THE MANUFACTURE OF A NON-FAT-LEAKING CHEDDAR CHEESE FROM RECONSTITUTED MILK.

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SUMMARY.

A process has been evolved for the commercial manufacture of a non-fat-leaking cheddar cheese.

The process depends on separating the whole milk, homogenizing the cream therefrom in a three-stage homogenizer to reduce most of the fat globules to less than 2μ in diameter, reconstituting the milk, and proceeding as in cheddar cheese manufacture, with minor modifications.

The underlying principles of homogenization, the method of manufacture, defects and their control, equipment and its layout, and costs of manufacture are discussed.

INTRODUCTION.

There has long been a need for a cheese which would be as attractive to eat in the tropics and hot inland regions of Queensland as ordinary cheddar in temperate climates. Cheddar cheese "sweats" freely when atmospheric temperatures are high, and its edible life is very short where refrigeration is not available.

In view of the increased importance of cheese as a wartime foodstuff in Great Britain and its possible production as an alternative to butter at a time when refrigerated vessels were difficult to secure for the Australian trade, investigations were initiated, in conjunction with the Queensland Butter Board, to produce a cheese which would not leak fat when subjected to high temperatures, and which would stand up to long periods of holding as unrefrigerated cargo. Apart from the advantages of a non-fat-leaking cheese in transport, its more extensive use in the tropics and hot inland regions could not be overlooked.

PRINCIPLE OF THE METHOD.

A cheddar cheese which is strongly resistant to fat leakage may be manufactured by separating the whole milk, homogenizing the cream so as to reduce the size of most of the fat globules from approximately 10μ to less than 2 μ in diameter, and then reconstituting the milk. For a satisfactory product it was found that 85 per cent. of the fat globules should be less than 2μ in diameter, well dispersed, and exhibit Brownian movement when viewed microscopically. When fat-globular clumping was evident, the homogenized cream became too viscous and the cheese made from the reconstituted milk exuded fat at high atmospheric temperatures. To prevent the clustering of the fat globules, it was found necessary to use an emulsifying agent, irrespective of the number of phases of homogenization.

The first-phase homogenization at high pressure results in a splitting of the fat globules and a subsequent clustering. Assisted by an emulsifying agent, the second and third phases at low pressures cause a complete dispersal of the globules. Plates 1–5 illustrate these changes.

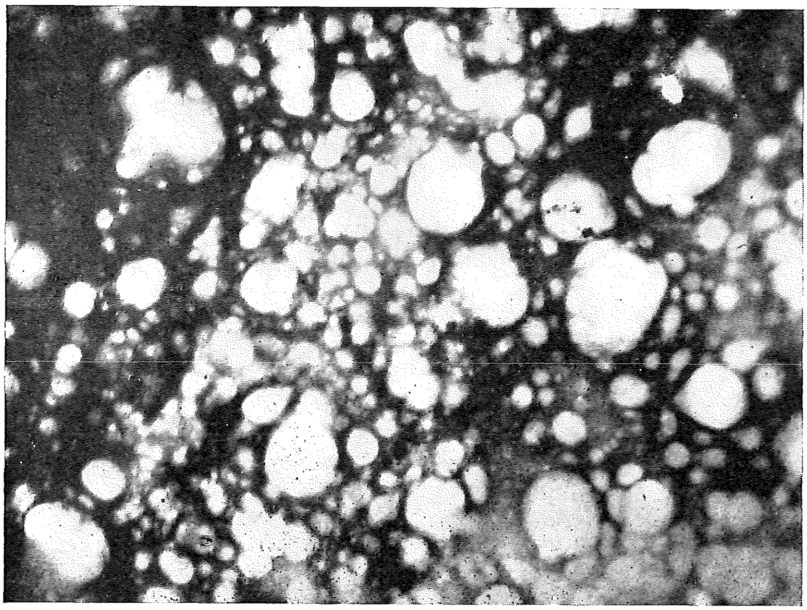


Plate 1.

Photomicrograph of fat globules in normal milk. (Diameter approx. 10 microns) × 1000.

If the homogenization is efficient, the fat globules are so finely dispersed that, after reconstitution with skim milk, each globule is completely and permanently encased by the milk serum. As the non-fat-leaking characteristic of the cheese depends essentially upon size and dispersion of the fat globules, the smaller the fat globules and the more even the dispersion, the more effectively are they incorporated in the reconstituted milk and the greater the resistance to fat leakage of the resulting cheese.

The method first attempted was to homogenize whole milk, but destabilization of the casein gave a "soft curd." It was ultimately found that homogenization of the cream portion, and not of the whole milk, was the key to the procedure.

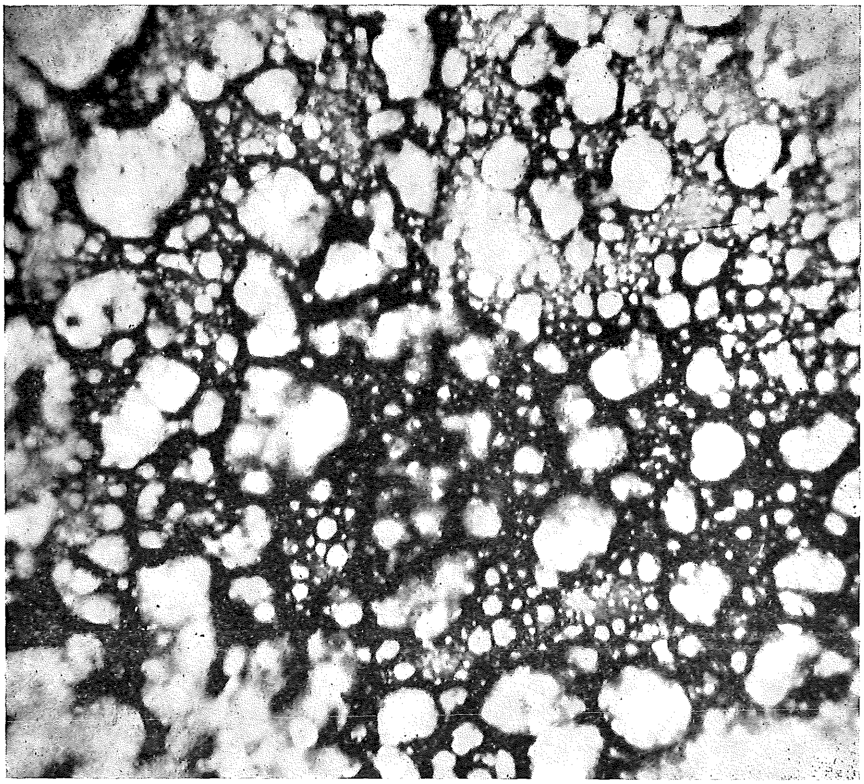


Plate 2.
Fat globules in normal cream × 1000.

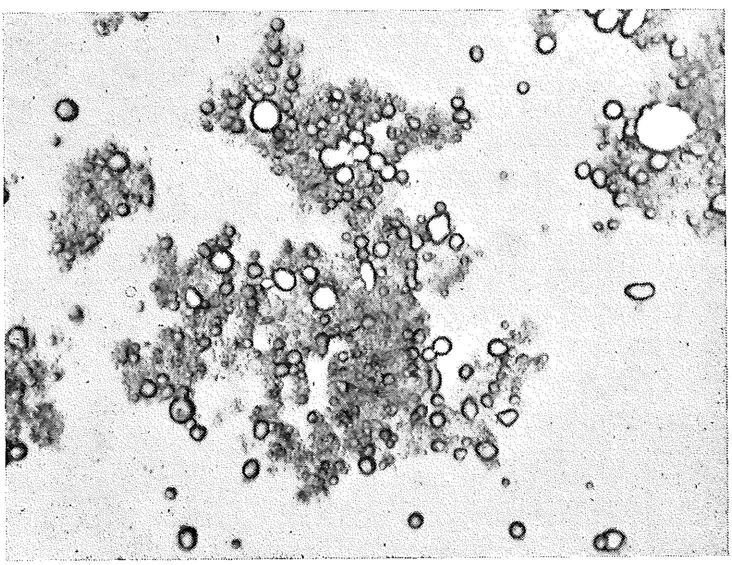


Plate 3.
Illustrating typical clumping of fat globules after first stage homogenization × 600.

EFFICIENCY OF HOMOGENIZATION.

The effects of the following factors on the efficiency of homogenization were studied by microscopic examination and observation of the cheese when held at high atmospheric temperatures:—

(1) Number of stages of homogenization and homogenizing pressures.

(2) Temperature of homogenization.

(3) Quantity and kind of emulsifier.

(4) Fat content of the cream.

(5) Acidity of the cream.

(6) Use of calcium salts in casein deficient milk.

(7) Excessive agitation or frothing in treating and reconstituting the milk.

Number of Stages of Homogenization and Homogenizing Pressures.

Single-stage homogenization at 1,500 lb. per square inch pressure gave excessive fat clumping with thickening of the cream (see Plate 3). The two-

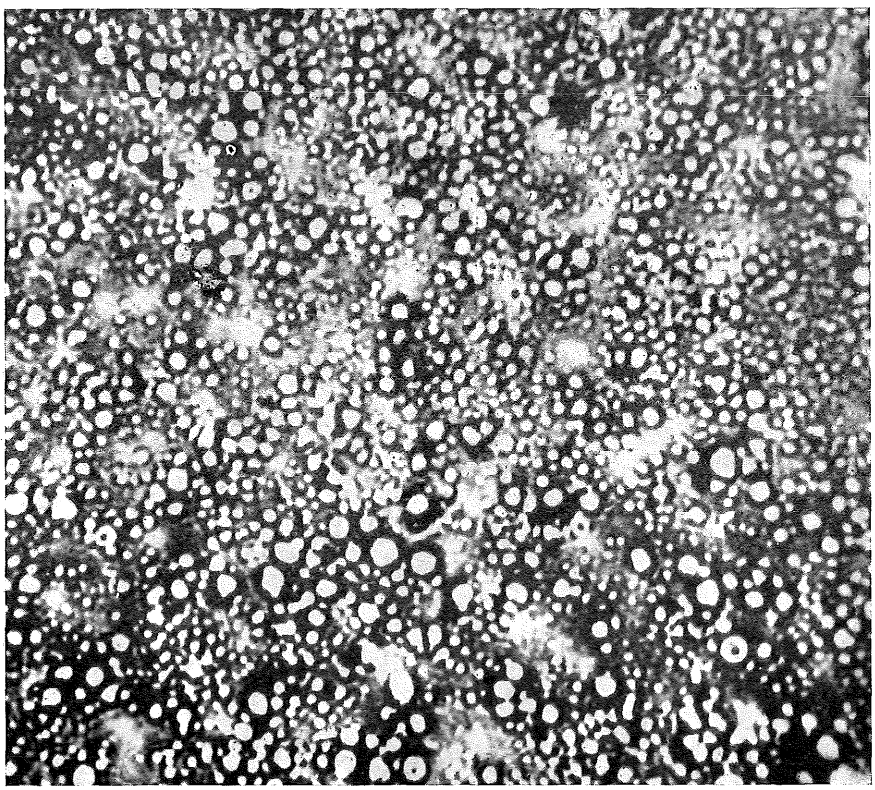


Plate 4.
Fat globules in cream of 20 per cent. fat content following 3-stage homogenization.

stage process at 1,250 lb. and 500 lb. pressure respectively resulted in a partial clumping of the fat globules, though the cream was less viscous than with single-stage homogenization at 1,500 lb. In these trials numerous fat globules exceeded 2μ in diameter, with some fat leakage in the resultant cheese. With first-stage pressure at 2,500 lb. to 3,000 lb., followed by 500 lb. pressure in the second stage, there was some clumping of the fat globules, with some fat leakage from the cheese.

The three-stage process, at 2,200 lb., 650 lb. and 150 lb. pressure in the first, second, and third stages respectively, gave satisfactory results; 85 per cent. of the fat globules were less than 2μ in diameter and well dispersed, and the cream was of the desired consistency.

Temperature of Homogenization.

Temperatures of 125°F., 145°F., 160°F., 170°F. and 180°F. were tried. At the higher temperatures of 160°F. and above, homogenization was most efficient, and fat clumping reduced. A temperature of 160°F. was finally decided upon to prevent a cooked flavour, as well as to ensure the complete destruction of lipolytic enzymes.

Quantity and Kind of Emulsifier.

Irrespective of the number of stages of homogenization, it was found necessary to use an emulsifier to aid the dispersal of the fat globules in the second and third stages.

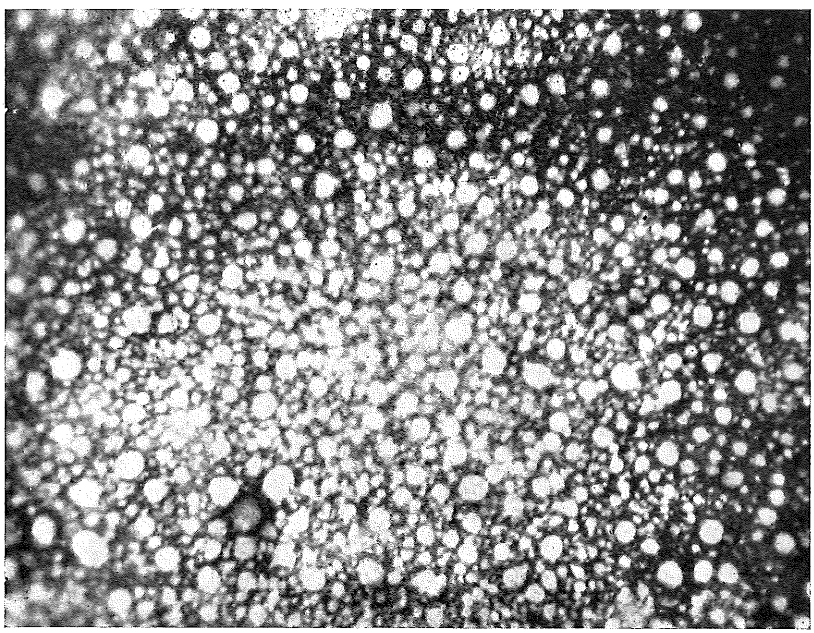


Plate 5.

Photomicrograph of fat globules in the reconstituted milk. (Diameter approx. 2 microns.)

Di-sodium hydrogen phosphate (0·1 per cent., 0·2 per cent., 0·25 per cent., 0·5 per cent., 0·75 per cent., 1 per cent. and 1·25 per cent.) and sodium citrate (0·1 per cent., 0·2 per cent., 0·3 per cent., 0·4 per cent., 0·5 per cent., 0·75 per cent. and up to 1 per cent.) were used in trial batches. Since sodium citrate gave more satisfactory results than di-sodium hydrogen phosphate, it was finally chosen as the emulsifying agent. Use of di-sodium hydrogen phosphate up to 1·25 per cent. resulted in fat clumping, thickening of the cream and fat leakage in the cheese. Use of sodium citrate below 0·75 per cent. gave different degrees of fat clumping, depending upon the quantity used. Sodium citrate was noted to impart a slight bitterness to cheese if used in excess of 0·75 per cent., and its use was limited to this quantity. As a further aid to reducing the citrate flavour, the cream was diluted with an equal quantity of hot water at 160°F.

Fat Content of the Cream.

When whole milk was homogenized there was efficient splitting and dispersal of the fat globules. As already mentioned, however, the casein was completely destabilized and the milk rendered unsuitable for the manufacture of cheddar cheese.

When a 38 to 40 per cent. fat content cream was homogenized, a large percentage of the fat globules exceeded 2μ in diameter, and a tendency to fat clumping was evident.

Homogenization of cream separated to 20 per cent. fat content resulted in casein destabilization due to the high serum-solids content, and there was a characteristic curd flaking in the whey. Efficient separation of a 20 per cent. fat content cream was found difficult.

The addition of an equal volume of skim milk to 40 per cent. fat content cream to reduce the fat content to 20 per cent. also resulted in casein destabilization, though in each case homogenization was efficient.

The replacement of the skim milk by an equal quantity of hot water to reduce the fat content of the mixture to 20 per cent. for homogenization gave satisfactory results.

Acidity of the Cream.

During the summer months the higher acidities in milk and cream (over 0·2 per cent.) caused excessive fat clumping and increased fat leakage from the cheese. Developed acidity in treated cream also caused excessive fat clumping and thickening. To obviate these disadvantages, small amounts of sodium bicarbonate were added to reduce the acidity of the milk to 0·18 per cent. calculated as lactic acid.

Effect of a High Calcium Content in the Milk.

Calcium chloride is sometimes added to milk with a view to improving the body and texture of cheese. Its use in reconstituted milk was discontinued after the initial trials, as it encouraged clumping of the fat globules.

Excessive Agitation or Frothing in Reconstitution.

Excessive agitation or frothing during treatment of the milk caused clumping of the fat globules in the reconstituted milk and a rough-textured curd. Consequently, efforts were made to reduce agitation and frothing during treatment and reconstitution. Fine wire gauze strainers were used over the reconstituting vat to minimise frothing of the skim milk. Where possible the skim milk, the homogenized cream, and the reconstituted milk were allowed to gravitate rather than be subjected to pumping. Where pumping could not be avoided, centrifugal pumps were installed. Immediate reconstitution of the skim milk and homogenized cream at the separated milk outlet of the separator, at the same temperature, also reduced frothing.

Testing Efficiency of Homogenization with the Microscope.

Microscopic observations on the homogenized milk and the behaviour of the cheese at high temperatures were used as criteria of efficiency of homogenization. Microscopically, when approximately 85 per cent. of the fat globules were broken up to 2μ or less in diameter without clumping, the resultant cheese showed no fat leakage. Counting the size and frequency of the fat globules in an effort to determine an homogenizing index (Farrel *et al,* 1942) also gave satisfactory results. However, the most important method was to observe the effect on the product.

Diluted suspensions in a hanging drop slide made from one part of homogenized cream to 99 parts of distilled water were examined with the oil immersion objective of the microscope. Reconstituted milk was similarly examined by using 10 parts to 90 parts of distilled water. Distilled water was used, because electrolytes in the water may effect clumping of the fat globules. A small drop of the dilution was placed on a cover glass and inverted over the depression in the hanging drop slide. The prepared slide was then examined with the oil immersion lens and the size of the globules and the degree of dispersion could be readily determined. The size of the globules may be measured with the aid of a filar micrometer calibrated against a stage micrometer. In many instances, however, mere observation determined whether the fat globules had been properly broken up, and curd tests confirmed the resistance to fat leakage.

A NOTE ON BABCOCK BUTTERFAT TESTS OF HOMOGENIZED CREAM AND RECONSTITUTED MILK.

The very fine state of division of the fat globules in the reconstituted milk necessitated certain modifications of the Babcock test to obtain accurate butterfat tests.

The normal butyl alcohol modification of the Babcock test (4 ml. of alcohol and 17·6 ml. of reconstituted milk) gave butterfat tests which were in agreement with those from the original milk. The same modification also gave slightly higher results than the Babcock test of the whey and homogenized cream. The data in Table 1 show that the modified Babcock test gave results on cheese which compared favourably with those secured by the the Roese-Gottleib method (Association of Official Agricultural Chemists, 1945). No difficulty was experienced in obtaining clear char-free fat columns (Trout and Lucas, 1945).

Table 1.

TYPICAL RESULTS OF BUTTER-FAT TESTS BY ORDINARY BABCOCK AND NORMAL BUTYL ALCOHOL METHODS.

—	Milk or Cream.	Milk or Cream after Homogenization.	
	Babcock Test.	Babcock Test.	Normal Butyl Alcohol Modification.
	%	%	%
Milk	3·6	3·3	3·6
Milk	3·6	3·4	3·7
Cream 9 gr.	25·0	21·0	26·0
Cream 9 gr.	38·0	33·0	39·0
—	Roese-Gottleib Method.	Normal Babcock Method.	Butyl Alcohol Modification.
	%	%	%
Whey	..	0·08	0·09
Whey	..	0·07	0·08
Fat in cheese	33·4	31·8	33·2
Fat in cheese	35·0	33·4	34·5

EVOLVING A COMMERCIAL PROCESS.

Following the development of an efficient system of homogenization, and the manufacture of experimental batches of non-fat-leaking cheddar cheese, efforts were made to evolve a system of manufacture on a commercial basis.

Initial Trials.

To reduce any financial loss while a suitable method of manufacture was being evolved, initial experiments were carried out with second-grade cream. These trials involved:—

(1) Separating the whole milk as received at the cheese factory.

(2) Pasteurizing the skim milk.

(3) Adding emulsifier to the cream and homogenizing at 145°F.

(4) Holding the cream for thirty minutes prior to cooling to 86°F.

(5) Mixing the skim milk and homogenized cream in the cheese vat.

(6) Following orthodox cheddar cheese manufacture.

This method was found impracticable, as it caused undue delays in factory routine.

It was considered that the process might prove more practicable if the cream were held overnight, then reconstituted and manufactured the following day. However, the holding of homogenized cream overnight presented difficulties: it necessitated additional refrigeration loads and vat storage space, and there was a loss of homogeneity. Normal cheddar cheese manufacture also proved unsuitable for this type of product.

In further trials the whole milk was separated, the cream homogenized and the milk reconstituted prior to pasteurization. However, this necessitated additional holding vats and delayed treatment. The abnormal physical characteristics of the reconstituted milk due to excessive frothing and agitation also affected cheese quality. A modified treatment in which the whole milk was pasteurized, then separated, homogenized and reconstituted, improved the physical characteristics of the milk. To increase the efficiency of separation, and for convenience of treatment, the temperature of the milk was raised from 98°F. to 160°F. Then followed the holding of the cream in hot-water jacketed vats to ensure destruction of lipase, emulsifying, homogenizing, and cooling to 88°F. prior to mixing in the cheese vat.

The quality of the cream did not appear to be affected by holding for 30 minutes at 160°F. either before or after homogenization. However, the quality of the manufactured product did not compare favourably with that of normal cheddar.

The process was further modified by reconstituting the skim milk and homogenized cream at the same temperature in a mixing vat just prior to being passed over the milk cooler, and gravitating it in the cheese-making vat. However, control of the texture and the condition of the manufactured product still presented difficulties.

The Continuous Process.

A continuous process was eventually evolved. The whole milk was pasteurized at 160°F. and this temperature was maintained throughout separation and homogenization. Immediately afterwards the milk was reconstituted at 160°F. in the reconstituting vat at the separated milk outlet of the separator. Each of the processes synchronised for continuous operation.

By maintaining a temperature of 160°F. for pasteurization, separation, homogenization, and reconstitution, lipolytic enzymes were destroyed and the bacteriological quality of the milk was improved. Physical agitation and frothing of the reconstituted milk was minimized and curd of normal texture resulted. If necessary during the summer months the milk was neutralized to 0·18 per cent. acidity for more effective separation and homogenization.

The following are the details of the continuous process:—

Separation.

The heated milk was taken direct from the pasteurizer to a high-power centrifugal (preferably foamless type) separator of 1,500 gallons-an-hour capacity, where it was separated to approximately 40 per cent. fat content cream. The high temperature separation gave efficient skimming, the fat content of the separated milk averaging 0·02 per cent. by the normal butyl alcohol modification of the Babcock test. Though fat tests up to 0·08 per cent. on the separated milk did not affect the resistance of the cheese to fat leakage, separation should be efficient.

Separation removed much dirt and cellular material from the milk and benefited milk quality. To reduce frothing the separated milk was gravitated into the reconstituting vat through a fine-gauze stainless steel strainer.

To reduce the viscosity of the cream by dispersal of the fat globules in the second and third phases of homogenization, 0·75 per cent. sodium citrate as an emulsifier was added by means of a drip system at the cream outlet of the separator. One part of emulsifier was dissolved in three parts of water. The emulsified cream was then "boosted" in temperature by passage through a tubular heater to ensure 160°F. during homogenization, and afterwards gravitated to a stainless steel holding vat adjacent to the homogenizer.

Homogenization.

The cream was standardized to a fat content of 20 per cent. by adding an equal volume of water at 160°F. in the holding vat. The standardized, emulsified cream was then homogenized in a 270-gallon-an-hour capacity, three-stage homogenizer at pressures of 2,200, 650, and 150 lb. per square inch in the first, second, and third stages, respectively. The pressures were accurately checked both on the pressure gauge and electrically by means of an ammeter. By-passes ensured that all cream was subjected to uniform pressures and a continuous flow of homogenized cream to the reconstituting vat.

Reconstitution.

The separated milk and homogenized cream were reconstituted at the same temperature in the stainless steel reconstituting vat near the separated milk spout of the separator. Following reconstitution the milk was pumped over the cooler, cooled to setting temperature, and gravitated to the cheese-making vat. Biologically, the treatment improved the milk for cheese manufacture.

Observations on Manufacture.

Because of the altered physical characteristics of the reconstituted milk, the normal cheddar process was gradually modified as follows:—

(1) Lower acidities were needed at various stages because of the higher moisture retained by the curd and the longer "cooking" time.

(2) The comparatively soft curd necessitated a slightly higher setting temperature, the milk being set at 88°F.

(3) Twice the normal quantity of rennet was required to set the milk because of the added sodium citrate and neutralizer (if used).

(4) The curd was cut finer because of the tendency to retain moisture and, being soft, was handled gently.

(5) After cutting, the curd was stirred gently by hand for approximately 10 minutes, followed by "slow gear" mechanical agitation for a further 10 minutes, and finally "top gear' agitation. This prevented a cloudy whey and a flaky, crumbly curd.

(6) The control of the moisture content of the curd was difficult, and cooking temperatures from 2° to 4° above normal were necessary. Consequently, a thermoduric starter culture (*Streptococcus thermophilus*) was used in association with a *Streptococcus cremoris* culture in the proportions of approximately 0·16 per cent. of the former and 1·5 per cent. of the latter. The starters were propagated in separated milk to prevent fat leakage from the cheese.

A comparatively slow "cook" to a high temperature was necessary for effective moisture control. The temperature was raised to 104–106°F., as the casein/fat ratio demanded, in approximately 40 to 50 minutes; the lower acidity during manufacture permitted of the longer cooking time.

The whey was drawn when the acidity was 0·16 per cent.

(7) Special attention was given to cheddaring the curd in order to control moisture content and texture. At the commencement of cheddaring the acidity of the whey (0·22–0·24 per cent.) was lower than for normal cheddar cheese practice. Otherwise normal cheddaring was carried out. A short, rough crumbly texture resulted from defective cheddaring, and the finished product was dry and crumbly.

(8) After "wheying off" there was limited extrusion of whey or white whey.

In the later stages of manufacture every encouragement was given for acidity to develop, so that a normal textured curd, with the desired moisture content, could be produced. Vats were covered and temperatures were maintained at approximately 90°F. by injecting steam into the jackets of the vats.

Despite a characteristic short and rough texture, the curd pressed well, giving a close-textured product.

(9) With a view to further improving the texture of the cheese, a system of manufacture reported to be successful in America (Wilson, 1945) was tried. The main departure from the procedure adopted is in the lower acidities developed at various stages of manufacture. The method compared favourably with the manufacturing procedure outlined, effecting a similar improvement in the texture of the cheese.

COMPOSITION OF THE CHEESE.

A typical analysis of the cheese (21 days old) is:—

Moisture	37·3%
Fat	33·5%
Salt	1·8%
Fat in dry matter ..	53·4%
pH	5·02

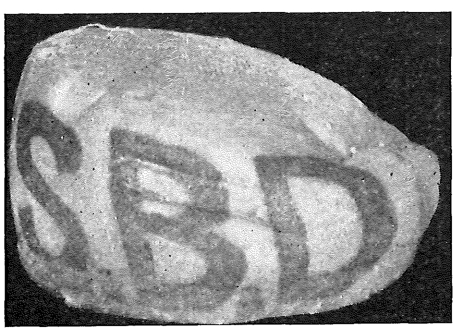
THE NON-FAT-LEAKING PROPERTY OF THE CHEESE.

Due to the fine state of division of the fat globules and their complete enclosure by the curd phase, there is a strong resistance against flowing of the fat at high temperatures. After prolonged holding, varying from 24 to 48 hours, at incubation temperatures varying from 100° to 130°F., there is negligible fat leakage from the cheese. Shape, condition, and appearance are maintained.

Normal cheddar cheese exudes fat profusely from 90°F. to 100°F., and at 120°F. becomes misshapen and finally a molten mass (see Plate 6).

A

B



C

D

Plate 6.

Comparison of normal cheddar cheese and cheddar cheese from reconstituted milk under incubator conditions. A. Normal cheddar cheese before incubation. B. Cheddar cheese from reconstituted milk before incubation. C. Normal cheddar cheese after incubation at 120 deg. F for 18 hours. D. Cheddar cheese from reconstituted milk after incubation at 120 deg. F for 18 hours.

Comparative fat losses determined on midget (1 lb.) normal and experimental cheeses from 100 batches were:—

Temperature.	Incubation Period.	Percentage Fat Loss.	
		Cheese under Experiment.	Controls.
	Hours.		
105°F. ..	6	Nil	6
106°F. ..	24	0·5	10

Variations in Resistance to Fat Leakage.

Varying resistance to fat leakage was observed in some samples. To ascertain the extent of variation, fat losses from cubes of cheese (approximately ¾-inch sides) were compared from several batches, together with normal cheddar.

The cubes of cheese were placed on fat-absorbent filter paper in petri dishes, weighed, then held for 24 hours at 106°F., and the percentage fat loss determined. Percentage fat losses were recorded as follows:—

Experimental Cheese.	Normal Cheddar.
0·3	8·7
0·3	8·1
1·3	8·0
0·1	—
0·5	—
1·3	—
1·3	—

Differences in the degree of resistance to fat leakage do occur. However, the fat loss is slight in comparison with similar determinations on normal cheddar

Effect of Ripening on Resistance to Fat Leakage.

It was considered that the production of free fatty acids during ripening might affect the condition of the homogenized fat and cause a reduction in resistance to fat leakage. However, samples tested after six months' ripening showed no appreciable reduction. Comparative percentage fat losses determined on cubes of cheese cut from matured cheddar and experimental cheese (6 months' old) were:—

Experimental Cheese ..	0·5
Matured Cheddar	10·0

TABLE 2.

COMPARISON OF YIELDS OF EXPERIMENTAL CHEESE AND NORMAL CHEDDAR.

Experimental Cheese.								Normal Cheddar.						
Gallons of Milk.		Average Test.	Cheese Yield.	Lb. Cheese per lb. Butterfat.	Lb. Cheese per Gallon of Milk.	Fat Lost in Whey.	Overrun or Underrun.	Gallons of Milk.	Average Test.	Cheese Yield.	Lb. Cheese per lb. Butterfat.	Lb. Cheese per Gallon of Milk.	Fat Lost in Whey.	Overrun or Underrun.
			Lb.			%	Lb.			Lb.			%	Lb.
Group 1	634	4·0	685	2·71	1·08	0·10	51 over	2,318 ..	3·9	2,163	2·39	0·93	0·40	155 under
	573	3·5	597	2·97	1·04	0·06	24 over	2,137 ..	3·9	2,036	2·44	0·95	0·38	101 under
	422	3·6	439	2·87	1·04	0·08	17 over	2,459 ..	3·8	2,357	2·52	0·96	0·40	102 under
Group 2	782	3·6	775	2·75	0·99	0·10	7 under	780 ..	3·6	743	2·64	0·95	0·45	37 under
	737	3·6	747	2·82	1·01	0·12	10 over	755 ..	3·6	750	2·75	0·99	0·30	5 under
	790	3·6	768	2·70	0·97	0·07	22 under	794 ..	3·6	745	2·60	0·93	0·50	49 under
	774	3·6	726	2·61	0·97	0·08	48 under	773 ..	3·6	722	2·59	0·93	0·46	51 under
695 ..	..	3·4	709	3·00	1·02	0·09	14 over	846 ..	3·4	822	2·85	0·97	0·35	24 under
800 ..	..	3·8	841	2·76	1·05	0·10	41 over	775 ..	3·8	800	2·70	1·03	0·32	5 over
860 ..	..	3·9	920	2·74	1·06	0·10	60 over	823 ..	3·7	800	2·62	0·97	0·30	23 under

As far as practicable, a representative bulk portion of the factory's milk supply was taken for yield comparisons. Casein contents were constant in both the experimental and control vats.

The results indicate the increased yield obtainable from reconstituted milk as compared with normal cheddar.

In the majority of batches, overruns were obtained from the homogenized milk as compared with underruns on the similar testing control batches. The district where the tests were carried out normally showed a lower casein content than surrounding districts, with lower yields. The reconstituted milk effected an appreciable improvement in cheese yield.

Other Factors Affecting Resistance to Fat Leakage.

Apart from the efficiency of homogenization and the method of manufacture, other factors affect fat leakage and require that the following precautions be taken:—

(1) Milk must be efficiently separated.
(2) Starter must be prepared in skim milk.
(3) Equipment such as coolers, vats, moulds, liners, &c., must be free of fat which has not been carefully homogenized.

YIELD OF CHEESE FROM THE RECONSTITUTED MILK.

Yields of cheese were somewhat higher than in the manufacture of normal cheddar. Typical results from the examination of 100 batches are given in Table 2.

In group No. 1, where farm conditions and pastures were normal, milk quality was affected by the warmer weather. In group No. 2, severe drought conditions operated and milk supplies were generally deficient in casein; consequently, yields were lower than normal.

Summarized, the yields were:—

——	Average Yield per lb. of Butter Fat.	Average Yield per Gallon of Milk.
Cheese from reconstituted milk ..	2·79	1·02
Normal cheddar	2·61	0·96

Factors responsible for the increased yield include:—

(*a*) The reduced fat losses in manufacture.
(*b*) The reduced fat losses during storage.
(*c*) The higher moisture content of the cheese.

Cheese from reconstituted milk was manufactured as readily from milk of high fat content as from low testing milk, without a greasy texture or weak body.

FAT LOSS IN MANUFACTURE.

Fat losses were considerably reduced in the manufacture of cheese from reconstituted milk as compared with normal cheddar. Fat content of the whey as determined by the normal butyl alcohol Babcock test varied from 0·06 per cent. to 0·12 per cent.. Control vats showed from 0·30 per cent. to 0·40 per cent. fat in the whey. Whey separated by modern high-speed centrifugal separators shows approximately 0·05 per cent. fat. It would therefore appear uneconomical to separate the whey from reconstituted milk cheese.

Comparative figures for fat losses are:—

Fat Test of Milk.	Percentage Fat in Whey.		Percentage Fat Lost in Whey. (Of all Fat Received).	
	Experimental Cheese.	Normal Cheddar.	Experimental Cheese.	Normal Cheddar.
% 3·8	0·06	0·30	1·57	7·89
4·0	0·08	0·40	2·0	10·0

MOISTURE CONTENT AND CONTROL.

The moisture content of cheese made from reconstituted milk tends to be higher than that of normal cheddar. In the initial trials it varied from 38 per cent. to 40 per cent., with difficulty in keeping some batches to 40 per cent. Control vats of normal cheddar cheese of the same day's make varied from 36 per cent. to 37 per cent. moisture. A slow "cook" at a high temperature (104-108°F.) assists in keeping moisture within the legal limit of 40 per cent.

Comparative moisture percentages in waxed cheese (21 days old) were as follows:—

Experimental Cheese.	Normal Cheddar Controls.
39·4	36·5
40·0	37·1
38·8	36·2
39·8	37·0
38·3	35·4

KEEPING QUALITY AND RIPENING.

The clarification of the milk during separation and the temperature maintained during milk separation and cream homogenization improve the cheesemaking quality of the reconstituted milk and the keeping quality of the cheese.

Homogenization, the use of an emulsifier, and the higher moisture content accelerated the ripening of the cheese.

Samples of the experimental cheese have been held for periods up to 6 months and compared with normal cheddar controls of the same day's make. Cheese from reconstituted milk ripened faster and in from four to six weeks had a flavour comparable with that of normal cheddar four months old.

There was a tendency to rapid drying-out if milk of a low bacteriological quality was used or manufacture was faulty.

DEFECTS AND THEIR CONTROL.

There were no indications that the cheese, if properly made from normal quality milk, should be inferior in keeping quality or more prone to defects than normal cheddar cheese.

Curd Flaking in Whey.

Normally the texture was very close and the whey clear. However, physical breakdown of the casein with consequent curd flaking in the whey sometimes occurred. Abnormal physical agitation through milk pumps and incomplete or faulty cheddaring produced an open crumbly curd and a finished product short and rough in texture. A rapid drying-out was typical of such cheese. Gentle handling of the curd, with a long and effective cheddaring, was necessary to rectify the defect.

High Acid Flavour.

The necessity for maintaining a comparatively low acid type of manufacture has been stressed. Acidity development typical of ordinary cheddar cheese manufacture results in a bleached, crumbly, high-acid reconstituted milk cheese. Controlled acidity in manufacture was essential to avoid the defect.

High Moisture Content.

A long "cook" at a temperature 2 to 4°F. above normal cheddar practice was essential for effective moisture control and firmness of body.

Rancidity.

Maintenance of a temperature of 160°F. throughout pasteurization, separation, homogenization, and reconstitution was necessary for complete destruction of lipolytic enzymes, thereby preventing the development of rancidity.

Weak or Soft Body.

Weak or soft body was a characteristic defect, and affected the keeping quality of the cheese. It may be due to the physical breakdown of casein in processing, but appeared to be more frequently due to ineffective moisture control by failure to "cook" long enough or at a sufficiently high temperature to dry out the curd effectively.

Rind Sweat.

With the development of a rind on the cheese after a period of approximately three weeks, a slight rind sweat may occur. The exact cause has not beer determined. However, the effect on resistance to fat leakage was negligible.

LAYOUT OF EQUIPMENT FOR MANUFACTURE.

The layout of equipment which was used for commercial manufacture is shown in Plates 7–9. This plant has been in operation at the Murgon factory of the South Burnett Co-operative Dairy Association.

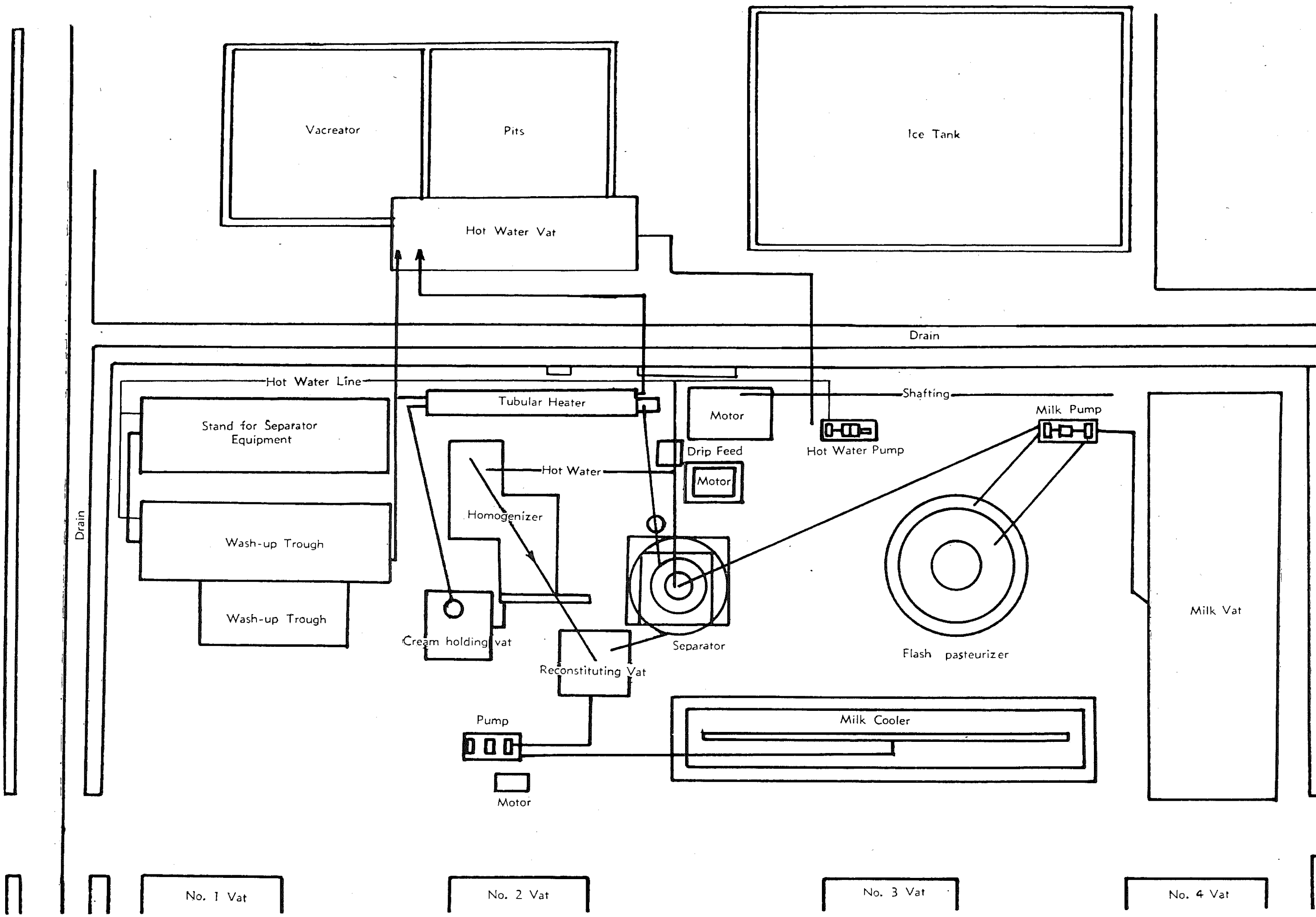


Plate 7.

Layout of equipment for manufacture of a non-fat-leaking cheese from reconstituted milk.

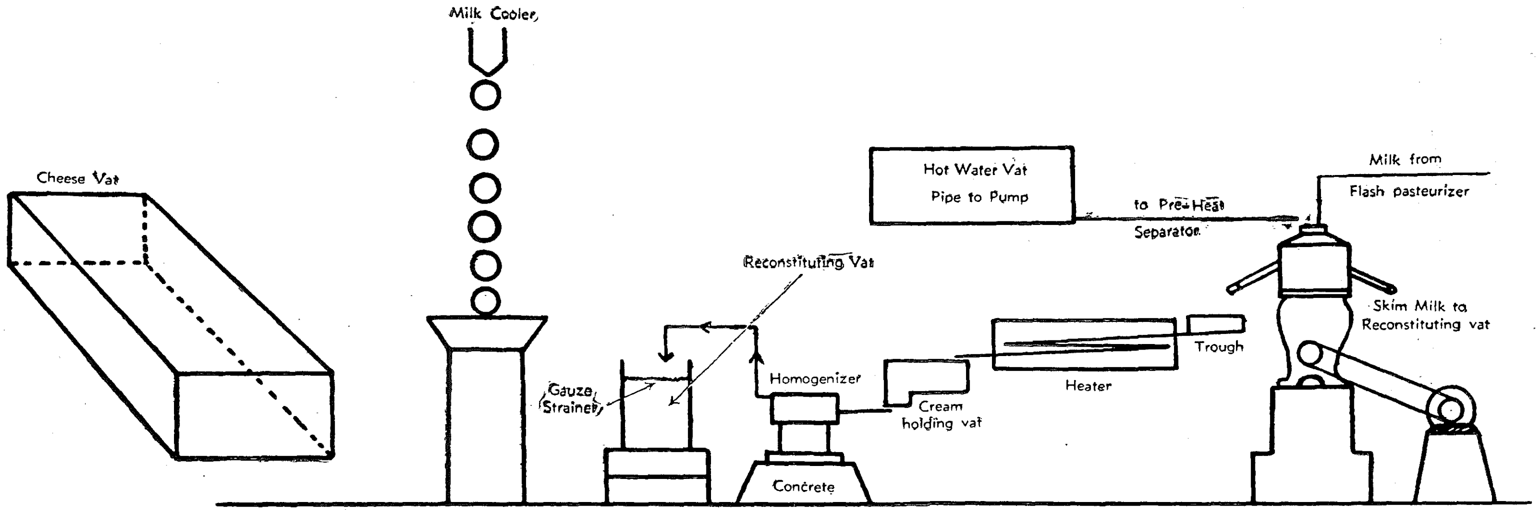


Plate 8.
Elevation of equipment for manufacture of a non-fat-leaking cheese from reconstituted milk.

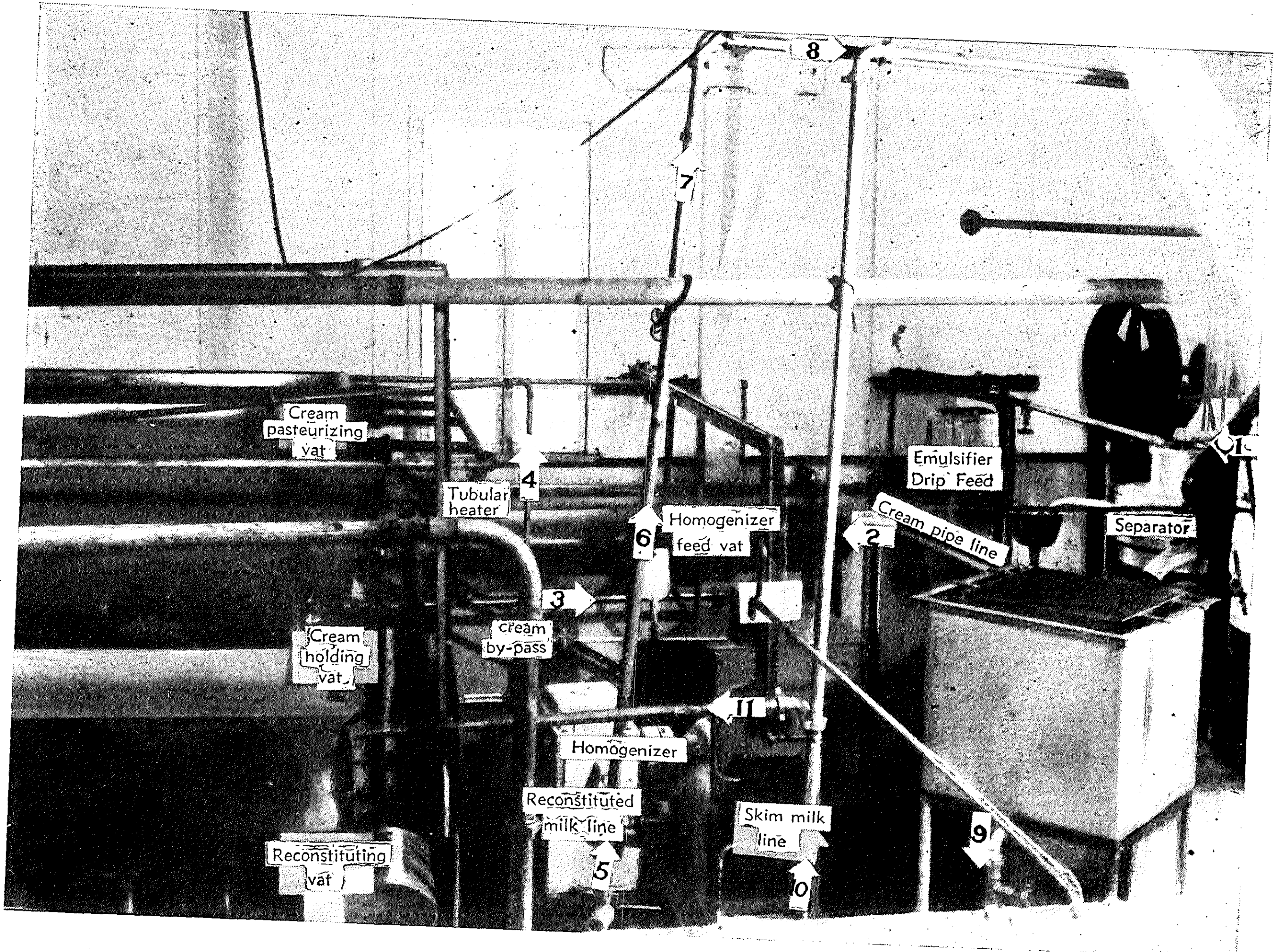


Plate 9.

Equipment used at the Murgon factory of the South Burnett Co-operative Dairy Association for the manufacture of a non-fat-leaking cheddar cheese from reconstituted milk.

COST OF MANUFACTURE.

It was estimated that the cost of making cheese from homogenized milk would not exceed $\frac{1}{4}$d. to $\frac{1}{3}$d. per pound more than the cost of making ordinary cheddar cheese. The increased cost was offset by increased yields, reduced fat losses and rapid ripening.

With a separator and homogenizer of adequate capacity, little extra time, additional labour, or inconvenience is involved in manufacture as compared with normal cheddar cheese.

CONCLUSIONS.

(1) By separating whole milk, homogenizing the cream and reconstituting the milk, a type of cheddar cheese can be manufactured which will not exude fat at high atmospheric temperatures.

(2) Yields were higher than with normal cheddar because of the higher moisture content and the reduced loss of fat in the whey.

(3) Fat losses during manufacture and storage are minimized.

(4) When properly made the cheese is close in texture.

(5) The cheese is quick-maturing and has good keeping quality.

(6) The advantages of this kind of cheese held under adverse conditions in factory curing rooms, during transport in tropical or sub-tropical areas or in shops can be appreciated.

(7) The product offers possibilities for marketing as a rindless cheese which, when hygienically and attractively packed in cartons of, say, 1 lb. size, should prove palatable and popular with consumers in tropical and sub-tropical areas.

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