major obstacles to the successful marketing of frozen milk product has been the instability of milk proteins during frozen storage. Destabilization of proteins in milk