THE MANUFACTURE OF CHEDDAR AND SURATI TYPE CHEESE WITH VEGETABLE FATS AND NONFAT DRY MILK

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ABSTRACT

THE MANUFACTURE OF CHEDDAR AND SURATI TYPE CHEESE WITH VEGETABLE FATS AND NONFAT DRY MILK

by Talari Vishwas Rao-Jude

The feasibility of manufacturing satisfactory Cheddar type and Surati type cheese by combining vegetable fat and nonfat dry milk (NDM) was studied. "Emulsion" or "cheese milk" in this study refers to reconstituted NDM containing vegetable fat. Two methods were employed in preparing the "cheese milk." Method I involved the preparation of a 20 percent fat mixture which was pasteurized at 145°F. for 30 minutes and homogenized at 500 p.s.i. and 140° to 143°F., and subsequently combined with the remainder of the reconstituted NDM resulting in 3.5 percent fat. Method II involved the preparation of 3.5 percent fat "cheese milk" which was pasteurized at 145°F. for 30 minutes and homogenized at 500 p.s.i. and 140° to 143°F. Method II was also used to prepare 6 percent fat "cheese milk" for the manufacture of Surati type cheese (a soft variety in India).

Emulsifiers type 2 lecithin and mono- and diglycerides were added at the rate of 0.05 percent on the fat basis. Emulsions were studied to determine the average fat globule size and their stability tested at various intervals of

time. Cheddar type cheese was stored at $50^{\circ} \pm 1^{\circ}$F. for 120 days. The products were scored organoleptically for flavor, body and texture. They were analyzed for fat, moisture and total solids content. The final yield was obtained.

Homogenization of the "cheese milk" caused a break up of the vegetable fat globules with the majority being 3 microns or smaller in size. Fat losses in the whey were determined by the modified Babcock method and averaged 0.09 percent as compared with 0.31 to 0.41 percent resulting from normal whole milk Cheddar cheese. The use of emulsifiers had no significant effect in reducing the fat loss in whey when compared with trials where no emulsifier was used.

As homogenization pressures were increased, the stability of the emulsion was also increased when examined after quiescent storage. At 500 and 1,000 p.s.i. the fat globules rose to the surface more rapidly to form an objectionable fat layer.

Quite satisfactory Cheddar type cheese was prepared from "cheese milk" of Methods I and II. Average organoleptic scores of cheese made by Method I "cheese milk" were as follows: those with no emulsifier were 37.20 for flavor and 27.09 for body and texture; those containing lecithin were 37.24 for flavor and 26.97 for body and texture; those containing mono- and diglycerides were 37.19 for flavor and 26.74 for body and texture. Slightly lower average organoleptic scores were given to cheese made by Method II "cheese milk." Cheese that did not contain an emulsifier was given an average score of 36.20 for flavor and 26.84 for body and texture. The cheese product containing lecithin scored 36.79 for flavor and 27.21 for body and texture. The most common criticisms were unnatural, oily, foreign fat and slight bitter, whereas body and texture was weak, short, open and crumbly. All the Cheddar type cheese were comparable with those made from normal whole milk in fat, moisture and total solids content. The average yield of Cheddar type cheese was slightly higher (10.64 percent) than often reported for normal whole milk Cheddar cheese.

Although a lower fat loss occurred in the cheese product whey (0.08 to 0.09 percent) as compared to normal whole milk cheese whey (0.39 percent), there was no significant reduction in fat loss due to the use of an emulsifier.

A comparison of the ingredient cost, revealed that the Cheddar type cheese made from vegetable fat was about 10.85 cents per pound lower than normal whole milk Cheddar cheese.

The flavor of Surati type cheese made from 6 percent vegetable fat "cheese milk" compared quite favorably with control cheese. However, the body and texture of Surati type cheese made from vegetable fat "cheese milk" was often criticized as weak and soft. Nearly 1.0

to 1.2 percent higher yield was obtained in the vegetable fat product as compared to a control, which was largely attributed to a greater moisture content. The average yield of Surati cheese was 20 percent of the weight of milk.

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A THESIS

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Dedicated to

my parents, my family and to

the people of developing countries

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INTRODUCTION

The continuous search or development of new foods that will meet the food requirements of the growing populations has become an urgent need. Developing countries are presently facing the prospect of a food supply shortage. This shortage necessitates a careful exploration into effective use of available raw material to be converted into edible, wholesome and nutritive food products. Cheese is a good food in the human diet and could help alleviate malnutrition in food deficient countries.

The objective of this study was to determine the possibility of manufacturing cheese type products after combining vegetable fat and reconstituted nonfat dry milk (NDM).

Cheese is an excellent source of protein, fat, calcium and several vitamins. The keeping quality of hard types of cheese is favorable. Of the better known cheese in the Western hemisphere, Cheddar cheese is commonly manufactured in India. Surati cheese, a soft variety, made from buffalo milk, is the best known of the indigenous cheese in India. The present cheese market, and the import restrictions placed on the foreign cheese into India, imposes a challenge to manufacture cheese products in a large quantity.

The total production of milk in the Indian Union in 1962 was reported (2) at 50 billion lb., of which a negligible quantity was converted into cheese. According to Krishnaswamy and Johar (19) the annual imports of cheese during the most recent years for which figures are available, 1955, were 925,000 lb.

The population explosion poses additional problems. Based on a conservative estimate of 1.5 percent increase per annum, India's population by 1981, may be 528 million. Basing the increase on a 2 percent population growth, the number could swell to 600 million (Sen, 38). Such a great increase in population presents problems in meeting requirements for wholesome food products possessing good keeping quality. The problem exists not only in India, but in many countries of the world.

India produces 4 to 5 million tons of vegetable oil annually, ranking the number one producer in the world (47). Nearly a third of the world's peanut oil is produced in India. The use of vegetable oils as a food fat has significant value in the economy and in meeting the nutritional requirements of the country.

Reconstituted NDM is an excellent source of animal protein. Milk serum solids are the only source of animal protein in India for the people who are vegetarians. The country produces a negligible quantity of NDM. However, a considerable quantity is received through donations and purchases from the United Nations International Children's

Emergency Fund, Australia, New Zealand, United Kingdom and the United States of America.

If NDM and vegetable fat can be combined to produce acceptable cheese products, the nutritional needs of many developing countries will be enhanced. Seasonal variations in milk production would have little effect in the manufacture of cheese type products made by combining ingredients.

REVIEW OF LITERATURE

The manufacturing process and the quality of Cheddar type cheese made from reconstituted NDM combined with milk fat or vegetable oil has been of interest during the past few years.

1. Homogenization of ingredients

Snyder and Hansen (39) reported Cheddar cheese made from raw whole milk, raw homogenized milk, or from milk containing as little as 10 percent of raw homogenized milk or cream, developed a rancid flavor which persisted to the last examination after 24 hours.

Nichols (25) reported a procedure for commercial manufacture of non-fat-leaking Cheddar type cheese. The process involved the separation of whole milk, followed by homogenization of the resulting cream, with a three stage homogenizer. Sufficient pressure was developed to reduce most of the fat globules to less than 2 microns in diameter. Homogenization pressures used in a three stage homogenizer were 2,200, 650 and 150 p.s.i. at 160^{o}F. Cream obtained from the separator containing 40 percent milk fat was diluted with equal portions of hot water and homogenized. This cream had a desirable consistency and 85 percent of the fat globules were less than 2 microns in diameter.

After blending the homogenized cream and skim milk together, the normal procedure for making Cheddar type cheese was followed.

Schwartz and Mumm (37) prepared cheese milks from fresh, raw, whole milk; pasteurized whole milk; and flash pasteurized skim milk and cream, subsequently homogenized between 2,200 and 2,940 p.s.i. at 104^{o} to 149^{o}F. Investigations revealed that cheese made from homogenized fresh, raw, whole milk exhibited rancid flavor and that due to other factors it was not recommended as being feasible for commercial operations.

Maeno and Sato (22) reported that a good quality cheese product was prepared from skim milk homogenized from 3 percent vegetable or animal fat. Peters (29) obtained a satisfactory Cheddar type cheese from milk prepared by mixing fresh skim milk and vegetable oil "filled milk." Similarly Cheddar cheese was prepared by combining reconstituted skim milk and vegetable oil "reconstituted filled milk." In both cases, homogenization pressures of 1,000 p.s.i. or less at 131^{o}F. were found to be superior to higher pressures in preserving curd characteristics. Body and texture scores were similar in cheese from "filled milk" and "reconstituted filled milk."

Kemeny (17), an Israeli worker, reported on the manufacture of hard cheese using low-heat NDM and homogenized milk fat. Lodin and Brelin (20), Swedish investigators, separated whole milk in a hermetic separator at

131°F. and pasteurized the skim milk in a plate heater at 161.6°F. for 20 seconds. Part of the skim milk was mixed with 10 to 15 percent corn oil at 131°F. and homogenized at a pressure of 1,440 p.s.i. The homogenized "corn oil cream" was then added to the remainder of the pasteurized skim milk resulting in a fat content corresponding to that desired on a dry matter basis. Svecia type and Port Salut type cheese were prepared from the "filled milk." After 4 months, Svecia type cheese differed in some respects from normal whole milk Svecia type cheese. The flavor was slightly acid and it had a weak aroma. The corn oil cheese had a characteristic off flavor and a weak and short body. The Port Salut type cheese generally appeared to fulfill the quality standards for this type of product. The resulting cheese of both types were somewhat poorer in quality than whole milk cheese, but usable for dietetic purposes.

The beneficial effects of homogenizing cream and subsequent recombination with skim milk in the manufacture of Gorgonzola and Niva cheese have been reported anonymously (1) from Czechoslavakia. Cream was homogenized at 1,470 to 2,200 p.s.i. and 167° to 176°F. and subsequently, recombined with skim milk. A relatively acceptable cheese was obtained.

Peters (28) and Peters et al. (30) investigated the manufacture of Cheddar type cheese from fresh, pasteurized whole milk, homogenized at 0, 500, 1,000 and 2,000 p.s.i. at $120^{\circ}F$. respectively. Homogenizing milk at increased pressures resulted in abnormal matting characteristics of curd during cheddaring and pressing operations. Homogenization pressures of 500 and 1,000 p.s.i. at $120^{\circ}F$. did not appear to have a deleterious effect on the curd during cutting, cooking, or cheddaring. However, a slight decrease in elasticity and matting property was noted. The differences in body and texture scores were found to be significant between 0.10 and 0.05 level of probability of chance occurrence with 500 and 1,000 p.s.i. resulting in superior body and texture.

Peters (32) prepared cheese milk by reconstituting Extra Grade low-heat NDM, tap water and unsalted cream butter. The resulting milk of 4 percent milk fat was homogenized at 1,000 p.s.i. and $120^{\circ}F$. A control whole milk containing 4 percent milk fat was standardized for comparative cheese manufacture by using skim milk. Such milk was used in the manufacture of raw and pasteurized Cheddar cheese. Trace minerals and Lactobacillus casei culture were added to note the effect on product quality. Results of this study indicated that the addition of trace minerals helped to improve the flavor, whereas, the addition of Lactobacillus casei improved the body, especially in reconstituted milk cheese.

2. Microscopic examination of emulsions

The microscope has been effectively and extensively used to determine fat globule size in emulsions and milk products. Burr and Weise (4) warned that skill and experience are necessary to obtain useful results.

Doan (9) made microscopic examinations of so called "viscolized" milk. Parfitt (27) also used the microscope to examine and determine homogenization efficiency. The Creamery Package Manufacturing Company (5) considered homogenization of milk to be good when 90 percent of the fat globules were under 2 microns in diameter.

Farrall, et al. (12) similarly developed a microscopic technique to check homogenization efficiency of milk. This technique utilized a standard dilution, counting the number of fat globules that are over 2 microns in 5 fields and then calculating the index known as the Farrall index.

Putnam (34) suggested that microscopic examination of 5 fields using a magnification of 1,000 and counting globule size in microns, would indicate an accurate test of evaluating homogenization efficiency.

The United States Public Health Ordinance Code (48, 49) defines homogenized milk as, "milk which has been treated in such a manner as to ensure breakup of fat globules to such an extent that after 48 hours of quiescent storage no visible cream separation occurs on the milk and the fat percentage of the top 100 ml. of milk in a quart bottle, or of proportionate volumes in containers of other sizes (50 ml. per pint and 25 ml. per one-half pint) does not differ by more than 10 percent of itself from the fat percentage of the remaining milk as determined after thorough mixing." However, problems were encountered in obtaining valid results (Trout and Scheid, 46; Doan and Mykleby, 10; Judkins, 16; and Doan, 11). These workers and also Steel (41) found it difficult to remove all of the cream that had risen to the top 100 ml. They found that simply by pouring the top 100 ml. was better and preferable to syphoning for the homogenization efficiency test of milk. Nichols (25) used this technique and found that 85 percent of the fat globules were less than 2 microns in diameter and were dispersed evenly.

3. Fat losses in whey and yield of cheese

Several investigators have observed the beneficial effects of homogenization of milk used for cheese manufacture. The decreased fat loss in whey and an increase in yield were noted.

Nichols (25) homogenized 20 percent butterfat cream and mixed this cream with skim milk to the desired fat content on a dry matter basis. Cheese was then made from this milk. Fat losses in the cheese whey were 0.08, 0.07 and 0.09, 0.08 percent as determined by the Babcock and normal butyl alcohol modification of Babcock test, respectively. Fat test of whey determined by the normal butyl alcohol method varied from 0.06 to 0.12 percent. Whey from control vats of normal whole milk cheese varied from 0.30 to 0.40 percent fat. Yields of cheese were reported somewhat higher from reconstituted milk than from normal whole milk. The average yield per pound of milkfat from reconstituted milk and normal whole milk Cheddar cheese was 2.79 and 2.61 per pound, respectively. According to Nichols (25) factors responsible for increased yields were:

a. The reduced fat losses in manufacture of cheese,

b. The reduced fat losses during storage of cheese, and

c. The higher moisture content of cheese (39.26 as compared to 36.44 percent in control).

Homogenization pressures ranging from 2,205 to 2,940 p.s.i. at 104° to 149°F., on fresh or pasteurized whole milk for cheese manufacture were reported by Schwartz and Mumm (37). They further reported that homogenization of milk, raw or pasteurized, lowered the fat in the whey from 0.52 to 0.28 and 0.64 to 0.22 percent respectively. Maxcy et al. (23) using a homogenization pressure of 2,500 p.s.i. at 140°F. reported that fat losses in whey ranged from 0.02 to 0.07 percent by the Babcock test with normal moisture and firmer body cheese made from homogenized milk fortified with NDM.

Peters (28) working on pasteurized whole milk reported that as homogenization pressures increased from 0 to 2,000 p.s.i., at 120°F. the fat loss in cheese whey decreased from 0.31 to 0.27 percent to 0.17 to 0.14 percent. At 500 p.s.i., he recorded fat losses in the whey as 0.22 to 0.23 percent. Peters (29) homogenized reconstituted "filled milk" for Cheddar cheese making at 500 and 2,000 p.s.i., at 131°F. and reported the milkfat content of the whey to be 0.06 and 0.08 percent, respectively. In cheese whey from milk prepared by combining skim milk and vegetable fat, fat losses at 500 and 1,000 p.s.i. are reported at an average of 0.07 and 0.06 percent, respectively, by normal butyl alcohol modification of the Babcock method. Peters (29) combined NDM and hydrogenated cotton seed oil (Wiley melting point 94.2°F.). He homogenized the mixture at 500 p.s.i. and 131°F. Cheddar type cheese was manufactured from the mixture. Fat losses in the cheese whey by the modified normal butyl alcohol method were 0.06 percent. The addition of monostearine to the mixture resulted in fat losses in the whey ranging from 0.05 to 0.09 percent. Peters (31) made Cheddar cheese from cheese milk by combining Extra Grade low-heat NDM and melted sweet butter. The milk mixture was homogenized at 120°F. and 500 p.s.i. He observed low fat losses in whey between 0.02 and 0.07 percent with no creaming during manufacture. While he observed little tendency of curd to mat during cooking, he reported that the curd lacked elasticity, showed slow matting and a weak rind in some of the finished cheese.

Work was conducted in Czechoslavakia on Niva cheese and reported anonymously (1) using homogenized cream and subsequently recombined with skim milk. Fat losses in the experimental cheese whey were 0.05 percent as compared to 0.16 percent in unhomogenized milk Niva cheese whey. The experimental cheese tended to have an increased yield and had a favorable effect on the quality.

4. Use of emulsifiers

In the cheese industry, emulsifiers are most commonly used in process cheese to prevent the separation of fat during the heating operation. Emulsifiers are substances which tend to concentrate in the interface between the fat and the plasma causing a reduction in surface tension. Emulsifiers are available in liquid, semi-solid, or powder forms, and may include glycerides, lecithin, fatty acid esters or inorganic salts as reported by Davis (7).

Commonly used emulsifying salts are di-sodium phosphate, and sodium citrate and mixtures of these salts. Sommer and Templeton (40) suggested the use of Rochelle salts, sodium pyrophosphate, and to a lesser extent, sodium metaphosphate salts. Templeton and Sommer (44 and 45) observed that disodium phosphate produced a weaker body when compared with sodium citrate.

Feuge (13) reported a wide use of mono- and diglycerides in the manufacture of products such as oil modified alkyd resins, superglycerinated shortenings and margarines. Commercially available products are composed of mixtures of mono-di- and triglycerides. The degree of interfacial tension is influenced substantially by monoglycerides when both mono- and diglycerides are present in the oil phase. The surface activity of the diglycerides is less than 1/100 that of monoglycerides. The interfacial tension against water of such oils as peanut, cottonseed and soybean is practically the same. Their interfacial tension is lowered by the addition of emulsifiers. One percent concentration of monoglycerides in the oil phase lowered the interfacial tension by 50 percent and 6 percent concentration by 100 percent.

Nichols (25) found it necessary to use an emulsifier to aid dispersal of fat globules in the second and the third stages of homogenization. The addition of 0.75 percent sodium citrate was found to be as satisfactory as 1.25 percent of disodium hydrogen phosphate. However, sodium citrate was noted to impart a bitter flavor to cheese if used in amounts exceeding 0.75 percent. Peters (29) added 0.5 percent monostearine on fat basis (0.5 lb. per 100 lb. fat) to filled milk and to the reconstituted filled. Both these milks were made into cheese. There was no apparent effect upon the percentage of fat loss in whey either with or without the addition of monostearine at the 0.5 percent level. Fat losses in cheese whey were 0.07 percent. There was no apparent effect on the degree of oiling off and pH of 1 month old cheese. Similarly no detectable differences in flavor, body and texture were noted among the various cheese.

Norman (26) added dried buttermilk to reconstituted homogenized milk, and found that it improved the palatability of cheese.

Reisfeld and Harper (35) developed a low fat soft ripened cheese containing added butterfat. These workers found that while added phospholipids had a beneficial effect on the body of cheese as did sweet cream buttermilk, the latter cheese possessed superior spreading qualities. Milk contains certain natural emulsifying agents such as milk proteins, fat, lecithin, phosphates and citrates. Egg yolk products are high in lecithin and have long been used in ice cream because of their emulsifying properties.

Whitehead (52), a New Zealand worker, added whey cream to milk that was used for cheese manufacture. Cheese made from milk to which whey cream was added and the corresponding control cheese from normal whole milk were ripened for 6 months at 55°F. Results showed no significant differences in quality and there were no free fat pockets in the experimental cheese.

Peters (29) combined 14 percent sweet cream buttermilk and spray dried low-heat NDM to obtain milk containing 4 percent milk fat. Cheese made from this milk showed a slight decrease in the percent of oiling off. There was also an improvement in the flavor of the 6-month old ripened cheese compared with the control cheese. Body and texture also were improved.

5. Ripening homogenized filled milk cheese

Stevenson (42) obtained a patent for ripening cheese from homogenized milk. The process involved homogenization of milk, converting it to curd, pressing whey from the curd, enclosing the curd surrounded by an inner gas in an air tight container from which air has been removed and permitting the curd to remain in the container at 50°F.

Freeman (14) ripened Cheddar cheese at 60°F. for 4 weeks followed by 8 weeks at 40°F. and obtained a cheese that scored high in flavor and body and texture as compared to ripening at 40°F. for 12 weeks. Cheddar cheese, made out of reconstituted NDM, had at least as high a score after 12 weeks as the cheese made from standardized fresh skim milk.

According to Peters (32) and Peters and Williams (33) a curing temperature of 50°F. for six months gave beneficial results on cheese manufactured from reconstituted milk with added culture of Lactobacillus casei and trace quantities of potassium chloride and manganese chloride. Also, the use of 4 ounces of rennet per 1,000 lb. of milk and ripening the cheese for 6 months at 50°F. resulted in a higher flavor score than controls. A modified salt (NaCl containing 48 gm. of KCl and 4 gm. of $NaCl.2H_2O$ per Kg. NaCl) was added at the rate of 4 or 5 ounces per 1,000 lb. of milk. Cheese was ripened in two stages. The first stage for 3 months at 60° to 80°F. and the second stage for 3 months at 50°F. The resulting cheese exhibited very desirable body characteristics.

6. Studies in India

Subrahmanyam et al. (43) and Krishnaswamy and Johar (19) manufactured Cheddar type cheese from groundnut (peanut) milk, and from a mixture of peanut and cow's milk. These investigators report that the enzyme renin did not give favorable clotting of peanut milk. Hence, a protein clotting enzyme from *Ficus carica* (Linn), a vegetable source enzyme, was used. This enzyme resulted in cheese which did not compare favorably with the normal product made from cow's milk. Cheese made from a mixture of peanut milk and cow's milk, and cheese made from pure peanut milk was classified as "semi-hard" type cheese. Flavor scores for the above cheeses were generally low as were those for body and texture. These cheeses were very weak and fragile with high moisture content. When excessive pressure was applied to the products to remove moisture there was a displacement of oil. The pressed cheese product became hard and crumbly.

7. Surati cheese

Surati cheese or "panir," which is often made from buffalo milk, is the best known of the few indigenous varieties of cheeses in India. It is usually made with crude rennet and is uncolored. Small patties of the cheese are made during manufacture which are steeped in whey during storage, transportation and distribution. The keeping quality of the product is only a few days. About 38 lb. of cheese is obtained from 100 lb. of buffalo milk containing 6 percent milkfat.

Very little information is available in the literature on the manufacturing process of the Surati cheese. Davis (6) recorded the manufacture of the Surati cheese in

India. However, Kothawalla and Verma (18) conducted the first systematic approach for establishing a manufacturing procedure for this cheese. They recommended the following procedure:

a) The fat content of the milk should be adjusted to about 6 percent in order to obtain the best yield with a minimum loss of fat in the whey.

b) The pasteurized milk should be tempered to 95°F. before the addition of rennet at a rate of 6 to 7 ml. per 1,000 lb. of milk.

c) Pure lactic starter (with 0.7 to 0.8 percent titratable acidity) is added to the milk immediately before the rennet at the rate of 0.5 ounce per 100 lb. milk to obtain a cheese which would ripen within a period of 32 hours.

d) Salt should be added at a rate of 4.75 lb. per 100 lb. of "green cheese" or 2 lb. to the yield obtained from 100 lb. of milk.

e) Cheese should be drained and moulded in special clean bamboo strip baskets and transferred to the whey to ripen for a period of about 12 to 36 hours depending upon the final acidity desired.

Warner (51) and Sanders (36) described some of the technical aspects given earlier in the manufacturing process of Surati cheese as recommended by Kothawalla and Verma (18).

EXPERIMENTAL PROCEDURE

Cheddar type cheese (semi-hard variety) and Surati type cheese (soft variety) were manufactured by combining vegetable fat and NDM. "Emulsion" or "cheese milk" in this study refers to reconstituted NDM containing vegetable fat. The cheeses were evaluated by chemical and organoleptic methods.

The following experimental procedure was adopted to evaluate the feasibility of manufacturing this type of product.

1. Ingredients used in the preparation of "cheese milk"

Spray dried NDM obtained by the low-heat treatment process was used for all reconstituted skim milk during the study. All of the NDM was obtained from one lot of skim milk. The NDM was produced in the Michigan State University Dairy Plant.

The vegetable fat source was a blend of hydrogenated cotton seed and soybean oils of approximately equal proportions. The product is sold under the trade name "Cirol." Data on Cirol, as provided by the supplier, were as follows:

Color:	1.5 percent R-15Y (max.)
Free fatty acids	0.05 percent (max.)
Wiley melting point	93 $\pm$ 1°F.

Stability (AOM)		60 hours (min.)
SFI	50°F.	27 ± 2
	70°F.	15 ± 2
	80°F.	10 ± 2
	92°F.	4 ± 2
	100°F.	0 ± 2

Mono- and diglycerides used were of the following specifications:

Color (Lovibond)	3. OR - 3 OY (max.)
Free fatty acids	1 percent (max.)
Alpha-monoglycerides	40 - 45 percent
Iodine value	65 - 75
Free glycerine	1 percent (max.)
Stability (AOM)	76 hours (min.)
Capillary melting points	115 - 120°F.

Type 2 lecithin was used during the study. Properties of the lecithin were:

Appearance:	Natural lecithin - yellow to brown, fluid to pasty. Granular (oil free) - golden, free flowing.
Odor:	Bland.
Taste:	Slightly nut-like in granular form, or characteristic of the carrier, eg. soybean oil.
Solubility:	Dispersible in water, soluble in mineral oils, animal and vegetable fats and oils, ethers, and most hydrocarbons.

2. Manufacturing Cheddar type cheese

Two different methods were followed in combining ingredients for making Cheddar type cheese.

The manufacturing steps followed in Method I were:

1. Low-heat NDM was reconstituted with a measured amount of tap water so that the resulting skim milk contained 9 percent solids.
2. A 20 percent vegetable fat mixture was prepared with a portion of the reconstituted NDM to which was added 0.05 percent emulsifier on a fat basis.
3. The 20 percent mixture was pasteurized at 145°F. for 30 minutes.
4. The mixture was homogenized at 500 p.s.i. and 140° to 143°F. using a two stage homogenizer.
5. The reconstituted NDM was pasteurized at 145°F. for 30 minutes.
6. The homogenized product was combined with the remaining reconstituted NDM to result in 3.5 percent fat "cheese milk."
7. Cooling to 86°F. was accomplished by circulating cold water in the jacket of the cheese vat.
8. A procedure for making Cheddar type cheese in the normal manner given by Wilster (53) was followed with modifications as indicated below:
    a. Six ounces of rennet per 1,000 lb. "cheese milk" were used.
    b. The time of cooking was 60 to 70 minutes.

c. The time allowed for cheddaring was 150 to 180 minutes.

A total of 10 lots of Cheddar type cheese were manufactured using Method I.

The manufacturing steps followed in Method II were:

1. Low-heat NDM was reconstituted with a measured amount of tap water, so that the resulting skim milk contained 9 percent solids.
2. The vegetable fat was heated to 135°F. and a weighed quantity of emulsifier was added at a rate of 0.05 percent on a fat basis.
3. The melted fat was combined with the reconstituted NDM to obtain 3.5 percent "cheese milk."
4. The "cheese milk" was pasteurized at 145°F. for 30 minutes and homogenized at 500 p.s.i. and 140° to 143°F. with a two stage homogenizer.
5. The product was then cooled to about 86°F.
6. The procedure for making Cheddar type cheese in the normal manner given by Wilster (53) was followed with the same modifications indicated for Method I.

A total of 4 lots of Cheddar type cheese was manufactured using Method II. Each trial consisted of 200 lb. of "cheese milk" in a 50-gallon cheese vat. The product was hooped in standard 20-lb. rectangular stainless steel hoops. Cheese blocks were pressed overnight. The blocks were then covered with Cryovac paper and pressed for an additional 6 hours after which they were removed and placed in the curing room at $50^{\circ} \pm 1^{\circ}F$.

Schematic diagrams describing the two methods are shown in Figures 1 and 2.

3. Manufacturing procedure for Surati type cheese

Surati cheese was prepared from standardized whole milk containing 6 percent butterfat and designated as "control." Surati type cheese was prepared by combining vegetable fat with reconstituted NDM following the general procedure outlined in Method II.

The following steps were involved in preparing Surati cheese for a control:

1. Raw milk containing 3.5 percent fat was obtained from the Michigan State University Dairy Plant. Sufficient cream was added to the milk to increase the milkfat content to 6 percent.
2. The procedure for making Surati cheese as described by Kothawalla and Verma (18) was followed with a few modifications given below:
    a. Ribbed plastic baskets that facilitated drainage of whey were used instead of the bamboo baskets. Dimensions of the plastic baskets were 4 inches square at the top, 3.5 inches square at the bottom, and 2.5 inches deep. Cheese cloth was placed in the basket. Curd was removed from whey with a spoon and placed on the cheese

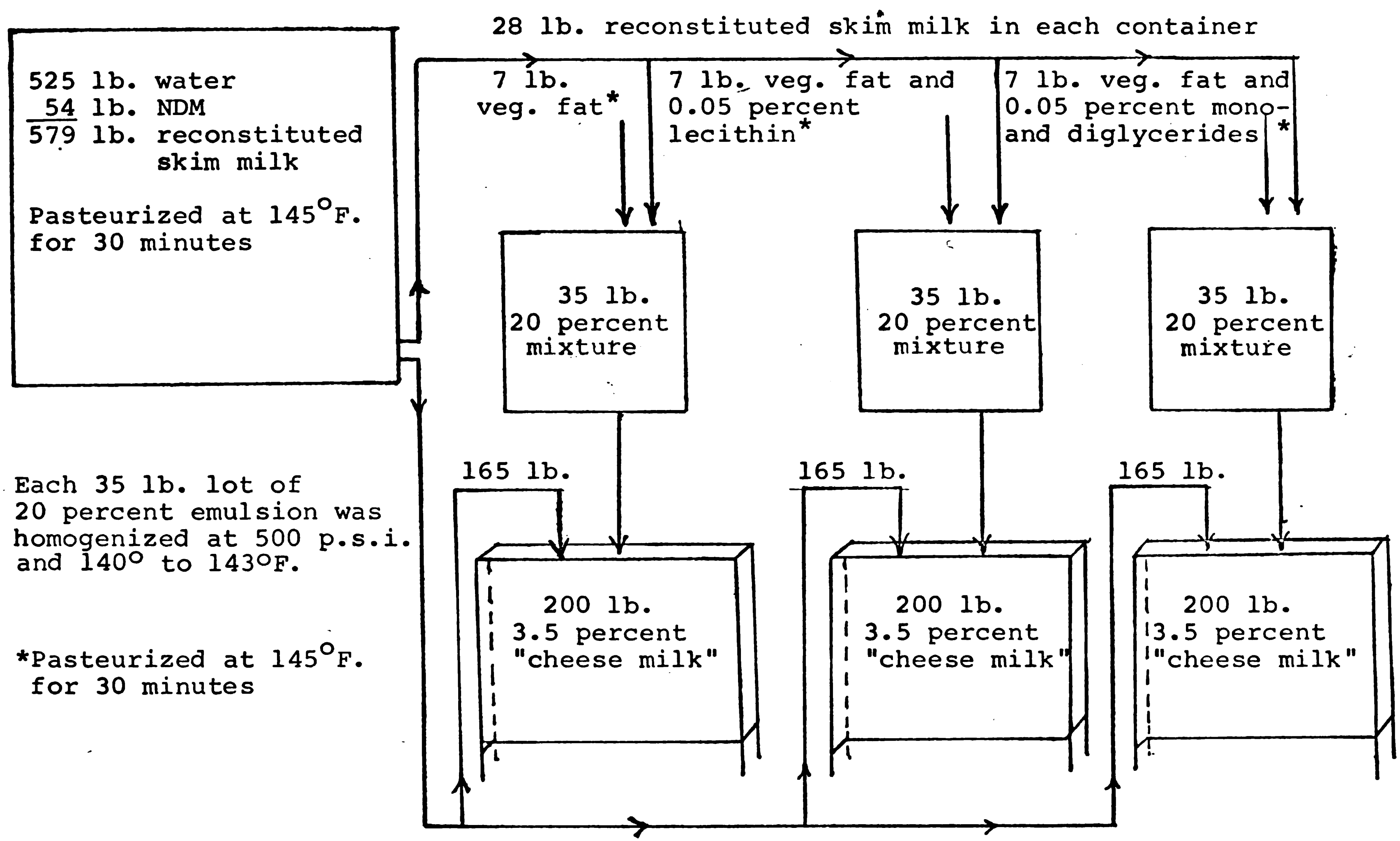


Fig. 1. Method I--Schematic flow of ingredients used in the manufacture of Cheddar type cheese.

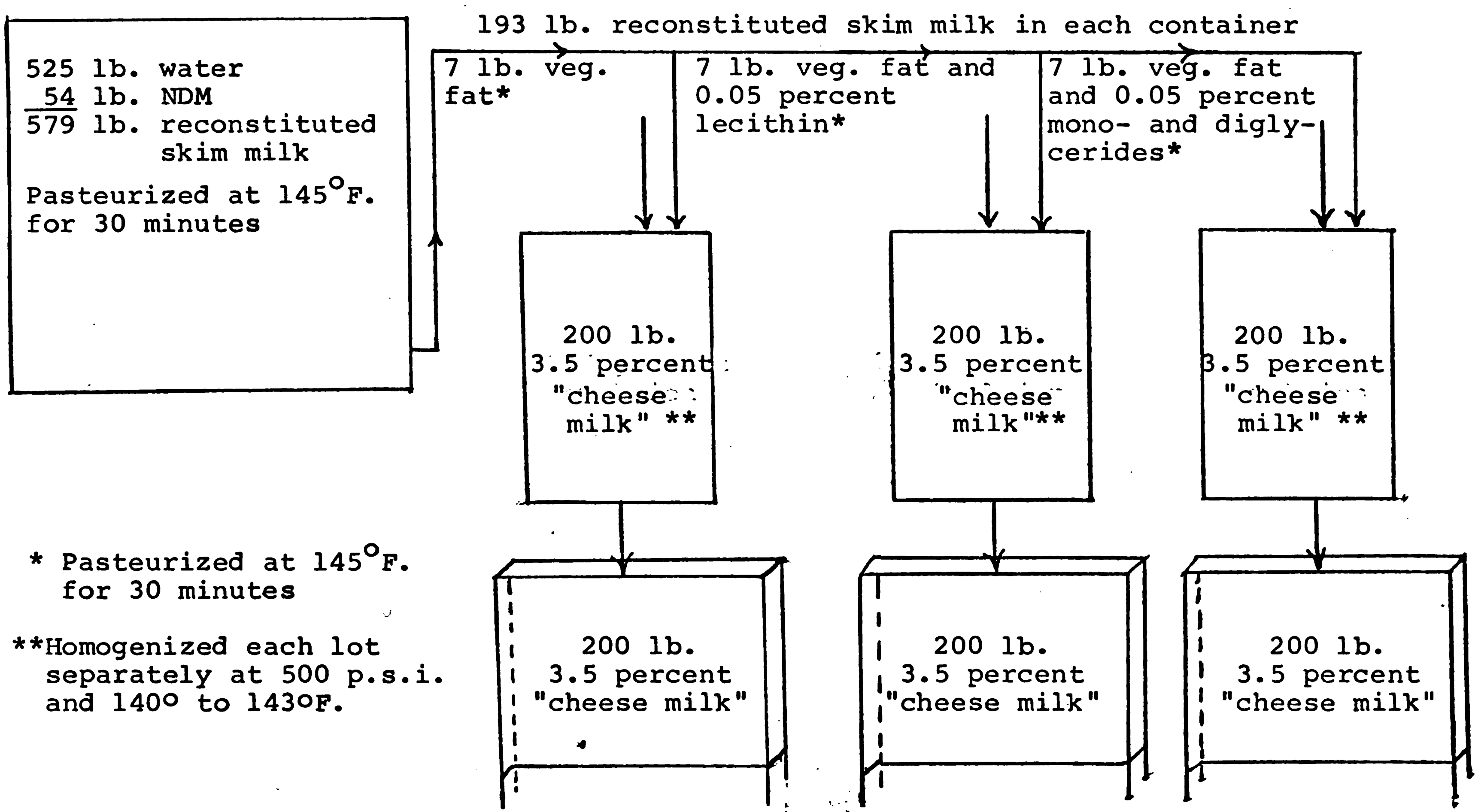


Fig. 2. Method II--Schematic flow of ingredients used in the manufacture of Cheddar type cheese.

cloth. The cheese cloth held the curd in place and facilitated drainage of whey.

b. Upon completion of drainage the curd was again placed in the whey for about 24 hours. The cheese was then removed from the whey, packed in clean plastic containers and stored at 32° to 34°F.

The steps followed in the manufacturing Surati type cheese were:

1. The procedure used to prepare "cheese milk" in Method II of Cheddar type cheese was adopted. Reconstituted NDM and vegetable fat were combined to produce a "cheese milk" containing 6 percent fat and 8.5 percent solids-not-fat (SNF).
2. Mono- and diglycerides were added at the rate of 0.05 percent on a fat basis.
3. Surati type cheese was manufactured similar to the procedure followed in making the control Surati cheese.

Five trials were conducted using 5 lb. of "cheese milk" in each trial.

4. Tests

A. Homogenization efficiency test

A homogenization efficiency test was adopted to determine the extent of fat rise in "cheese milk" prepared by Methods I and II. Fat tests were conducted according to

Trout and Schied (46), Judkins (16) and the test described for homogenized milk by Lucas and Trout (21). The homogenization efficiency index was calculated according to the United States Public Health Service Milk Ordinance and Code (48, 49), and referred to in this research as "percentage emulsion instability."

B. Determination of fat percentage in cheese whey

Fat percentage in cheese whey was determined according to the modified butyl alcohol Babcock method described by Van Slyke and Price (50), and the normal Babcock method (24).

C. Microscopic measurement of size of fat globules

Fat globule size in the cheese milk was measured microscopically according to the procedure given by the Milk Industry Foundation (24). The microscope was calibrated so that each ocular micrometer unit was equal to 3 microns when the high dry objective was used.

D. Determination of fat percentage in Cheddar and Surati type cheese

The fat percentage in the Cheddar and Surati type cheese was determined according to the test prescribed by the Association of Official Agricultural Chemists (3).

E. Determination of total solids in Cheddar and Surati type cheese

The total solids content of the Cheddar and Surati type cheese was determined in accordance with the procedure described in the Instructional Manual for the Mojonnier Milk Tester (15).

F. Determination of moisture in Cheddar and Surati type cheese

The moisture content in Cheddar and Surati type cheese was calculated as follows: loss in weight divided by the sample weight x 100 = percent moisture.

G. Scoring Cheddar type cheese

The official score card for Cheddar cheese adopted by the American Dairy Science Association, Wilster (53) was used.

H. Scoring Surati and Surati type cheese

To the best knowledge of the author, no score card has been developed for evaluating Surati cheese. Therefore, the American Dairy Science Association score card for Cheddar cheese was modified slightly and used for the evaluations.

SCORE CARD FOR SURATI CHEESE

Sample number ______________

		Score given
Flavor 45 No criticism Normal range 36 to 40 Score 39.5 or less	Desirable: Creamy, smooth, rich flavor, slight acid, pleasant flavor Defects: Flat, Fermented Rancid, Heated Oxidized, Acid Salty, Bitter Unclean, Feed Fruity, Foreign	______
Body and texture 30 No criticism Normal range 25 to 29.5 Score 29.0 or less	Desirable: Smooth, velvety surface and texture, compact, retains shape. Defects: Hard, Spongy Soft, Weak Pasty, Soggy Gassy, Crumbly Yeasty, Grainy	______
Finish 15		15
Color 10		10
	Total score	______

Scored by ______________

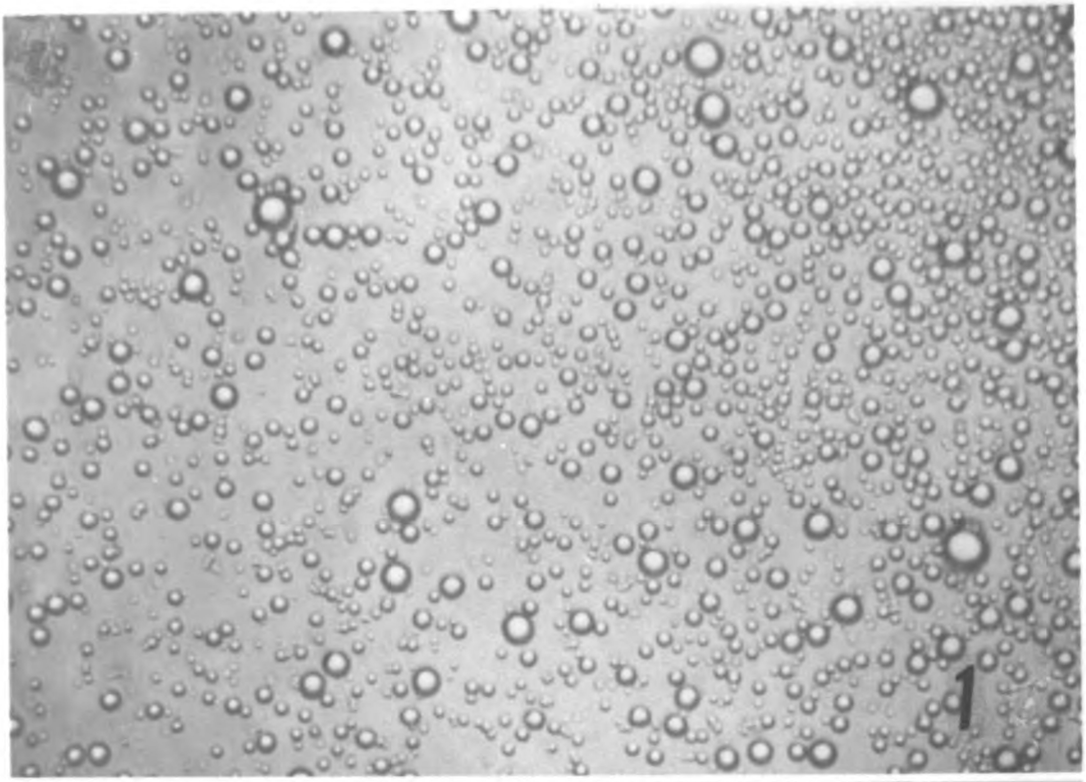
Date ______________

RESULTS AND DISCUSSION

1. Study of emulsion stability

The size of vegetable fat globules in various emulsions resulting from subjection to several homogenization pressures was investigated. "Cheese milks" were allowed to remain quiescent in a quart bottle for varying periods of time after homogenization to note the rise of fat. The percentage distribution of fat globules of various sizes shown in Table 1 represents 20 percent emulsions and their corresponding 3.5 percent fat "cheese milk." Photomicrographs of fat globules in emulsions that did not contain emulsifier (Plates 1 and 2) and emulsions that contained emulsifiers (Plates 3 to 6) were obtained according to the technique previously described.

Homogenization of emulsions was essential to obtain uniform fat distribution. The average fat globule size in 20 percent emulsion having no emulsifier (Plate 1, Table 1) was 3.36 microns; whereas in 3.50 percent "cheese milk" (Plate 2, Table 1), the fat globules averaged 3.02 microns. Twenty percent emulsions containing type 2 lecithin had an average globule size of 2.98 microns (Plate 3, Table 1), and after adjusting to 3.5 percent "cheese milk" (Plate 4, Table 1) the average fat globule measured 3.0 microns. The average fat globule in 20 percent emulsion containing



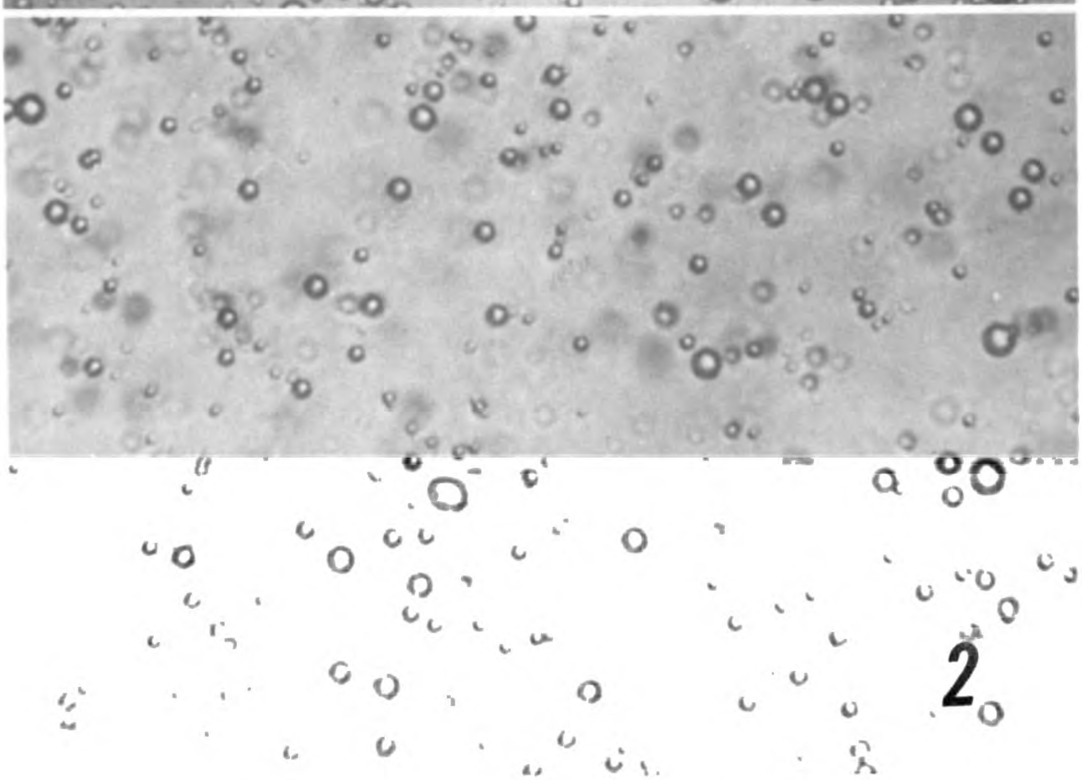
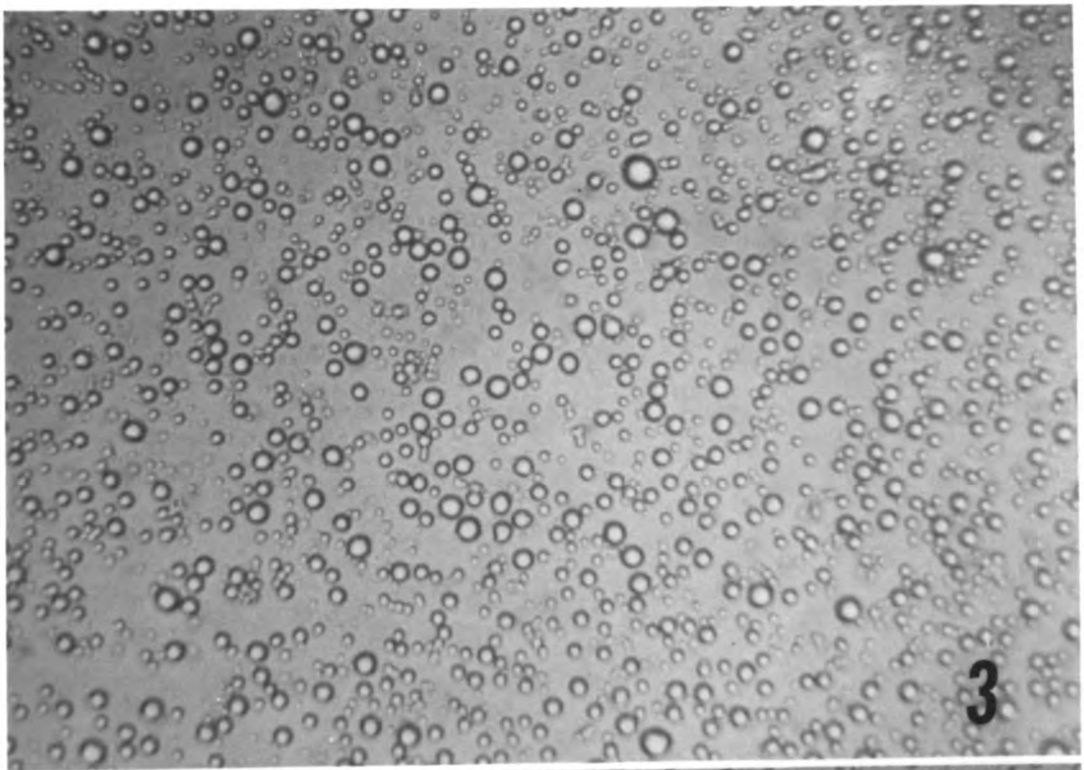


Plate 1. Photomicrograph of 20 percent fat emulsion containing no emulsifier following homogenization at 500 p.s.i.

Plate 2. Photomicrograph of 3.5 percent fat "cheese milk" prepared from the 20 percent fat emulsion shown in Plate 1.



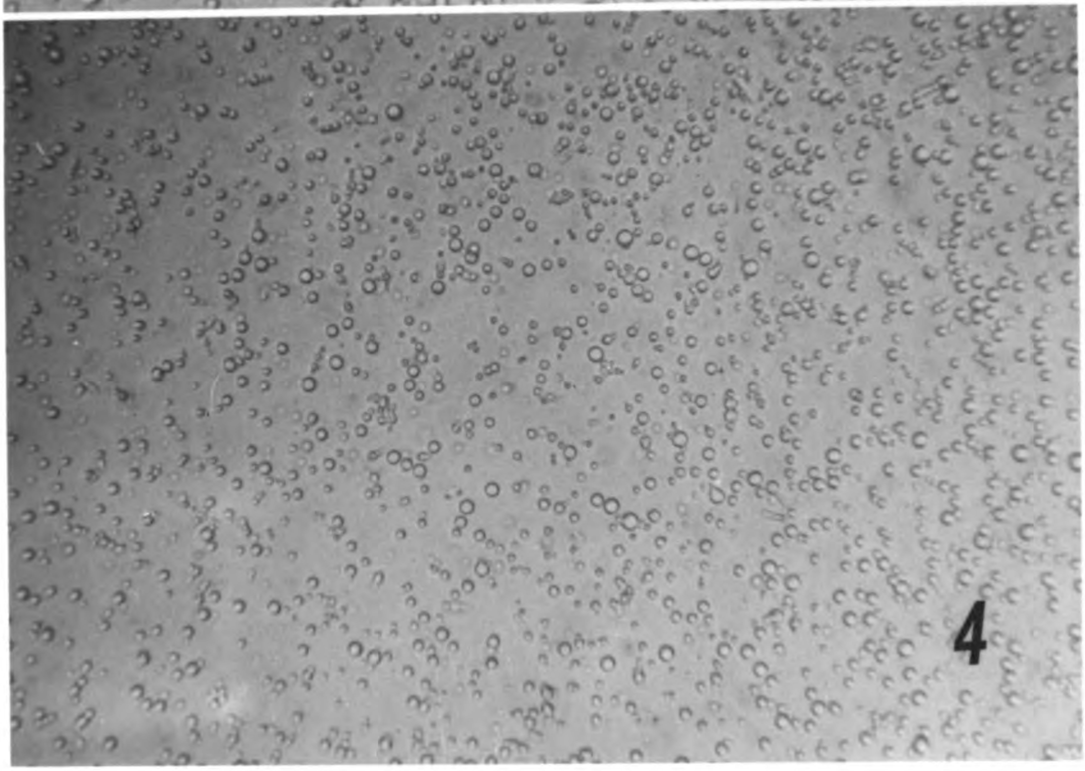
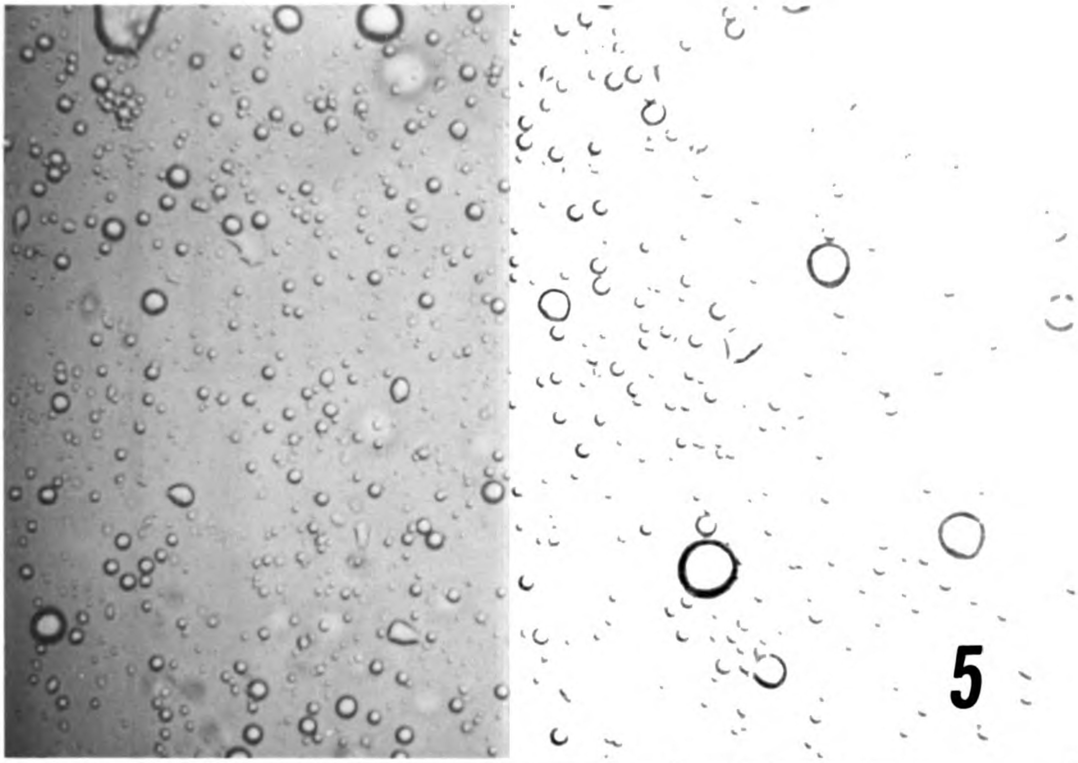


Plate 3. Photomicrograph of 20 percent fat emulsion containing lecithin following homogenization at 500 p.s.i.

Plate 4. Photomicrograph of 3.5 percent fat "cheese milk" prepared from the 20 percent fat emulsion shown in Plate 3.



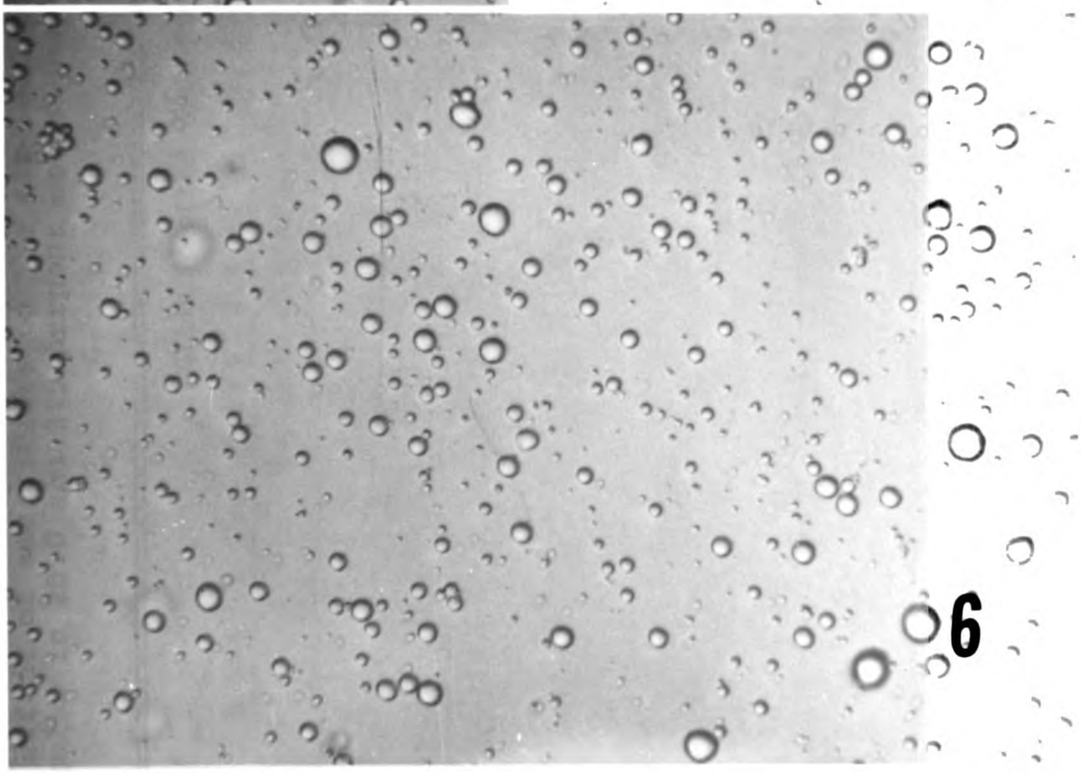


Plate 5. Photomicrograph of 20 percent fat emulsion containing mono- and diglycerides following homogenization at 500 p.s.i.

Plate 6. Photomicrograph of 3.5 percent "cheese milk" prepared from the 20 percent fat emulsion shown in Plate 5.

Table 1. **The effect of emulsifiers on the size and** percentage distribution of fat **globules in 20.0 and 3.5 percent emulsions**

Type of emulsion	Globule size (microns)							Total	Average size (microns)	Percentage less than 3 microns
	0.1-1	1.1-2	2.1-3	3.1-4	4.1-6	6.1-8	8.1-10			
	Percent distribution									
No emulsifier 20 percent fat	6.4	11.3	49.2	12.9	15.1	4.2	0.8	100	3.36	67
No emulsifier 3.5 percent fat	9.7	17.9	44.2	13.7	10.5	2.4	1.6	100	3.02	72
Lecithin 20 percent fat	2.9	24.1	48.8	10.8	11.7	0.9	0.6	100	2.98	76
Lecithin 3.5 percent fat	10.2	22.4	41.0	7.7	15.7	1.7	1.0	100	3.00	74
Mono- and diglyceride 20 percent fat	4.1	26.8	41.8	9.7	12.3	3.7	1.4	100	3.15	73
Mono- and diglyceride 3.5 percent fat	6.2	14.8	53.8	11.7	9.6	1.7	2.0	100	2.96	75

mono- and diglycerides (Plate 5, Table 1) was 3.15 microns. Following adjustment to 3.5 percent fat "cheese milk" (Plate 6, Table 1), the average globule measured 2.96 microns. The majority of the fat globules in all emulsions in Table 1 ranged from 2 to 3 microns in diameter. Between 67 and 76 percent of fat globules in all of the emulsions were 3 microns or less in diameter.

2. Effect of homogenization pressures on the size of fat globules in various emulsions

Homogenized samples of emulsions indicated that a large percentage of fat globules were between 2 and 3 microns irrespective of the fat percentage. The data in Table 2 show that, in all of the emulsions observed, between 64.0 and 79.5 percent of the fat globules were less than 3 microns. Similar results were noted by Nichols (25) who reported that 85 percent of the fat globules were 2 microns or smaller.

Data in Fig. 3 show that as homogenization pressure decreases, the emulsion instability becomes greater. All of the experimental 3.5 percent "cheese milk" subjected to homogenization pressures ranging from 500 to 2,000 p.s.i. did not qualify as "well homogenized." According to USPHS standards there was a gradual decrease in homogeneity of the "cheese milk" upon standing. Homogenization pressure appeared to be important to gain sufficient fat dispersion and emulsion stability for satisfactory manufacture of the cheese product with setting and cooking

Table 2. Fat globule size and percentage distribution in various emulsions homogenized at 500 p.s.i.

Percent fat	Globule size (microns)									Globule size weighted aver. (microns)	Percent less than 3 microns
	0.1-1.0	1.1-2	2.1-3	3.1-4	4.1-6	6.1-8	8.1-10	10.1-12	12+		
	Percent distribution										
14.5	4.1	23.7	36.2	4.1	20.3	3.6	4.9	2.0	0.4	3.76	64.0
3.5	9.4	17.7	45.8	11.1	14.8		0.8			3.0	72.9
16.0	3.6	30.5	37.9	1.8	23.1	2.2	0.7			3.23	72.0
3.5	2.8	15.5	50.5	10.7	18.0		2.2			3.37	68.8
20.5	14.6	23.7	37.6	3.9	18.2	0.39	1.1			2.81	75.9
3.5	4.3	12.0	50.2	17.4	13.1	1.6	1.0			3.29	66.5
25.0	14.8	23.7	32.5	6.5	19.0	1.4	1.8			3.13	71.0
3.5	3.9	10.8	50.1	16.2	17.2	0.49	0.4	0.49		3.36	64.8
32.0	2.2	20.0	44.0	4.0	28.0	0.57	1.1			3.50	66.2
3.5	1.1	9.9	59.9	10.5	14.9	0.55	2.7			3.34	70.9

characteristics similar to those of whole milk. To prevent excessive rising of the fat, it was important to set "cheese milk" within a short time after preparation.

The data on degree of emulsion instability in "cheese milks" prepared according to Method I are shown in Fig. 4. Fat concentration in the top of a quart milk bottle was greater during the first, than during the second 12-hour holding period. "Cheese milk" containing no emulsifier appeared to be less stable than those containing an emulsifier. No significant difference was evident between lecithin and mono- and diglycerides in their ability to emulsify the fat used in the study.

The degree of emulsion instability of "cheese milks" prepared by Methods I and II are presented in Fig. 5. "Cheese milk" prepared by Method I displayed a more rapid rise of fat and eventually formed an objectionable fat layer. A possible explanation may be that in Method I only a part of the product was homogenized while in Method II, the entire quantity was subjected to homogenization. After 12 hours "cheese milk" by Method I showed an emulsion instability index of 55, whereas "cheese milk" prepared by Method II was 42. However, the difference in the degree of fat concentration became less between the "cheese milk" prepared by the two methods after 24 hours. The "cheese milk" prepared according to Method I had an emulsion instability index of 59.0. By Method II the index was 55.5. The rise of fat was very rapid in both types

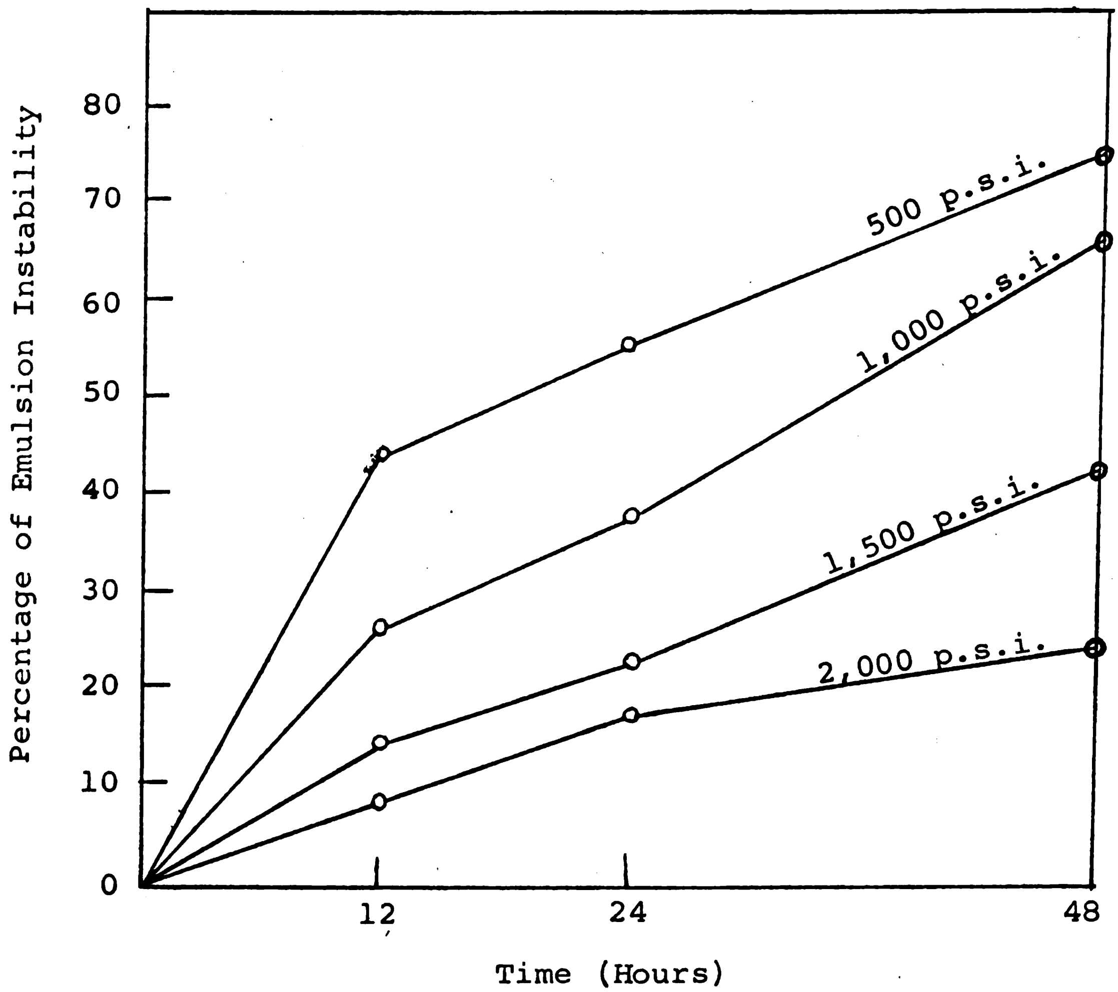


Fig. 3. Rise of fat globules in Method II "cheese milk" homogenized at various pressures and tested at different intervals of time expressed as USPHS homogenization index.

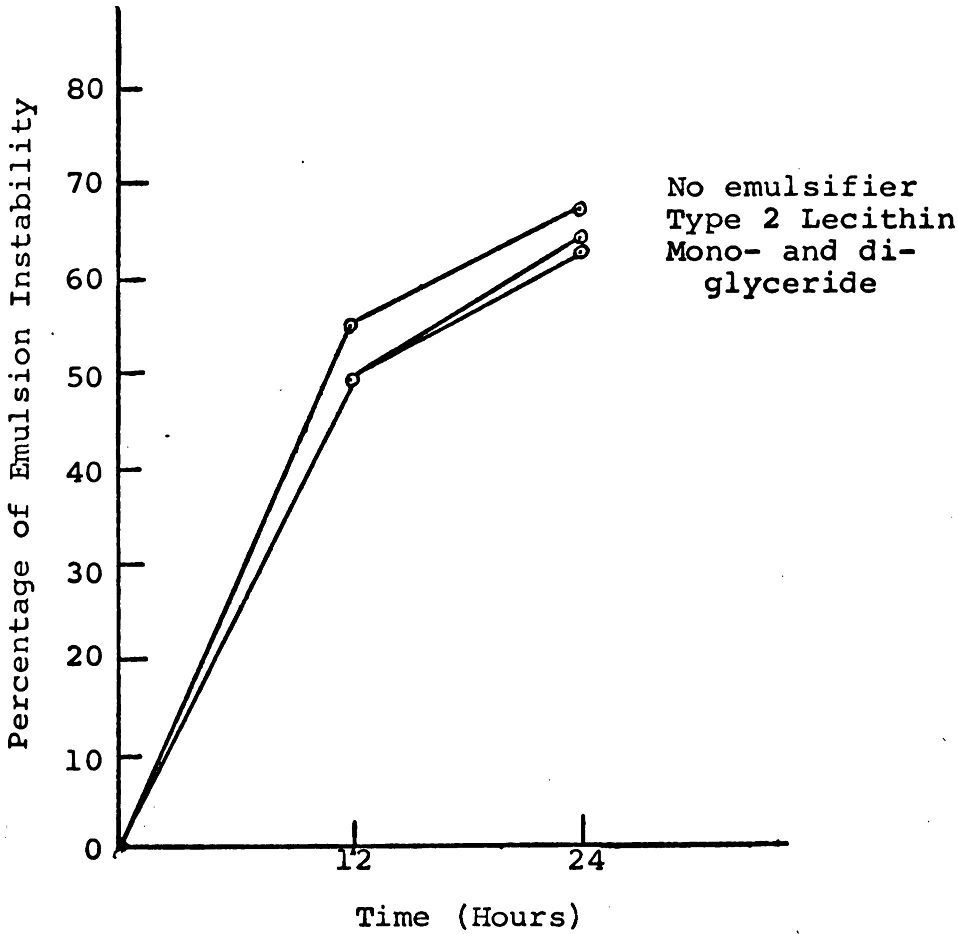


Fig. 4. The effect of emulsifiers on the rise of fat globules in "cheese milk" prepared by Method I, homogenized at 500 p.s.i., tested after 12 and 24 hour intervals expressed as USPHS homogenization index.

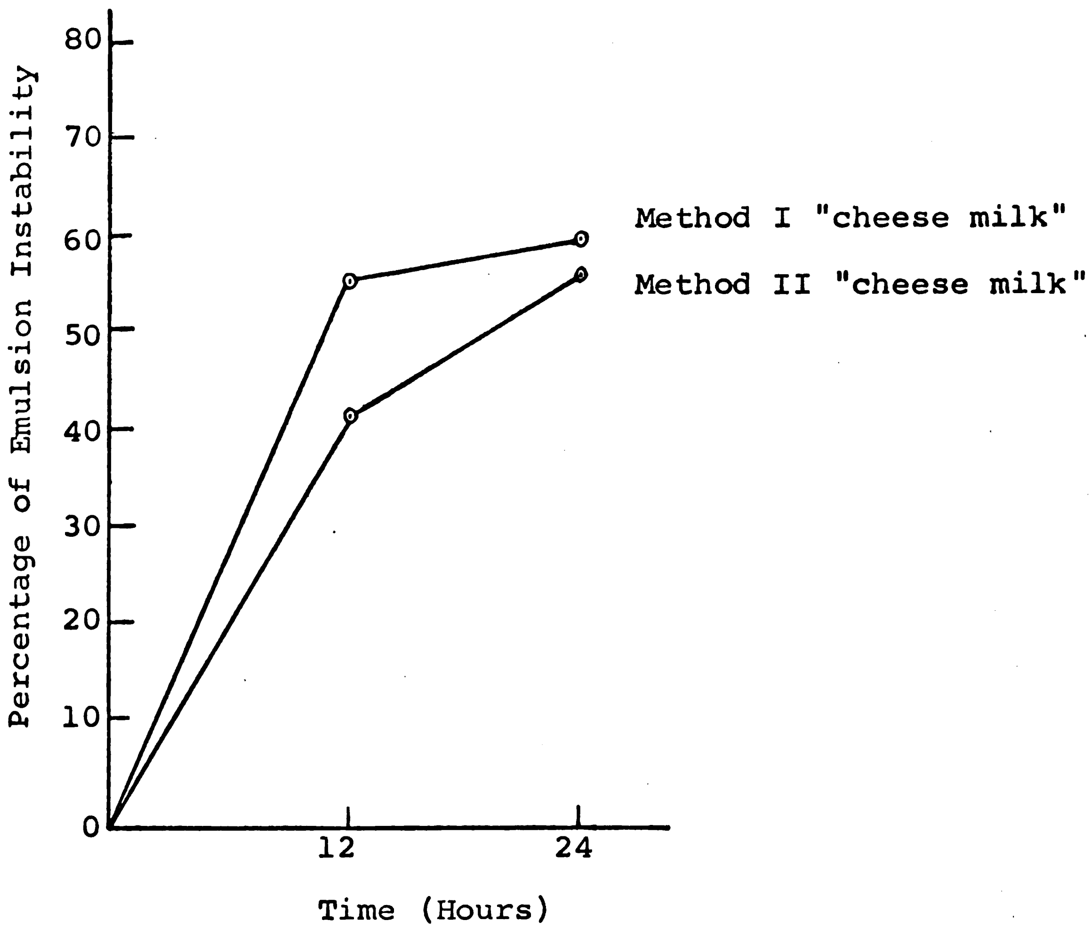


Fig. 5. Rise of fat globules in "cheese milk" by Methods I and II homogenized at 500 p.s.i. and tested initially and after 12 and 24 hour intervals expressed as USPHS homogenization index.

of "cheese milk" preparations. Greater rise of fat is indicated by a higher instability index. It is, therefore, essential that the "cheese milk" be converted to cheese product soon after preparation.

3. Homogenization pressure and quantity of rennet for the manufacture of Cheddar type cheese

The effect of different homogenization pressures on the formation of coagulum during Cheddar type cheese manufacture was studied and the data are given in Table 3. "Cheese milk," as obtained by Method II using lecithin as an emulsifier, was subjected to various homogenization pressures ranging from 500 to 2,000 p.s.i. at 140° to 143°F.

A poor coagulum was obtained when a homogenization pressure of 2,000 p.s.i. was used. The coagulum was too soft for satisfactory cutting with cheese knives.

Pressures of 1,000 and 1,500 p.s.i. produced similar soft body characteristics of the coagulum, but to a lesser degree. However, a pressure of 500 p.s.i. resulted in a "cheese milk" which would set in about 30 minutes. The coagulum had a desirable firmness. When cut into cubes with cheese knives, the coagulum produced satisfactory cubes which withstood the agitation needed during cooking.

In the manufacture of normal whole milk, Cheddar cheese rennet is added at the rate of 2.5 to 4.0 ounces per 1,000 lb. of milk (Van Slyke, 50). In the present

Table 3. Effect of various homogenization pressures on the coagulum during the manufacture of Cheddar type cheese

Pressure p.s.i.	Starter acidity (percent)	Starter added (percent)	Cutting curd acidity (percent)	Rennet per 1,000 lb. milk (oz.)	Total elapsed setting time	Characteristics of curd at cutting
2,000	0.90	1.0	0.145	6.0	240	Soft
1,500	0.95	1.0	0.150	6.0	90	Soft
1,000	0.90	1.0	0.150	6.0	50-90	Soft
500	0.95	1.0	0.150	6.0	30-50	Firm

studies, the quantity of rennet added was 6.0 ounces per 1,000 lb. of milk. The increase in the quantity of rennet was due in part to the use of NDM and the soft curd resulting from homogenization. Maxcy et al. (23) suggested that the reduction of gel strength was directly related to the effectiveness of homogenization. The possible explanations for reduced gel strength were (1) "the adsorption of proteins on the newly created fat surfaces" and (2) "fat disrupts the continuity of gel structure and that increasing the number of fat globules therefore, increases the number of weak points."

4. Flavor scores of Cheddar type cheese made by Method I

Cheddar type cheese manufactured from "cheese milk" which did not contain an emulsifier were scored for flavor and the results are shown in Table 4. Flavor scores ranged from 34.0 to 40.0 with an average of 37.2. The most common flavor criticisms were slightly unnatural, oily, slight acid and slight bitter.

Cheese containing type 2 lecithin showed a slight improvement in flavor as compared to cheese that did not contain emulsifier (Table 5). The flavor scores ranged from 35.0 to 40.0 and the average of all cheese in this group was 37.2. Slight bitterness, lacking true Cheddar flavor and unnatural were the most common criticisms. The flavor scores of Cheddar type cheese prepared from "cheese milk" containing mono- and diglycerides are presented

Table 4. Flavor score of Cheddar type cheese containing no emulsifier made by Method I (four judges)

Trial	Days in storage	Flavor score				Average score	Criticism
		1	2	3	4		
1	120	36.0	35.0	36.0	38.0	36.25	Slightly unnatural, oily, slightly bitter, lacks Cheddar flavor
2	120	36.5	37.0	37.0	38.5	37.25	Slightly bitter, slightly unnatural, slightly acid, slightly bitter, sour, oily, not a true Cheddar
3	122	37.5	37.5	37.0	38.5	37.62	Very slightly sour, unnatural, slightly bitter, acid
4	121	37.0	37.0	36.5	38.0	37.12	Sour, slightly fermented, unnatural
5	118	38.5	34.0	37.0	38.5	37.00	Acid, slightly unnatural
6	120	38.0	37.5	36.5	39.5	37.87	Weak, crumbly, sour, unnatural
7	120	38.5	37.5	36.0	40.0	38.00	Slightly unnatural, sour, heated
8	120	36.0	35.0	35.0	38.0	36.00	Unnatural, acid, fermented, very sour, bitter
9	129	38.0	36.5	37.5	38.0	37.50	Slightly foreign fat
10	125	38.0	37.0	37.0	39.0	37.75	Acid
Av. of all scores						37.20	

Table 5. Flavor score of Cheddar type cheese containing lecithin made by Method I (four judges)

Trial	Days in storage	Flavor score				Average score	Criticism
		1	2	3	4		
1	120	35.0	37.0	36.5	37.0	36.37	Slightly bitter, unnatural, lacks flavor, slightly oily, fruity, not true Cheddar type
2	120	37.5	37.0	37.0	39.5	37.75	Unnatural, slightly bitter, oily, acid, not a true Cheddar, very slightly acid
3	122	38.5	37.5	38.0	39.0	38.25	Acid, slightly unnatural
4	121	37.5	36.5	36.0	37.5	36.87	Sour, slightly fermented, acid unnatural, unclean, very slightly bitter
5	118	38.5	36.5	37.0	39.0	37.75	Acid, slightly unnatural, lacks cheese flavor
6	120	38.0	37.5	36.5	39.5	37.12	Slightly unnatural, sour, unnatural
7	120	38.5	37.0	36.0	39.0	37.62	Slightly unnatural, sour, heated
8	120	35.5	35.0	35.0	38.0	35.87	Acid, slightly bitter, very sour, unnatural
9	129	38.0	36.0	37.0	37.5	37.12	Slightly acid
10	125	38.0	36.0	37.0	40.0	37.75	Slightly acid
Av. of all scores						37.24	

in Table 6. The flavor scores ranged from 35.0 to 39.0 with an average of 37.2. Most common flavor criticisms were not a true Cheddar flavor, slight bitter and unnatural. The average flavor score of the three groups of cheese varied only 0.05.

The lack of true Cheddar cheese flavor in the Cheddar type cheese was probably due to the presence of extremely low percentages of lower molecular weight fatty acids, as compared to the presence of such fatty acids in butterfat.

The characteristic flavor of ripened cheese is really a blend of several odors and tastes, most of which are derived from volatile and soluble substances. In mild cheese the odor of diacetyl is faintly present (Calbert and Price, cited by Van Slyke, 50). In well aged cheese several odoriferous fractions are noted including: traces of odors of butyric and caproic acid; aromatic fractions resembling the odors of esters of alcohol and salts of propionic and acetic acid; and in very old cheese, the pungent odors of compounds of ammonia and sometimes hydrogen sulphide (Van Slyke, 50). The fat in Cheddar cheese probably undergoes slight chemical changes during ripening. The odor components of the flavor of Cheddar cheese indicate the presence of some of the fatty acids of lower molecular weight.

Table 6. Flavor score of Cheddar type cheese containing mono- and diglycerides made by Method I (four judges)

Trial	Days in storage	Flavor score 1	Flavor score 2	Flavor score 3	Flavor score 4	Average score	Criticism
1	120	35.0	37.0	36.5	37.0	36.37	Unnatural, slightly bitter, lacks Cheddar flavor, oily
2	120	37.5	37.0	37.0	39.0	37.62	Slightly acid, slightly unnatural, slightly bitter, acid
3	122	38.5	37.5	37.0	38.5	37.87	Acid, slightly unnatural, slightly bitter
4	121	38.0	36.5	36.0	37.5	37.00	Sour, slightly acid, unnatural, bitter, unclean
5	118	38.0	36.5	37.0	38.5	37.50	Acid, unnatural, high acid, lacks cheese flavor
6	120	37.0	37.5	37.0	39.0	37.62	Unnatural, sour, slightly acid
7	120	38.0	37.0	36.0	39.0	37.50	Slightly unnatural, sour, slightly acid
8	120	36.0	35.0	35.0	37.5	35.87	Acid, fermented, very sour, unnatural, bitter
9	129	38.0	36.0	36.5	38.0	37.12	Sour
10	125	38.0	37.0	36.0	39.0	37.50	Unclean, acid
Av. of all scores						37.19	

5. Body and texture scores of Cheddar type cheese made by Method I

The body and texture of cheese made from "cheese milk" containing no emulsifier prepared by Method I had an average score of 27.1 as shown in Table 7. The scores ranged from 24.0 to 29.5. The most common criticisms were short, crumbly and weak. Body and texture scores given in Table 8 are those of cheese prepared from "cheese milk" containing lecithin. The average score of this cheese was 26.97 with a range of 23.0 to 29.0. Open, weak, crumbly and short were the most common criticisms. Cheese with mono- and diglycerides, Table 9, had an average score of 26.7 and the range was 23.0 to 28.5. This cheese was criticized for body and texture similar to those containing lecithin and those containing no emulsifier. The average body and texture scores in the three groups of cheese were within the normal range of 25.0 to 30.0. The addition of emulsifiers to the "cheese milk" prepared by Method I did not improve the body and texture.

The effect of heat treatment during manufacture of NDM and homogenization on protein stability apparently tends to lower the scores of Cheddar type cheese when compared with normal whole milk cheese. The scores of all the cheese were within the normal range for regular whole milk Cheddar cheese, which were in agreement with those given by Peters (29).

Table 7. Body and texture scores of Cheddar type cheese containing no emulsifier made by Method I (four judges)

Trial	Days in storage	Body and texture				Average score	Criticism
		1	2	3	4		
1	120	28.5	25.0	26.0	27.0	26.62	Slightly crumbly and weak, slightly short, open, sticky
2	120	27.0	26.0	27.0	26.5	26.62	Crumbly, dry, open, short
3	122	28.0	26.0	27.0	28.0	27.25	Crumbly, open
4	121	27.0	25.0	26.0	26.0	26.00	Crumbly, weak, very open
5	118	28.0	27.5	27.0	29.0	27.87	Short, slightly open
6	120	28.0	26.0	26.0	28.0	27.00	Crumbly, slightly open
7	120	28.5	27.5	27.0	28.0	27.75	Weak, short, weak, open, slightly rubbery
8	120	27.5	24.0	25.0	25.0	25.37	Crumbly, weak, pasty, very open, dry
9	129	28.0	27.0	28.0	29.5	28.13	Open
10	125	28.5	27.0	27.5	28.5	27.87	Short
Av. of all scores						27.09	

Table 8. Body and texture score of Cheddar type cheese containing lecithin made by Method I (four judges)

Trial	Days in storage	Body and texture				Average score	Criticism
		1	2	3	4		
1	120	28.0	27.0	26.5	28.0	27.37	Short, crumbly, firm, or rubbery, slightly open, slightly greasy, slightly open
2	120	27.5	25.5	27.5	27.0	26.87	Pasty, short, crumbly, open
3	122	28.0	26.5	27.5	29.0	27.75	Short, open, firm, slightly mottled
4	121	27.0	25.0	26.0	25.5	25.87	Crumbly, weak, open
5	118	28.0	27.0	27.0	27.0	27.25	Short, open, dry, crumbly
6	120	28.0	25.8	26.0	27.5	26.81	Crumbly, open
7	120	28.5	25.0	27.0	27.5	27.00	Weak, short, open, oily, soft
8	120	27.5	23.0	25.0	25.0	25.12	Weak, crumbly, pasty, crumbly, very open, dry
9	129	28.5	27.0	27.0	29.0	27.87	Corky
10	125	28.5	27.0	27.5	28.5	27.87	Short
Av. of all scores						26.97	

Table 9. Body and texture score of Cheddar type cheese containing mono- and diglycerides made by Method I (four judges)

Trial	Days in storage	Body and texture				Average score	Criticism
		1	2	3	4		
1	120	28.0	26.0	25.0	26.5	26.37	Short, crumbly, open, very crumbly
2	120	27.0	25.5	27.0	26.0	26.37	Slightly pasty, short, crumbly, open, dry
3	122	28.0	26.0	27.0	26.5	26.87	Short, crumbly, open dry
4	121	27.5	25.0	26.0	25.5	26.00	Crumbly, short, pasty
5	118	27.5	26.5	26.5	27.5	27.00	Short, open, crumbly
6	120	28.0	25.8	26.0	27.0	26.64	Crumbly, weak, open, mealy
7	120	28.5	26.0	27.0	28.5	27.50	Short, weak, open, slightly open, slightly oily
8	120	27.5	23.0	25.0	25.0	25.12	Weak, crumbly, pasty, open, dry
9	129	28.5	26.0	26.5	27.0	27.00	Corky, open
10	125	28.0	27.0	27.5	28.0	28.62	Open
Av. of all scores						26.74	

6. Total scores of Cheddar type cheese made by Method I

Calculated total scores for all trials are presented in Tables 10, 11 and 12. Cheese containing no emulsifier recorded in Table 10 had an average score of 89.30. The scores ranged from 84.0 to 93.0. Table 11 gives the scores of cheese containing lecithin. The range of scores for 10 trials was from 83.0 to 93.5 with an average of 89.32. Table 12 shows a slight increase in the scores given to cheese made from "cheese milk" containing mono- and diglycerides. The average score for ten trials in this group was 89.88 with a range of 83.0 to 92.5. "Cheese milk" containing lecithin and mono- and diglycerides did not improve the average score of the Cheddar type cheese. The differences in flavor or body and texture scores were not sufficiently great to cause significant differences in the total scores. The average score of Cheddar type cheese without an emulsifier was 89.30, while those containing lecithin and mono- and diglycerides were 89.32 and 89.88, respectively.

7. Fat losses in whey when cheese was made by Method I

The data on fat content of whey, from cheese made by Method I are presented in Table 13. With the modified Babcock method the "cheese milk" that did not contain an emulsifier had the maximum average fat loss in cheese whey of 0.095 percent. A slightly lower fat loss of 0.091

Table 10. Total score of Cheddar type cheese containing no emulsifier made by Method I (four judges)

Trial	Days in storage	Flavor scores 1	2	3	4	Average score
1	120	89.5	85.0	87.0	90.0	87.87
2	120	88.5	88.0	89.0	90.0	88.87
3	122	90.5	88.5	89.0	91.5	89.87
4	121	89.0	87.0	87.5	89.0	88.12
5	118	91.5	86.5	89.0	92.5	89.87
6	120	91.0	88.5	87.5	92.5	89.87
7	120	92.0	90.0	88.0	93.0	90.75
8	120	88.5	84.0	85.0	88.0	86.37
9	129	91.5	89.0	90.5	92.5	90.75
10	125	91.5	89.0	89.5	92.5	90.62
Av. of all scores						89.30

Table 11. Total score of Cheddar type cheese containing lecithin made by Method I (four judges)

Trial	Days in storage	Total score 1	2	3	4	Average score
1	120	88.0	89.0	88.0	90.0	88.75
2	120	90.0	87.5	89.5	91.5	89.62
3	122	91.5	89.0	90.5	93.0	91.00
4	121	89.5	86.5	87.0	88.0	87.75
5	118	91.5	88.5	89.0	91.0	90.00
6	120	91.0	88.35	87.5	92.0	89.68
7	120	92.0	88.0	88.0	91.5	89.87
8	120	88.0	83.0	85.0	88.0	86.00
9	129	91.5	88.0	89.0	91.5	90.00
10	125	91.5	88.0	89.5	93.5	90.62
Av. of all scores						89.32

Table 12. Total score of Cheddar type cheese containing mono- and diglycerides made by Method I (four judges)

Trial	Days in storage	Total score 1	2	3	4	Average score
1	120	88.0	88.0	86.5	88.5	87.75
2	120	89.5	87.5	89.0	90.0	89.00
3	122	91.5	88.5	89.0	90.0	89.75
4	121	90.5	86.5	87.0	88.0	88.0
5	118	90.5	88.0	88.5	91.0	89.50
6	120	90.0	88.3	88.0	91.0	89.31
7	120	91.5	89.0	88.0	92.5	90.25
8	120	88.5	83.0	85.0	87.5	86.00
9	129	91.5	87.0	88.0	90.0	89.12
10	125	91.0	89.0	88.5	92.0	90.12
Av. of all scores						89.88

percent was observed in cheese whey obtained from the "cheese milk" that contained lecithin. The lowest fat loss of 0.087 percent was noted in cheese whey obtained from the "cheese milk" containing mono- and diglycerides.

Table 13. Fat content of cheese whey obtained by Method I as determined by two different tests

	Modified Babcock method			Babcock method		
Trial	Control (percent)	Lecithin (percent)	Mono- and diglycerides (percent)	Control (percent)	Lecithin (percent)	Mono and diglycerides (percent)
1	0.057	0.087	0.092	0.050	0.072	0.075
2	0.135	0.125	0.130	0.105	0.105	0.122
3	0.120	0.115	0.070	0.125	0.100	0.070
4	0.110	0.080	0.087	0.085	0.070	0.060
5	0.057	0.052	0.060	0.060	0.070	0.060
Av.	0.095	0.091	0.087	0.085	0.083	0.080

The same samples tested by the Babcock method show a similar trend. The "cheese milk", which did not contain an emulsifier, had an average fat loss of 0.085 percent, whereas, the loss in "cheese milk" containing lecithin was 0.083 percent. "Cheese milk" containing mono- and diglycerides had the lowest fat loss of 0.080 percent in the whey. In the samples tested by both methods the fat loss in 3 cheese wheys was lower than those in normal whole milk whey. Cheese whey fat losses in normal whole milk were reported as high as 0.20 to 0.35 percent by Wilster (53) and 0.31 to 0.41 percent by Van Slyke (50).

Homogenization of emulsions at 500 p.s.i. lowered the fat losses in cheese whey. Similar findings were reported by earlier workers. Nichols (25) prepared Cheddar cheese from homogenized milk and observed a range of 0.06 to 0.12 percent fat loss in cheese whey, while Maxcy et al. (23) reported 0.02 percent loss. Peters (29) and Peters et al. (30) reported fat loss in cheese whey up to 0.08 percent. When reconstituted skim milk was standardized with sweet butter, Peters (31) showed fat losses in cheese whey as low as 0.02 percent. Addition of emulsifiers decreased fat losses a slight degree. Tested by the modified Babcock method the fat losses in cheese whey were 0.095, 0.091 and 0.087 percent in "cheese milks" containing no emulsifier, lecithin and mono- and diglycerides, respectively. Although the use of emulsifiers such as lecithin and mono- and diglycerides appeared to cause a decrease in fat losses in whey, there was no significant difference in the use of emulsifiers when subjected to analysis of variance, tested at the 5 percent level.

Statistical treatment of the data presented in Table 13 using Analysis of variance test, Dixon and Massey (8) showed the smallest variation of all in main effects in the treatments (emulsifiers). Largest variation was between the lots of whey. The next largest variation was in the two methods of testing the fat content of whey (Babcock vs. modified Babcock methods).

No significant effect can be attributed to the use of emulsifiers in reducing fat losses in cheese whey. Similar results were reported by Peters (29) in which no apparent effect was noticed either with or without the addition of monostearine on fat losses in whey or in oiling off of the cheese after one month storage.

8. The percent of fat, total solids, moisture and yield of cured cheese made by Method I

Cheddar type cheese manufactured from "cheese milk," Method I, was tested for fat, total solids, moisture and weighed at the end of 120 days curing period. The results are presented in Tables 14, 15 and 16. Data on cheese containing no emulsifier, Table 14, show that the fat ranged from 25.01 to 33.87 percent with an average of 30.65. The total solids ranged from 57.61 to 63.23 percent with an average of 60.79. Moisture ranged from 36.77 to 42.39 and the average was 39.21 percent. Final weight of the cured cheese ranged from 20.0 to 23.0 lb. averaging 21.28 lb. representing a 10.64 percent yield on a milk weight basis.

The analytical results of 10 trials of lecithin emulsified "cheese milks," Method I, are shown in Table 15. The fat percentages ranged from 21.88 to 33.82 with an average of 30.76. This was slightly higher than the fat of 30.65 percent in cheese obtained from Method I "cheese

Table 14. Yield and percentage of fat, total solids and moisture in Cheddar type cheese made by Method I containing no emulsifier

Trial	Storage (days)	Yield (lb.)	Fat (percent)	Total solids (percent)	Moisture (percent)
1	120	21.50	33.05	59.59	40.41
2	120	22.00	33.87	61.73	38.27
3	122	20.00	33.73	62.59	37.41
4	121	21.00	25.01	59.74	40.26
5	118	21.00	28.73	59.42	40.58
6	120	23.00	30.91	60.41	39.59
7	120	20.00	29.68	60.44	39.56
8	120	23.00	27.00	57.61	42.39
9	129	20.37	32.63	63.07	36.93
10	125	20.00	31.89	63.23	36.77
Av.		21.28	30.65	60.79	39.21

Table 15. Yield and percentage of fat, total solids and moisture in Cheddar type cheese made by Method I containing lecithin

Trial	Storage (days)	Yield (lb.)	Fat (percent)	Total solids (percent)	Moisture (percent)
1	120	20.8	33.82	61.93	38.07
2	120	23.0	33.58	61.56	38.44
3	122	20.0	33.65	65.64	33.36
4	121	21.5	21.88	57.92	42.08
5	118	22.0	31.66	61.77	38.23
6	120	23.6	31.20	60.36	39.64
7	120	20.0	30.14	60.38	39.62
8	120	23.5	26.58	58.27	41.73
9	129	21.5	33.12	63.35	36.65
10	125	21.5	31.74	64.08	35.92
Av.		21.7	30.76	61.53	38.47

milks" which contained no emulsifier. The total solids ranged from 57.92 to 65.64 and the average for all trials was 61.53. Moisture ranged from 34.36 to 42.08 and the average was 38.47 percent. Final weights of the cured cheese ranged from 20.00 to 23.62 lb. averaging 21.71 lb. representing 10.88 percent yield.

Data presented in Table 16 give the percentages of fat, total solids, moisture and the weights of cured cheese from Method I "cheese milks" containing mono- and diglycerides. Slightly higher fat and total solids content were noted when mono- and diglycerides were added as compared with lecithin. The range of fat content in this group of cheese was from 28.00 to 34.05 percent with an average of 31.65. The total solids content ranged from 55.89 to 65.06 percent with an average of 61.66. Moisture ranged from 34.94 to 44.11 and the average for all trials was 38.84 percent. The final yield ranged from 20.0 to 23.5 lb., and the average for all 10 trials was 21.41 lb. or 10.70 percent on a milk weight basis.

Cheddar type cheese made by Method I compares favorably in composition with Cheddar cheese made from whole milk as shown in Table 17.

Although slightly lower fat percentages were noted in cheese made by Method I as compared to that of normal milk Cheddar cheese, the fat in dry matter averaged 50 percent or more. A maximum of 51.3 percent fat in dry matter was present in cheese containing mono- and

Table 16. Yield and percentage of fat, total solids and moisture in Cheddar type cheese made by Method I containing mono- and diglycerides

Trial	Storage (days)	Yield (lb.)	Fat (percent)	Total solids (percent)	Moisture (percent)
1	120	21.50	34.05	61.65	38.35
2	120	23.00	33.44	61.75	38.25
3	122	20.00	32.93	65.06	34.94
4	121	21.50	28.00	55.89	44.11
5	118	21.50	31.43	63.83	36.17
6	120	21.75	31.15	60.67	39.33
7	120	20.00	32.25	61.98	38.02
8	120	23.50	28.46	58.40	41.60
9	129	21.37	33.13	63.45	36.55
10	125	20.00	31.72	63.96	36.04
Av.		21.41	31.65	61.66	38.34

Table 17. Composition of Cheddar cheese from whole milk and Cheddar type cheese made by Method I

Product	Fat (percent)	Moisture (percent)	Total solids (percent)	Fat in dry matter (percent)
Whole milk (cow)*	32.20	37.00	63.00	51.1
"Cheese milk" with no emulsifier	30.65	39.21	60.79	50.2
"Cheese milk" with lecithin	30.76	38.47	61.53	50.0
"Cheese milk" with mono- and diglycerides	31.65	38.84	61.66	51.3

*Wilster (53).

diglycerides. Higher average yields were obtained by Method I than those for whole milk containing 3.5 percent fat as reported by Wilster (53) as shown in Table 18. Homogenizing Method I emulsions at 500 p.s.i. resulted in higher yields as evidenced in Table 18. "Cheese milk" containing no emulsifier yielded 10.64 percent. Those containing lecithin and mono- and diglycerides yielded 10.85 and 10.70 percent, respectively. Those yields are all higher than the 9.45 percent yield which was reported as obtained from 3.5 percent fat whole milk. Higher yields of cheese by homogenizing milk were obtained by Nichols (25), Peters (28), Peters et al. (30) and by workers in Czechoslavakia (1). It could be that homogenization causes low fat losses in whey, increased moisture content in cheese and, therefore, greater yields were obtained, Nichols (25).

Table 18. Percentage yield of Cheddar cheese obtained from 3.5 percent fat whole milk and Cheddar type cheese made by Method I

Milk or emulsion	Emulsifier added	Fat (percent)	Yield (percent)
Whole, cow's milk	None	3.5	9.45
"Cheese milk" with Cirol	None	3.5	10.64
"Cheese milk" with Cirol	Lecithin	3.5	10.85
"Cheese milk" with Cirol	Mono- and diglycerides	3.5	10.70

The fat content data shown in Tables 14, 15 and 16 were analyzed statistically with the results presented in Table 19.

The results of analysis showed that there was no significant difference at the 5 percent level due to the addition of emulsifiers. Although arithmetic averages in Table 17 indicated a slight difference in fat percentages, no distinct advantage was obtained by adding emulsifiers. Similarly there does not appear to be an advantage of mono- and diglycerides over lecithin in increasing the fat content of the final product.

The results of statistical analysis of the data on total solids (Tables 14, 15 and 16) are shown in Table 20.

Table 19. Analysis of variance and test of significance of data on fat percentages in 10 trials of Cheddar type cheese made by Method I

Source of variation	Number of degrees of freedom	Sum of squares	Variance	Variance ratio
Total	29	314.67		
Between treatments	2	4.97	2.48	0.2162
Within treatments	27	309.70	11.47	

Degrees of freedom $n_1 = 2$, $n_2 = 27$.

F values at 5 percent level = 3.35.

Table 20. Analysis of variance and test of significance with reference to total solids in 10 trials of Cheddar type cheese made by Method I

Source of variation	Number of degrees of freedom	Sum of squares	Variance	Variance ratio
Total	29	151.11		
Between treatments	2	9.35	4.67	0.8895
Within treatments	27	141.76	5.25	

Degrees of freedom $n_1 = 2$, $n_2 = 27$.

F value at the 5 percent level = 3.35.

No significant difference at the 5 percent level in the total solids content of the cheese was evident through the use of emulsifiers. While arithmetic averages given in Table 17 show a slight increase due to the addition of emulsifiers, no definite advantage was noted. Statistical treatment of the data show no significant effect or superiority of one emulsifier over the other in increasing the total solids of the product.

A homogenization pressure of 500 p.s.i. caused a fine distribution of the oil globules. Prompt conversion of the "cheese milk" to Cheddar type cheese reduced oil leakage during curing. While statistical analysis of composition showed no real advantage from emulsifiers, it was evident that a homogenization pressure of 500 p.s.i. is a factor in obtaining uniform composition in the cured cheese.

9. The flavor scores of Cheddar type cheese made by Method II

The flavor scores of four trials of Method II Cheddar type cheese are presented in Table 21. Flavor scores of cheese manufactured from emulsions containing no emulsifier averaged 36.8. The most common criticisms were, slightly bitter, oily, foreign, and not true Cheddar type flavor. Cheddar type cheese manufactured from "cheese milk" containing lecithin were given flavor scores ranging from 35.5 to 39.0 and averaged 36.8. Common flavor criticisms were similar to those in Method I Cheddar type cheese.

Table 21. Flavor scores of Cheddar type cheese made by Method II (four judges)

		No emulsifier				Lecithin added			
		Flavor score				Flavor score			
Trial	Storage (days)	1	2	3	4	1	2	3	4
1	120	35.0	37.5	36.0	38.0	35.5	37.0	36.0	38.0
2	120	35.5	35.0	36.5	38.5	37.0	37.0	36.0	38.0
3	121	38.0	37.0	36.5	39.0	36.0	37.0	35.5	39.0
4	119	37.5	36.0	37.0	38.5	37.0	36.5	36.0	38.0
Av. of all scores					36.8				36.8

10. The body and texture scores of Cheddar type cheese made by Method II

Table 22 presents the body and texture score of Cheddar type cheese manufactured from "cheese milk" containing no emulsifier. Slightly better body and texture cheese was obtained from emulsions containing lecithin. However, cheese in both groups were criticized for poor body. Brittle, short and crumbly were common criticisms.

11. The total scores of Cheddar type cheese made by Method II

The total scores presented in Table 23 ranged from 87.0 to 91.0 and the average was 88.8. Cheese with lecithin showed slightly higher total scores ranging from 86.5 to 91.5 with an average of 89.0. The use of lecithin in the "cheese milk" had no significant influence on the average total score of Cheddar type cheese.

The average total score of Cheddar type cheese prepared by Method I and II containing no emulsifier varied no more than 0.50 percent (Tables 10 and 23). Those containing lecithin varied 0.31 percent (Tables 11 and 23). Since a smaller portion of the emulsion was homogenized in Method I as compared to homogenizing the entire quantity in Method II, the softening effect of homogenization on the curd was less in Method I. The total time to complete the manufacturing steps was reduced with Method I "cheese milk" because a shorter cheddaring time was required. This cheese had slightly less acid at the time of pressing

Table 22. Body and texture scores of Cheddar type cheese made by Method II (four judges)

Trial	Storage (days)	No emulsifier				Lecithin added			
		Flavor score				Flavor score			
		1	2	3	4	1	2	3	4
1	120	28.0	26.0	27.0	26.5	28.0	25.0	28.0	29.0
2	120	28.0	27.0	25.5	27.0	28.0	26.0	26.0	27.0
3	121	27.0	27.0	26.5	27.0	28.0	27.0	26.0	27.5
4	119	28.0	27.0	27.0	26.5	27.0	27.0	28.0	28.0
Av. of all scores					26.8				27.2

Table 23. Total scores of Cheddar type cheese made by Method II (four judges)

Trial	Storage (days)	No emulsifier				Lecithin added			
		Flavor score				Flavor score			
		1	2	3	4	1	2	3	4
1	120	88.0	88.5	88.0	89.5	88.5	87.0	89.0	92.0
2	120	88.5	87.0	87.0	90.5	90.0	88.0	87.0	90.0
3	121	90.0	89.0	88.0	91.0	89.0	89.0	86.5	91.5
4	119	90.0	89.5	88.0	90.0	90.0	89.0	88.5	90.0
Av. of all scores					88.8				89.0

which likely contributed to flavor and body improvement. However, the differences in organoleptic factors are not sufficiently large to cause a definite distinction in cheese obtained by using "cheese milk" from either of the two methods.

12. Composition and final yield of Cheddar type cheese made by Method II

Cheddar type cheese manufactured from emulsions obtained by Method II were analyzed for fat, total solids, moisture and yield at the end of the curing period. These data are presented in Table 24. Cheese with no emulsifier had average percentages of 33.26, 59.15 and 40.86 for fat, total solids and moisture, respectively. Whereas cheese with lecithin contained an average of 34.54, 61.48 and 38.51 percent for fat, total solids and moisture, respectively. While the average yield of 21.18 lb. was slightly greater from lecithinated "cheese milk," it was not a significant increase over the 21.12 lb. obtained without an emulsifier.

There does not appear to be an appreciable difference between the organoleptic evaluations or in the composition of the cheese manufactured from "cheese milk" of both methods as seen in Table 25.

13. Ingredient cost of Cheddar type cheese

The ingredient cost of normal Cheddar and Cheddar type cheeses were compared. Prices assumed for the various ingredients were as follows: butterfat $0.70 per lb.;

Table 24. The percentage of fat, total solids, moisture and yield of Cheddar type cheese made by Method II

	No emulsifier added				Lecithin added			
Trial	Fat (percent)	Total solids (percent)	Moisture (percent)	Yield (lb.)	Fat (percent)	Total solids (percent)	Moisture (percent)	Yield (lb.)
1	33.57	58.16	41.84	19.5	33.07	62.81	37.19	21.25
2	33.27	60.60	39.48	21.5	35.61	60.48	39.52	20.50
3	32.80	38.01	41.99	22.5	34.55	61.38	38.62	22.50
4	33.42	59.84	40.16	21.0	34.95	61.26	38.74	20.50
Av.	33.26	59.15	40.86	21.12	34.54	61.48	38.51	21.18

Table 25. Average organoleptic scores and the composition of Cheddar type cheese made by Methods I and II

	Flavor	Body and texture	Total score	Fat (percent)	Moisture (percent)	Total solids (percent)	Yield (lbs.)
METHOD I							
No emulsifier	37.20	27.09	89.30	30.65	39.21	60.79	21.28
Lecithin	37.24	26.97	89.32	30.76	38.47	61.53	21.71
Mono-diglycerides	37.19	26.74	89.88	31.65	38.34	61.66	21.41
METHOD II							
No emulsifier	36.79	26.84	88.88	33.26	40.86	61.48	21.18
Lecithin	36.83	27.21	89.01	34.54	38.51	59.15	21.12

serum solids $0.10 per lb.; vegetable fat $0.23 per lb.; and NDM $0.15 per lb. The cost of butterfat in 100 lb. of milk containing 3.5 percent fat was $2.45, and the cost of serum solids at 8.6 percent was $0.86. Assuming a yield of Cheddar cheese from 100 lb. of milk to be 10.73 lb. (same yield obtained from Method I in present studies), the cost of milk ingredients in cheese would be $3.31 ÷ 10.73, or 30.84 cents per lb. of cheese. Similarly the cost of vegetable fat in 100 lb. of "cheese milk" at 3.5 percent would be 80.5 cents. The cost of 8.685 lb. of serum solids supplied by NDM containing 3.0 percent moisture would be $1.34. Therefore, the cost of these ingredients for Cheddar type cheese would be $2.145 or 19.99 cents, per lb.

A cost difference of 10.85 cents per lb. in favor of Cheddar type cheese was due to the lower cost of vegetable fat when compared with butterfat.

14. Organoleptic scores of Surati cheese

Surati cheese was organoleptically evaluated for flavor and the results are shown in Table 26. The flavor scores of the control samples ranged from 36.5 to 39.0 with an average of 37.32. While flavor scores of Surati cheese made from "cheese milk" without an emulsifier ranged from a low of 36.0 to a high of 39.5 with an average of 37.34; those containing mono- and diglycerides scored 36.0 to 39.5 with an average of 37.37. The most common flavor criticisms

Table 26. Flavor scores of Surati cheese made from whole milk (control) and Surati type cheese made from vegetable fat "cheese milk" (three judges)

Trial	Control (cows milk)			Vegetable fat "cheese milk"					
				No emulsifier			Mono- and diglycerides		
	1	2	3	1	2	3	1	2	3
1	39.00	37.00	38.00	37.00	36.00	39.50	37.00	36.00	39.00
2	38.00	38.00	37.00	37.00	36.00	39.00	37.00	36.00	38.50
3	37.00	36.50	37.00	37.00	36.50	38.50	37.00	36.00	39.50
4	37.00	36.50	38.00	37.00	37.00	38.00	37.00	37.50	38.00
5	37.00	36.75	37.00	37.00	37.50	39.00	37.00	37.00	39.00
	37.60	36.95	37.40	37.00	36.42	38.62	37.00	36.50	38.62
Av. of all scores			37.32			37.34			37.37

were oily and slight unnatural. A favorable comparison was noted in the flavor scores of cheese made from "cheese milk" when compared with control cheese.

Table 27 gives the body and texture scores of Surati cheese. The scores in control cheese ranged from 26.0 to 30.0 with an average of 28.1. Surati cheese obtained from "cheese milk" without an emulsifier averaged 26.53 and ranged from 21.0 to 30.0; while those containing mono- and diglycerides scored an average of 26.1 and ranged from 21.0 to 30.0. The body and texture of cheese obtained from "cheese milk" was criticized for being too soft and weak. This condition might be explained on the basis that homogenizing the "cheese milk" caused "soft curd" formation.

15. Composition of Surati and Surati type cheese

The results of fat, total solids, moisture and yield analysis are shown in Table 28. Control cheese contained 28.5 percent fat, 44.8 percent total solids and 55.1 percent moisture. The cheese obtained from "cheese milks" that did not contain an emulsifier had 27.7, 38.9 and 61.0 percent of fat, total solids and moisture, respectively. The average composition of the cheese that contained an emulsifier was 28.2 percent fat, 38.9 percent total solids and 61.0 percent moisture. The average yield of cheese made from control milk was 19.4 percent, and that from "cheese milk" containing no emulsifier 20.6 percent. The average yield of cheese made from "cheese milk"

Table 27. Body and texture scores of Surati cheese made from whole milk (control) and Surati type cheese made from vegetable fat "cheese milk" (three judges)

Trial	Control (cows milk)			Vegetable fat "cheese milk": No emulsifier			Vegetable fat "cheese milk": Mono- and diglycerides		
	1	2	3	1	2	3	1	2	3
1	29.0	28.0	30.0	29.5	24.0	26.5	29.5	22.0	25.0
2	29.0	28.0	29.0	29.5	24.0	26.5	29.5	24.0	26.0
3	29.0	26.0	27.0	29.5	24.0	26.5	29.5	24.0	26.0
4	29.0	26.0	28.0	30.0	23.0	27.0	30.0	21.0	26.0
5	29.0	26.0	28.0	30.0	21.0	27.0	30.0	23.0	26.0
	29.0	26.8	28.4	29.7	23.2	26.7	29.7	22.8	25.8
Av. of all scores			28.06			26.53			26.10

Table 28. Percentages of fat, total solids, moisture and yield of Surati cheese made from whole milk (control) and Surati type cheese made from vegetable fat "cheese milk"

					Vegetable fat "cheese milk"							
	Control				No emulsifier				Mono- and diglyceride			
Trial	Fat (per-cent)	Total solids (per-cent)	Mois-ture (per-cent)	Yield (oz.)	Fat (per-cent)	Total solids (per-cent)	Mois-ture (per-cent)	Yield (oz.)	Fat (per-cent)	Total solids (per-cent)	Mois-ture (per-cent)	Yield (oz.)
1	28.0	44.5	55.5	15.5	27.4	39.2	60.8	17.0	27.0	39.0	60.9	16.5
2	28.6	44.8	55.2	15.0	27.8	38.5	61.5	17.0	28.8	39.0	60.9	17.5
3	27.5	44.0	56.0	16.0	28.0	38.9	61.1	15.5	28.5	38.2	61.7	15.0
4	29.1	45.3	54.7	15.5	28.1	39.4	60.6	15.5	28.0	39.4	60.6	15.5
5	29.0	45.6	54.4	15.5	27.4	38.6	61.4	17.5	28.6	39.7	60.8	17.0
Av.	28.5	44.8	55.1	15.5	27.7	38.9	61.0	16.5	28.2	38.9	61.0	16.3

containing mono- and diglycerides was 20.4 percent. In all trials lower yields were obtained than the 38 percent reported by Kothawalla and Verma (18). Buffalo milk may produce somewhat higher yields, however, because of the solids content. An estimation of yield based on the composition of the cheese reveals that 20 percent yield is more realistic. Higher yields were obtained with the "cheese milks" due to higher moisture content and very low fat losses in cheese whey as shown in Table 29.

Table 29. Fat loss in whey of Surati cheese and Surati type cheese

Trial	Control whey	"Cheese milk" whey: With no emulsifier	"Cheese milk" whey: With mono- and diglycerides
1	0.38	0.09	0.07
2	0.39	0.10	0.08
3	0.40	0.10	0.09
4	0.40	0.09	0.10
5	0.39	0.09	0.08
Av.	0.39	0.09	0.08

If vegetable fat and NDM are available in the developing countries certain cheese products may be made. Attempts should also be made to utilize the whey in the human diet to assure that these nutrients are not lost in the whey as a result of cheese manufacture.

SUMMARY AND CONCLUSION

Over 70 percent of the fat globules in "cheese milk" prepared by Methods I and II were 3 microns or smaller in size. When homogenization pressures were varied from 500 to 2,000 p.s.i. at 140° to 143°F. the least objectionable fat separation was noted when higher pressures were used.

While "cheese milk" prepared by Method II had greater emulsion stability than Method I, the latter was preferred due to firmer curd formation and easier handling during cheese manufacture. Similarly a pressure of 500 p.s.i. was preferred over higher pressures due to desirable curd formation with rennet. Homogenization results in a relatively "soft curd" which is different from the normal whole milk curd at the time of cutting. Therefore, the cooking time was longer. Matting in most cases was prolonged to obtain reasonably complete cheddaring.

Beneficial effects of emulsifiers at the 0.05 percent level on a fat basis appears negligible on emulsion stability, organoleptic scores or composition of Cheddar type cheese.

More desirable cheese product characteristics were obtained from Method I than from Method II "cheese milks." The organoleptic scores of all Cheddar type cheese in both "cheese milks," and in most of the Surati type cheese

were within the normal range of scores given to whole milk Cheddar and Surati cheese.

The loss of fat (0.08 to 0.09 percent) in cheese whey was lower from vegetable fat "cheese milk" than from normal whole milk cheese whey. There was no significant reduction in fat loss due to the use of an emulsifier.

Current prices were used to compare the ingredient cost and it was found that Cheddar type cheese made from vegetable fat and reconstituted NDM was about 10.85 cents per pound lower than whole milk Cheddar cheese.

The flavor of Surati type cheese made from vegetable fat "cheese milk" compared well with control cheese. While higher yields of cheese were obtained from vegetable fat "cheese milk," the body and texture was criticized as weak and soft.

Homogenization of the vegetable fat mixture caused greater holding of moisture in the cheese, thus increasing the final yield of Cheddar type cheese (10.64 percent), than is sometimes reported for regular whole milk Cheddar cheese.

In conclusion, combining reconstituted nonfat dry milk and vegetable fat and homogenizing the mixture at 500 p.s.i. and 140° to 143°F. Cheddar type and Surati type cheese can be manufactured which are comparable with Cheddar and Surati cheese in flavor and composition but may lack in body and texture.

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