1942

Studies on Edam cheese

Frank Warne Crews
Iowa State College

NOTE TO USERS

STUDIES ON EDAM CHEESE

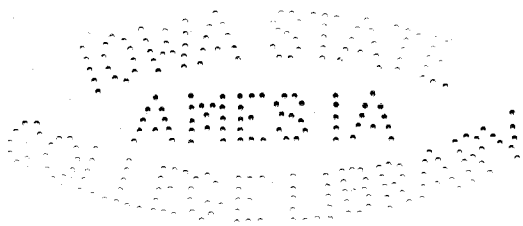
by

Frank Warne Crews

A Thesis Submitted to the Graduate Faculty
for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: Dairy Bacteriology



Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State College

1942

TABLE OF CONTENTS

Page

INTRODUCTION

Until recent years much of the edam cheese sold on the markets of the United States was imported. Domestic demand and a curtailment of world trade have increased the manufacture in this country of various foreign cheeses, including edam.

Apparently there is no definite agreement as to the typical flavor, body and texture of edam cheese. The cheese is essentially a sweet curd type with the flavor usually varying from a sweet and pleasantly mild, cheddar-like flavor to a slightly acid cheddar flavor. The body and texture range from a dry mealiness to a soft body which is almost pasty, although some of the older reports describe it as a cheese of very firm body, rather dry, mealy and very highly salted. Some cheese are free of eyes, while others develop eyes of varying sizes. Occasionally, edam is referred to as the "cannon ball" cheese because of its spherical shape.

The pasteurization of milk for the manufacture of various cheeses presents a problem in flavor development in the finished product. Such treatment of the milk is desirable because of public health reasons and also in order to control objectionable fermentations. However, it appears that enzymes essential to desirable fat hydrolysis and protein decomposition, or organisms responsible for such changes are destroyed by pasteurization. Apparently, the amount of lipolysis and proteolysis in various cheeses manufactured from pasteurized milk is limited; as a result the cheese ripens slowly and flavor development is unsatisfactory with some cheeses showing a tendency to develop a bitter flavor.

STATEMENT OF PROBLEM

The results presented herein represent an attempt to determine the effects of various factors on flavor and body and texture of edam cheese.

The factors studied include: (a) pasteurization of the milk; (b) partial skimming of the milk; (c) enzyme materials from various sources added to the milk or curd; and (d) certain bacteria. Size of the cheese, composition of the cheese, time of paraffining and curing in oil also were considered.

HISTORICAL

Manufacture of Edam Cheese

The early development of edam cheese was reviewed by Van Rijn (69) in 1915. He stated that dutch cheese originally was made in North and South Holland. The cheese made in the province of North Holland having the shape of a ball was commonly known as edam cheese, the name being derived from the town of Edam, which formed the center of the North Holland cheese district. The cheese made in the province of South Holland was flat in shape and was known as gouda cheese after the principal town and market of the South Holland cheese district. Van Rijn reported that both varieties of cheese originally were made of whole milk. When the making of butter was transferred from the farms to large creameries it was essential to find an outlet for the skimmed or separated milk. As a result the cheese was made from milk with different fat contents. Since the well known shapes of the edam and gouda cheese varieties were chosen for the manufacture of cheese from partially skimmed milk, it was not possible to differentiate from the appearance between the original full cream article and the one from partially skimmed milk. Van Rijn did not consider the manufacture of the partially skimmed article objectionable. He thought that all of the fat should not be removed because the cheese containing little or no fat dries to a hard texture and also that a partially skimmed milk cheese should always

contain more moisture to give it a soft texture. Van Rijn disclosed that the cheese made in Holland at that time in the edam and gouda shapes could be anything between the full cream article and a product containing only a few per cent butter fat. He stated that only cheese made from whole milk should be sold as full cream dutch cheese.

Experimental edam cheese was described by Haecker (34) in 1893. Partially skimmed evening milk mixed with morning milk was employed. It was set at 86° F., color was added at the rate of 1.5 ounces per 1000 pounds of milk and also sufficient rennet to permit the curd to be cut in 15 to 20 minutes. The curd was cut to the size of wheat kernels and allowed to settle. It was stirred gently and heat was applied to raise the temperature to 98° to 102° F. The curd was cooked until firm and elastic and then allowed to settle. The whey was removed and the curd was dipped directly into the molds. The cheese were pressed 15 to 60 minutes, removed from the molds and placed in sweet whey or hot water at 125° to 130° F. After exposure in the bath for 2 to 3 minutes, the cheese were dressed and carefully returned to the molds. They were then placed under pressure of 60 to 120 pounds for 6 to 12 hours. The cheese were dry salted 5 to 6 days in a salting mold, or brine salted 5 to 8 days at 60° to 70° F., and then placed in a moist room to cure at 55° to 65° F.

The New York Agricultural Experiment Station (21) reviewed the manufacture of edam cheese in 1893. It was described as a sweet curd cheese made from partially skimmed milk and marketed in the form of round, red balls weighing from 3.5 to 4 pounds each when cured. The cheese were manufactured from milk which had one-fourth to one-third of the fat

removed. The manufacturing procedure suggested was exactly the same as that described by Haecker. The cheese were cured at 50° to 65° F. in a humidity of 85 to 95 per cent. Edam cheese was described as possessing a mild, clean and pleasantly saline flavor, a solid, rather dry and mealy or crumbly body and a close texture free from pores.

The manufacture of edam cheese was outlined by Doane and Lawson (27) in 1918. They stated that the best product is made of unskimmed cows milk but that much edam cheese is made from milk which has had at least one-half the fat removed. The method described by them differs only slightly from that of Haecker. They specified that the milk be set at 90° to 95° F. and sufficient rennet added to coagulate the milk in 15 minutes. They recommended that the cheese be ripened at 50° to 70° F. and when 1 month old should be washed, dried and rubbed with linseed oil.

Van Slyke and Publow (75) described edam cheese as a sweet curd cheese manufactured from partially skimmed milk; usually one-half to one-third of the fat was removed from the milk. They stated that the milk should be set at 85° to 88° F. and sufficient rennet added to coagulate the milk in 12 to 18 minutes. After uniformly cutting the curd to very small pieces, it should be heated to 93° to 96° F. as quickly as possible with constant agitation. As soon as the curd shows signs of hardening, the whey should be drawn off until the upper surface of the curd appears and then the cheesemaker should commence to fill the molds. Van Slyke and Publow stated that the cheese should be pressed for 25 to 30 minutes under a pressure of 20 to 25 pounds and then placed in whey at 120° to 130° F. for 2 minutes. The cheese should be bandaged and

pressed for 6 to 12 hours under continual pressure of 60 to 120 pounds. The cheese may be salted dry or wet. They recommended dry salting for 5 to 6 days in a salting mold or brine salting for 7 to 8 days in a brine containing 1 pound of salt to 2.5 quarts of water. After curing, the cheese should be thoroughly cleaned and made smooth by turning in a lathe. A color treatment was described in which the cheese were dipped for 1 minute in a bath containing carmine dissolved in alcohol or ammonia and later rubbed with boiled linseed oil to prevent checking. Van Slyke and Publow characterized edam cheese as mild, clean and pleasantly saline in flavor, with a rather dry and mealy body and a close texture free from pores.

A description of the manufacture of edam cheese by Thom and Fisk (63) was essentially the same as that of Van Slyke and Publow. Harvey and Hill (41) also outlined the manufacturing method and the process was much like those previously noted; they stated that the partly skimmed milk should be set at 93° F. and cooked at a constant temperature of 94° F.

The manufacture of edam cheese was described by Sammis (57) as closely resembling the method of making cheddar cheese by the granular process. His outline of the procedure is essentially like that of Van Slyke and Publow. Sammis stated that the curd may be lightly salted in the granular form although the actual salting process involves application of dry salt to the entire surface of the cheese and holding of the cheese in salting hoops. The cheese should be treated in the salting hoops for 4 or 5 days and turned each day with fresh salt added to the

upper surface of the cheese. Sammis specified a curing temperature of 60° to 65° F. He pointed out that by using half skimmed milk, a rather dry and well salted cheese is produced. Instead of paraffining the cheese, they may be rubbed with boiled linseed oil or sugar solution when partly cured to prevent cracking of the rind. The red color may be applied later by dipping in an alcoholic solution of carmine or berlin red.

Stocking (61) stated that the loss of fat in the making of edam cheese was considerably higher than in the making of cheddar cheese. The amounts of fat in 100 pounds of partially skimmed milk varied from 2.45 to 3.20 pounds (average 2.77 pounds). Of these amounts, from 0.30 to 0.50 pounds of fat (average 0.39 pounds) was lost in the whey which is equivalent to 11.18 to 18.87 per cent (average 14.0 per cent) of the fat in the milk.

Weigmann (76) described the manufacture of edam cheese very completely. He stated that in northern Holland a mixture of partially skimmed evening milk and fresh morning milk is utilized; it shows about five-sixths of the original fat content or about 2.5 per cent fat. The resulting cheese never contains less than 40 per cent fat in the dry matter and sometimes contains over 55 per cent. In Friesland, cheese commonly is manufactured from milk containing 1.2 to 1.8 per cent fat. Weigmann pointed out that the largest part of the production was from milk having five-sixths of the original fat content and that the smaller portion was full or half fat cheese. Formerly, slimy whey was employed as a culture but a common acid culture made from skimmed milk was

utilized after it was ascertained by bacteriological investigation that an acid producing organism caused the ropiness in the whey. Weigmann also stated that with fresh milk in the winter months, 0.5 to 1.0 per cent of culture was added to the milk, while during the summer 0.1 to 0.15 per cent was employed; 0.1 to 0.2 per cent culture was used with pasteurized milk. Weigmann also pointed out that the culture should bring about slow acid formation and care should be taken that the culture is not rapid and vigorous. If care is not used in selecting the culture, the cheese will be short (sour and brittle), especially with pasteurization of the milk.

The milk is set at 28° to 30° C. or with partially skimmed milk at 27° to 28° C. Approximately 25 ml. of rennet is added to 100 kg. of milk and the milk is usually ready to cut in 35 minutes. After cutting, the curd is agitated until it is the size of peas and then permitted to settle for about 5 minutes. About one-third of the whey is removed and the curd is then stirred for approximately 20 minutes, after which the curd particles should be reduced to the size of barley grains. The curd is permitted to settle again and whey is removed until the volume in the vat is approximately one-half the original. Water is added to the vat to the extent of 10 to 15 per cent of the milk volume and then the curd is cooked at 35° to 37° C. for approximately 12 minutes. When cheese of about 20 per cent fat content is made, the curd is worked only to the size of small peas, permitted to settle once and then cooked only at about 32° C. The curd has been cooked sufficiently dry when it mats well on being pressed together but still can be easily separated. After cooking

the curd is permitted to settle, the whey is drained and the curd is moved to one side of the vat. The matted curd is weighted to free more of the whey. The work must be performed quickly to prevent the temperature of the curd from falling below 28° C. Blocks of curd are transferred to warm hoops. The curd is turned about twice in the hoops to obtain a spherical shape and permit more whey to drain. The cheese are then dressed in linen cloths, returned to the hoops and placed under the press before the temperature of the curd falls. The period of pressing varies from 3 to 12 hours and it is longer during the winter than during the summer. The length of pressing depends not only on the season or the prevailing temperature but also on the dryness of the curd when put into the hoops. After pressing has been completed, the cheese are removed from the hoops and linen cloths, the edges are cut off and the cheese placed in brine. At one time the cheese were dry salted and they still are in some places, but now brine salting generally is used. The period of salting varies from 4 to 6 days, according to the size of the cheese, in brine at 13° to 15° C. Sometimes two brine baths are used when careful treatment is desired; the first bath is weak and the second of full strength.

Weigmann also stated that after salting the cheese should remain in the curing room for about 1 week and then be removed for washing. The washing usually is accomplished by churn-like machines which rotate slowly. It removes to some extent the salt present in large quantities in the rind. The cheese curing rooms are above the ground, well ventilated and should have a reasonable degree of humidity. The

temperature should not be above 22° C. or below 10° C. The cheese are placed on boards having shallow cavities and are turned daily, then every other day and finally twice a week. Before marketing, the cheese are either carefully washed, brushed or scraped clean with a scraping machine; the cheese become even more spherical as a result of such treatment. The smooth cheese are either rubbed or painted about twice with boiled linseed oil or with a red coloring preparation. Rosanilin dissolved in alcohol is used or the cheese is treated with red paraffin. According to Weigmann, the expected yield of edam cheese is 10 to 11 kg. of green cheese and 8 to 9 kg. of cured cheese from 100 kg. of milk. The loss in curing averages 8 per cent.

Later Weigmann (77) pointed out that the higher degree of acidity at which milk is manufactured means that edam cheese is more easily made in summer than the more sensitive gouda cheese, and therefore in many regions of Holland the operators confine the manufacture of edam cheese to the summer.

A comparative study of large and small eyed gouda and edam cheeses manufactured from half fat and full fat milk was reported in 1919 by Funder (32). The half fat milk cheese received higher scores than the full fat milk cheese. Also, it was easier to make cheese from half fat milk than from full fat milk. Funder found that 20 to 25 minutes more were required in manufacturing the type with the large eyes than in making the type with the small eyes, the difference being due to additional stirring of the curd and treatment in the vat after the whey had been removed. The yield of the type with large eyes was slightly

higher than that with small eyes and chemical analyses showed a higher moisture content in the former. The method of removing the curd for the large eyed types makes it difficult to expell the gases and moisture from the curd mass. Funder concluded that the manner of eye formation does not depend upon microbiological changes alone but also on the plasticity of the mass. Cooling of the curd particles caused small eyes, and lactic acid fermentation before hooping affected the amount of eye formation.

Ripening of Edam Cheese

There has been relatively little investigation of the ripening of edam cheese and of the various agents responsible for flavor development. Boekhout and Ott de Vries (9) reported some studies in 1899. Culture tests were made to discover what types of bacteria were in the cheese. Only lactic acid bacteria were found. Cheese was made from milk pasteurized at 70° C. and inoculated with lactic acid bacteria isolated from edam cheese. The cheese did not ripen. The manufacture of cheese from milk inoculated with various cultures of lactic acid bacteria and mixed cultures also was unsuccessful. The same tests performed with milk pasteurized at 55° C. resulted in cheese showing a more definite ripening, but it was not normal. Milk drawn from cows under as nearly aseptic conditions as possible also was used for the studies. Portions were inoculated with young cheese, with lactic acid bacteria and with ordinary commercial milk. The cheese from milk inoculated with young cheese and also from milk inoculated with commercial milk ripened well

but that from milk inoculated with lactic acid bacteria did not ripen.

Boekhout and Ott de Vries (10) also studied the ripening of edam cheese in 1905. They reported that the influence of salt on the curing is most conspicuous in the exterior layer, less in the mean layer and slight on the interior because the concentration of salt is very high in the exterior layer and the salt penetrates into the cheese only slowly. They concluded that the organisms which produce the curing can resist a large quantity of salt. The authors found that an edam cheese 6 months of age contained 0.272 gm. of ammonia in 1000 gm.; in cheese 10 days old they found 0.646 and 0.781 gm. of ammonia in 1000 gm. of cheese and concluded that the ammonia decreases greatly during the curing.

It was suggested by Boekhout and Ott de Vries (11) that in order to find the cause of the curing of edam cheese it would be necessary to carry the investigations in the direction of what precedes the lactic fermentation rather than what occurs during and after the lactic fermentation.

Boekhout and Ott de Vries (13) demonstrated that organisms found in edam cheese possess a proteolytic action with the characteristic property of liquefying gelatin. They manufactured cheese from milk inoculated with the characteristic types and concluded that the bacteria secrete enzymes which affect the curing of the cheese.

Investigations of the ripening of edam cheese were completed in 1910 by Van Dam (65). He noted that the hydrogen ion content exerts an effect on the digestion of paracasein and that the velocity of the digestion is proportional to the hydrogen ion content. The curing is

accomplished by the formation of decomposition products from paracasein. Decomposition products in turn are attacked by bacteria, or their enzymes, with the formation of substances which give the cheese its special odor and flavor. The formation of soluble nitrogen combinations in normal edam cheese occurs more rapidly in the first days and diminishes more and more in the following days.

Orla-Jensen (51) noted that the peptonizing bacteria do not assist to any appreciable extent in the ripening of edam cheese, which is generally made with a lactic acid culture, and did not succeed in demonstrating other specific ripening bacteria. Edam cheese is poor in typical products of bacterial action, namely, volatile acids and amino acids. Therefore, it appears that the bacteria play a subordinate part and that the principal changes are due to the rennet. Orla-Jensen stated that the interior of edam cheese 4 months old contained 26.90 per cent of the total nitrogen as soluble nitrogen, 3 per cent as nitrogen of protein decomposition products and 0.60 per cent as ammonia nitrogen. The nitrogen of protein decomposition products represented 11.15 per cent of the soluble nitrogen, and ammonia represented 2.23 per cent. The author believed that it is the rennet which produces the perceptibly soluble proteins and the micro-organisms carry the degradation farther. Action of the most important of the enzymes of the cheese ripening bacteria is inhibited by the presence of acid, while that of rennet is promoted and therefore it is easily understood why the practically neutral hard cheeses contain larger proportions of amino acids than the soft cheeses. Orla-Jensen found that 1000 gm. from the interior of an edam cheese

contained the equivalent of 15.6 ml. of normal volatile acids and of 15.0 ml. of normal total ammonia; 1000 gm. from the interior of a swiss, partially skimmed milk cheese contained 81.6 ml. and 267.5 ml., respectively, while 1000 gm. from the interior of an emmenthal cheese contained 88.0 ml. and 75.0 ml., respectively.

The influence of pasteurization of milk on the decomposition of the protein substances of edam cheese was studied by Van Dam (68). He found that the amounts of the disintegration products of the proteins decreased with an increase in the temperature at which the milk was pasteurized. The flavor was slower in developing with an increase in pasteurization temperature. An excellent body was obtained regardless of the temperature. Van Dam stated that the character of the odor and taste of edam cheese is not altered by pasteurization of the milk, while the causes for the retardation of the ripening process are not known.

Hindriko (43) observed the effect of different quantities of rennet on the flavor development of edam cheese. Amounts of rennet which were twice normal or more caused the development of a bitter flavor. The bitterness did not develop with increases of 33 per cent or less. The texture and consistency of the cheese were not noticeably affected by increased quantities of rennet. Hindriko concluded that larger amounts of rennet cause increased proteolysis and therefore accelerate the curing process.

Composition of Edam Cheese

Apparently there is a wide variation in the actual chemical composition of edam cheese and in opinion as to what the range in composition should be. The salt content of the cheese is of interest because of its probable relation to moisture content, body and texture, rate of curing and amount of flavor development. Boekhout and Ott de Vries (10) studied salt diffusion in relation to curing and obtained the following results:

Cheese freshly removed from the brine:

	Per cent dry matter	Per cent NaCl contained in moisture
Exterior layer	61.60	13.3
Mean layer	54.0	4.0
Interior layer	52.0	0.4

Cheese 4 weeks after removal from brine:

Exterior layer	65.4	5.0
Mean layer	56.2	5.2
Interior layer	56.4	4.4

Boekhout and Ott de Vries (16) studied the structure of the cheese mass and noted that the salting process removed a considerable quantity of the moisture; the loss in moisture during salting ranged from 2.9 to 5.2 per cent.

Van Dam (67) studied the influence of different factory methods on the moisture contents of the curd of edam cheese. The contents ranged from 46.8 to 52.0 per cent. He found that poorly coagulated curd tested higher than normal curd. When the curd was worked at a high temperature

of 29.0° C., a higher moisture content resulted than when worked at 26.6° C. A low heating temperature of 33.5° C. also was conducive to a high moisture content.

A study of the composition of gouda and edam cheeses was reported by Van Rijn (69). He found that full cream gouda cheese manufactured from milk with fat contents ranging from 2.51 to 4.22 per cent contained from 44.2 to 52.9 per cent fat in the dry substance. There was no consistent variation in the fat contents of the dry matter with a variation in the fat contents of the milk. It was concluded that those cases in which milk with a relatively low percentage of non-fatty solids gave a cheese with less fat in the dry matter than might be expected were due to the fact that such milk contained a relatively high percentage of casein. When milk with high non-fatty solids gave a cheese with a relatively large amount of fat in the dry matter, the percentage of casein in the non-fatty solids must have been low. A study also was made of the influence of skimming the milk on the fat content of the cheese; milk was partially skimmed to different degrees so that it contained 0.5 to 2.0 per cent fat. The results showed that an increase in the percentage of fat in partially skimmed milk had a very marked effect on the amount of fat in the cheese. An increase of 0.1 per cent in the amount of fat in partially skimmed milk gave, on an average, an increase of 1.75 per cent in the fat in the dry matter. It was not possible to calculate exactly the amount of fat which would be found in the dry matter of the cheese when the percentage of fat in the partially skimmed milk was known. Differences were found in the composition of cheese made from milk with

the same percentage of fat. The amounts of fat in the dry matter of 80 cheese, all made from skimmed milk containing 1.55 per cent fat, varied from 30.2 to 39.4 per cent. Van Rijn stated that edam cheese is not considered a whole milk cheese but it is generally agreed that this cheese should contain not less than 40 per cent fat in the dry substance.

Doane and Lawson (27) listed results of analyses which showed a variation in moisture content of ripened cheese from 29.3 to 60.38 per cent; fat contents of the cheese ranged from 3.83 to 33.99 per cent.

Funder (32) reported that the weight loss of unwaxed, small eyed cheese manufactured from half fat milk averaged 10.79 per cent, while that of cheese manufactured from full fat milk averaged 12.40 per cent. Large eyed cheese from half fat milk showed an average loss of 11.58 per cent and that from full fat milk showed an average loss of 13.03 per cent. The waxed cheese did not lose as much weight. Waxed, small eyed cheese manufactured from half fat milk averaged 5.48 per cent loss, while that from full fat milk averaged 6.38 per cent. The waxed, large eyed cheese made from half fat milk averaged 4.36 per cent loss, while that from full fat milk averaged 7.95 per cent.

Variations in fat and moisture contents of cheese with variations in fat contents of the milk were listed by Eugling and Weigmann (29). Cheese manufactured from milk with a fat content of 3.55 to 2.90 per cent contained 31.7 to 25.9 per cent fat (51.9 to 43.2 per cent fat on a dry basis) and 41.7 to 36.4 per cent moisture. Cheese made from milk with a fat content of 2.80 to 2.14 per cent contained 27.1 to 20.9 per cent fat (46.3 to 35.8 per cent fat on a dry basis) and 43.8 to 36.0 per cent

moisture. The product manufactured from milk containing 1.95 to 1.60 per cent fat contained 19.1 to 14.6 per cent fat (32.9 to 25.3 per cent on a dry basis) and 42.9 to 38.4 per cent moisture.

According to Weigmann (77) edam cheese has an average moisture content of 42.25 per cent when 2 to 3 months old and after extended storage of one-half to a whole year, the moisture content averages 38.5 per cent. Weigmann (76) also stated that the fat in the dry matter of factory cheese was between 43.6 and 46.5 per cent and with farm cheese it ranged from 45.1 to 49.3 per cent. There were no samples below 40 per cent. The average per cent fat in the dry matter of edam cheese was 45.6 for the years 1907 and 1910.

A study of the changes in the lactose contents of the curd after addition of water in the manufacture of edam cheese was made by Sirks (60). He reported that the change in concentration was very slow and 20 to 30 minutes were required to establish equilibrium. The fat content and temperature of the whey showed little influence on the rate of diffusion.

Defects of Edam Cheese

Most of the studies on defects of edam cheese have dealt with body and texture. Boekhout and Ott de Vries (15) investigated the defects known as "short" and "knijpers". A cheese is criticized as short when it possesses a hard, brittle and chalk-like body. They concluded that the defect was due to the formation of bilactate of paracasein which resulted from insufficient calcium to neutralize the lactic acid formed. "Knijpers" refers to cheese which is cracked or split. The authors

found that cheese which showed the "knijpers" defect were very rich in paracasein bilactate and consequently the plasticity was much less than normal. The defect develops when considerable gas formation occurs. The gas was found to be composed of carbon dioxide, hydrogen and nitrogen.

A detailed study of the "knijpers" defect was reported by Boekhout and Ott de Vries (17) who found that apparently there was some relationship between the occurence of the defect and a butyric acid fermentation.

There are several factors which apparently exert important influences on the consistency and structure of the cheese mass. Calcium content of the milk, pH of the cheese, salt and moisture contents of the cheese, lactose content of the curd and casein and fat contents of the milk are considered important factors contributing to the body and texture of cheese. Van Dam (66) studied the influence of the concentration of salt in the moisture of the cheese on the swelling of the cheese mass. He found that the maximum swelling occurred at a concentration of approximately 5 per cent. At a lower or higher concentration, swelling decreased. At concentrations of 10 to 15 per cent salt in the cheese moisture, no swelling of the casein occurred. The author also reported that the swelling of the cheese mass as a result of the presence of lactic acid and salt was a function of the hydrogen ion concentration. With low hydrogen ion concentration the mass swells markedly, whereas with high hydrogen ion content, only slight swelling occurs. Van Dam concluded that the production of short cheese from calcium poor milk has no relation to the lesser neutralizing property of the milk but that such milk is a factor since the cheese retain more whey which results in the

production of a sour cheese.

Boekhout and Ott de Vries (16) observed that cheese of high acidity but of normal or even above normal moisture content may be short. They favored the presumption that milk poor in calcium gives short cheese. The defect appeared to be due to insufficient neutralizing power.

According to Weigmann (76) in both gouda and edam cheese, and especially in the latter, defects occur which are known as "short", "cracked" and "split". A cheese becomes "short" when a larger amount of acid is formed than can combine with the calcium and calcium para-caseinate. The defect will occur when excessive amounts of whey remain in the curd. Milk which has a low content of calcium salts gives a sour and brittle cheese. Over-ripening of the milk also produces the defect. A preventive measure consists of expulsion of as much whey as possible from the curd by prolonged agitation and cooking, or by replacing whey with water during the cooking process. Such treatment removes lactic acid and lactose from the curd particles. Cracking is caused when gas develops in an unplastic sour curd. After about 12 days, lense-shaped slots about 1 cm. long are formed. The defect is known as "Boekel-scheuren" in Holland. In the case of split cheese, the mass is cross-sectioned with one or several large breaks, whereby the rind is left intact. The defect may be recognized from the outside by a depression in the rind where the crack is located. It differs from "Boekelscheuren" only in that the gas formation is more violent. If the mass had been plastic, the large amount of gas would have formed several eyes. The same preventive measures should be applied here as for the "short" defect.

A defect of edam cheese known as "white rim" was discussed by Van Beynum, Van Dam and Holwerda (64). A cheese 3 to 4 weeks old may show a "white rim" defect under the rind when it is cut. The authors concluded that the defect may be due to insufficient fermentation of the curd and the fact that conditions were not suitable for the development of a normally swollen and ripened cheese. A high, active acidity contributes to the defect. A pH of 5.1 to 5.2 is suitable for an edam cheese 3 weeks old. A high salt concentration in the cheese moisture causes a reversible "salting out" or coagulation. Salt concentration is related to the occurrence of the white rim defect. Also, the defect will occur if there is insufficient moisture present for hydration of the protein.

METHODS

Preparation of Milk

The pasteurized milk employed in the studies was heated by the holding method, using 143.5° F. for 30 minutes. It was cooled at once on a refrigerated surface cooler.

Preparation of raw, partially skimmed milk involved the separation of a portion of the milk and addition of the skimmed milk to whole milk. The pasteurized, partially skimmed milk was prepared by removing a portion of the cream from pasteurized milk that had been held at 40° F. in 10-gallon cans; the milk from the different cans was thoroughly mixed to obtain uniformity.

In all trials the volume of milk employed for each lot of cheese ranged from 120 to 320 pounds.

Manufacturing Procedure

The procedure used in manufacturing edam cheese was essentially that employed by the Iowa State College cheese department in the manufacture of commercial cheese. Usually 1 per cent cheese culture was added to the milk which was ripened at 86° F. for 30 to 45 minutes, or sufficiently long to increase the titratable acidity approximately 0.02 per cent over the initial acidity. The milk commonly was set at 86° F.

with titratable acidities ranging from 0.17 to 0.20 per cent. When sufficiently firm, the curd was cut to pieces the size of kernels of wheat; the acidities of the whey then ranged from 0.11 to 0.14 per cent. The curd was stirred for approximately 20 minutes to facilitate removal of the whey after which the size of the curd particles was reduced considerably. After stirring the curd was permitted to settle and whey was removed to the extent of approximately one-third the total milk volume. The curd was brought to a cooking temperature of 104° F. for whole milk and 102° to 104° F. for partially skimmed milk by replacing the volume of whey at once with water at 145° to 150° F. Addition of water brings about removal of some lactose from the curd particles. When it was desired to have more whey removed from the curd than usual, the temperature was raised gradually by adding the water slowly or in small portions so that the time required for the heating amounted to 20 or 25 minutes. The period of cooking varied with the fat content of the milk and ranged from 20 to 60 minutes. The curd was considered sufficiently cooked when the particles readily separated after matting. Cheese manufactured from partially skimmed milk usually required 20 to 30 minutes for cooking, while with whole milk from 30 to 60 minutes were required.

As soon as the curd had settled to the bottom of the vat it was pushed to one end of the vat to permit matting, and the whey was drained. After thorough matting the curd was cut into blocks of 4 to 5 pounds each and placed in edam hoops. The curd was turned twice in the hoops, bandaged and placed in a vertical press. The period of pressing ranged from 4 to 6 hours. After 2 hours the cheese were removed, trimmed,

turned and returned to the press. After pressing they were trimmed again, turned in the hoops and placed in the cooler at 45° to 50° F. without pressure. The cheese were removed from the hoops 12 to 16 hours after pressing, placed in a 24 per cent brine bath and held for 36 to 48 hours. The temperature of the brine ranged from 45° to 50° F.

After removal from the brine the cheese were dried and cured at 50° to 55° F. in a humidity of approximately 70 per cent. The cheese were paraffined at various ages.

Enzyme Sources and Preparations

Extract of desiccated mammary tissue.

A mixture of 100 gm. of desiccated mammary tissue and 1 liter of a 10 per cent sodium chloride solution was agitated for 1 hour in a glass container, using an experimental churn, and filtered. Portions of the filtrate were utilized in the studies.

Extract of frozen mammary tissue.

Frozen mammary tissue was ground in a food chopper and permitted to thaw. It was mixed with fine sand and pressed in a hydraulic press. The resulting liquid was employed in the trials.

Extract of frozen chicken pancreas.

Frozen chicken pancreas also was ground in a food chopper and permitted to thaw. An adequate volume of liquid was obtained by either

filtering or decanting since only small portions were needed.

Oat flour.

Either oat flour obtained by pulverizing oats with a mortar and pestle and screening or commercial oat groat flour was employed in the studies.

Determination of Butter Fat, Total Solids and Acids in Milk

The percentage of butter fat in milk was determined by the official Babcock method. The total solids content was obtained from the Quevenne lactometer reading and the percentage of butter fat. The acid was measured by titrating 18 gm. of milk with N/10 sodium hydroxide, using phenolphthalein as an indicator.

Determination of Total Solids, Fat and Salt in Cheese

Preparation of cheese sample.

A slice of uniform thickness was taken through the center of the cheese. After removing from 0.125 to 0.25 inch from the periphery of the slice, the remainder immediately was passed through a food chopper four times to assure uniformity. The cheese then was placed in a small glass jar and sealed to prevent loss of moisture.

Total solids.

A sample of approximately 5 gm. was weighed into a tared aluminum

dish containing a small amount of sand. It was dried to constant weight in an oven at 212° F., and the percentage of total solids was calculated from the weights of the sample and the dry matter.

Fat.

The Mojonnier modification of the Roese-Gottlieb fat extraction method was employed for the determination of butter fat content. In some cases the percentage of fat was determined by the Babcock method.

Salt.

The method employed was that adopted by the Association of Official Agricultural Chemists for the determination of chlorides in cheese (1).

Determination of Acid Number on Cheese Fat

The fat was obtained from a mixture of shredded cheese and fine sand by use of a hydraulic press as described by Lane and Hammer (48). The mixture of cheese fat and serum was tempered at approximately 113° F. to permit the fat to separate. The fat was decanted to tubes and centrifuged for 5 minutes; it was then decanted to fresh tubes and again centrifuged for 5 minutes. Portions were pipetted from the tubes for weighing.

The procedure used for the determination of acid number on the cheese fat was essentially that of Breazeale and Bird (19). Ten gm. of prepared fat was weighed into a 125 ml. erlenmeyer flask and dissolved

in 25 ml. of acid free petroleum ether. After the addition of 10 ml. of absolute alcohol to the mixture it was titrated with N/20 alcoholic potassium hydroxide (prepared with absolute alcohol), using phenolphthalein (1 per cent in absolute alcohol) as an indicator.

pH Determination

pH determinations on cheese were made with a Leeds and Northrup potentiometer, modified quinhydrone electrode and a calomel half-cell. A cheese was plugged, a portion was macerated and mixed with quinhydrone and the voltage was determined at once to avoid a shift. The pH value was obtained from the voltage reading and temperature at the time of the reading.

Determination of Weight Losses of Cheese

Cheese were weighed to the nearest 0.1 gm. immediately after removal from the press, after salting and at 2, 4 and 6 weeks during the ripening period. Losses of weight then were calculated for the various periods.

Plating of Cheese

Preparation of sodium citrate solution.

A 2 per cent solution of sodium citrate was prepared in distilled water; 9 ml. portions, and also 9 ml. water blanks, were sterilized in

the autoclave at 15 pounds pressure for 20 minutes.

Media utilized.

Various media were used for the examination of cheese. Beef extract agar was employed for detection of micrococci and the special gelatin agar described by Long and Hammer (50) was used in examination for Pseudomonas putrefaciens. Cheese were examined for Escherichia-Aerobacter organisms by means of lactose broth and eosin-methylene blue agar.

Preparation of plates.

Plates were poured with the culture medium to be used and permitted to solidify before making inoculations. A 1 gm. sample of cheese was weighed on sterile paper and macerated in a sterile mortar using 9 ml. of sodium citrate solution to help emulsify the cheese. Dilutions were prepared from 1:10 to 1:1,000,000, using 9 ml. water blanks, and the previously poured and solidified plates were inoculated with 0.1 ml. transfers from the dilutions. Special sterile glass rods were employed to smear the inocula over the surface of the medium. Plates were incubated at 70° F. in the examination of the cheese for micrococci and Ps. putrefaciens.

EXPERIMENTAL

In commenting on both the flavor and the body and texture of the experimental cheese, the statements are based largely on the results given in the tables, but other considerations, particularly small differences not readily shown in tables, also are involved.

Comparison of Raw and Pasteurized, Whole Milk for Cheese

Portions of milk were obtained from the same lots of mixed herd milk before and after pasteurization and manufactured into cheese. The milk was ripened to titratable acidities of 0.18 to 0.19 per cent, and the acidities of the whey after cutting the curd varied from 0.13 to 0.14 per cent. With some trials cheese were ripened at both 50° and 55° F. in order to include a study of the effect of curing temperature on the quality of the cheese, but in two trials cheese were ripened only at 55° F.

After 3 months the cheese were criticized for flavor and body and texture, and in four trials the total solids, fat and salt percentages were determined. Some of the cheese cured at 55° F. were re-examined after 6 months in order to observe any change in quality over that previously observed.

Raw milk cheese cured 3 months at 50° or 55° F. commonly developed more flavor than the cheese from pasteurized milk (table 1). In general,

TABLE 1. RAW AND PASTEURIZED, WHOLE MILK CHEESE

General flavor and body and texture criticisms

Trial No.	Milk used	Curing temp.° F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
1	raw	50	sl.* lacking	pasty, few med. ragged eyes		
3.8% fat in milk		55	sl. unclean	pasty, many sm. ragged eyes		
	past.	50	lacking	pasty, few sm. eyes		
		55	lacking, sl. bitter	pasty, few med. eyes		
2	raw	50	cons. swt. fl.	v. sl. mealy		
3.9% fat in milk		55	cons. cheese fl. desirable	few cracks, few large eyes		
	past.	50	lacking, sl. bitter	v. sl. mealy		
		55	lacking	mealy		
3	raw	50	desirable, salty	few sm. eyes		
4.15% fat in milk		55	v. desirable	many sm. ragged eyes	v. desirable	excellent, few sm. eyes
	past.	50	lacking, salty			
		55	lacking, sl. salty	v. few eyes	lacking, salty	desirable, v. few sm. eyes

TABLE 1. (Continued)

Trial No.	Milk used	Curing temp. °F.	Criticisms at 3 months: flavor	Criticisms at 3 months: body and texture	Criticisms at 6 months: flavor	Criticisms at 6 months: body and texture
4	raw	50	lacking	sl. weak		
4.0% fat in milk		55	v. desirable	mech. holes	desirable	sl. dry, few med. eyes
	past.	50	lacking	sl. weak		
		55	sl. lacking	mech. holes	desirable, sl. lacking	dry, v. few sm. eyes
63	raw	55	cons. fl.	excellent, v. few med. eyes		
3.9% fat in milk	past.	55	lacking	excellent, v. few mech. holes		
64	raw	55	v. desirable	v. desirable		
4.0% fat in milk	past.	55	lacking	v. desirable		

* Abbreviations used in various tables are:

cons.:	considerable	fl.:	flavor	mech.:	mechanical	med.:	medium
sl.:	slight	sm.:	small	swt.:	sweet	v.:	very

the raw milk cheese cured at 55° F. developed more cheese flavor than that of the same lot cured at 50° F. However, some of the cheese manufactured from pasteurized milk showed only slightly better flavor at 55° F. than at 50° F. In trial 4 there was no difference in the flavor of the raw and pasteurized milk cheese cured at 50° F., whereas at 55° F. there was a definite difference.

There was no significant difference in the body and texture of the raw and pasteurized milk cheese cured at 50° and 55° F. for 3 months. More eyes were formed in the raw milk cheese than in the pasteurized milk cheese, and they were either small or medium and usually ragged. The eyes in cheese cured at 55° F. were either larger or more numerous than in the corresponding cheese cured at 50° F.

After 6 months at 55° F. the raw milk cheese again had a more desirable flavor than the pasteurized milk cheese. Some of the cheese were criticized as dry in body and texture, which was probably due to additional loss of moisture during the longer curing. In general, the body and texture of the cheese were good.

The total solids contents of the raw and pasteurized milk cheese differed somewhat in each trial, but the variation was not consistent (table 2). At 55° F. the percentages of total solids were higher than at 50° F. in 7 of the 8 comparisons; the differences varied from a minimum of 0.40 per cent to a maximum of 1.79 per cent. The total solids contents at 3 months ranged from 62.91 to 66.14 per cent for cheese cured at 50° F. and from 64.60 to 66.54 per cent for cheese cured at 55° F.; the fat contents on a dry basis varied from 50.75 to 52.64

TABLE 2. RAW AND PASTEURIZED, WHOLE MILK CHEESE

Chemical analyses

Cheese paraffined at about 2 months

Trial No.	Milk used	Curing temp. °F.	Percentage Composition at 3 months					Values at 6 months	
			total solids	fat	fat dry basis	salt	salt dry basis	pH of cheese	acid no. on fat
1	raw	50	62.91	32.86	52.23	1.93	3.07		
		55	64.60	33.65	52.09	2.04	3.16	5.49	5.71
	past.	50	63.73	33.23	52.14	2.04	3.20		
		55	64.88	33.75	52.02	2.15	3.31	5.38	3.90
2	raw	50	66.09	34.00	51.44	1.78	2.69		
		55	65.74	33.59	51.10	1.90	2.89	5.77	5.76
	past.	50	64.42	33.69	52.30	2.03	3.15		
		55	66.21	33.90	51.20	1.97	2.98	5.55	2.84
3	raw	50	64.89	34.16	52.64	2.86	4.41		
		55	66.48	35.16	52.89	2.89	4.35	5.38	5.17
	past.	50	64.09	33.03	51.54	2.66	4.15		
		55	65.42	33.41	51.07	2.77	4.23	5.31	2.98
4	raw	50	66.14	34.25	51.78	2.41	3.64		
		55	66.54	34.45	51.77	2.14	3.22	5.55	6.14
	past.	50	64.63	32.80	50.75	2.22	3.43		
		55	65.26	33.73	51.69	2.48	3.80	5.46	3.81

per cent for cheese cured at 50° F. and from 51.07 to 52.89 per cent for cheese cured at 55° F. In trial 1 all of the cheese were criticized as pasty and the total solids ranged from 62.91 to 64.88 per cent, while the fat on a dry basis varied from 52.02 to 52.23 per cent. Cheese from pasteurized milk ripened at 55° F. in trial 2 was definitely mealy; it contained 66.21 per cent total solids and 51.20 per cent fat on a dry basis. The body and texture of the pasteurized milk cheese cured at 50° F. in trial 3 were not criticized; the cheese had 64.09 per cent total solids and 51.54 per cent fat on a dry basis. In trial 4 the raw and pasteurized milk cheese cured at 50° F. were criticized as slightly weak; the total solids contents were 66.14 and 64.63 per cent and the fat contents on a dry basis were 51.78 and 50.75 per cent, respectively.

Apparently there was no definite correlation between the moisture and salt contents of the finished cheese, which probably was due to the many factors influencing the amount of salt absorbed by cheese. The salt contents ranged from 2.69 to 4.41 per cent on a dry basis. The cheese in trial 3 contained the most salt, and they were criticized as salty.

Raw and pasteurized milk cheese which were cured 6 months at 55° F. showed only small differences in pH values, but in each trial the raw milk cheese had a slightly higher pH value than the pasteurized milk cheese. Raw milk cheese cured at 55° F. showed definitely higher acid numbers on the fat than the pasteurized milk cheese; with the former the values ranged from 5.17 to 6.14, whereas with the latter the variation was from 2.84 to 3.90. The higher acid numbers on the fats of the raw

milk cheese than on the fats of the pasteurized milk cheese are in general agreement with the flavor differences and reflect the apparent importance of fat hydrolysis to flavor development in cheese.

Effect on the Cheese of Partially Skimming the Milk

Raw, whole milk and raw, partially skimmed milk cheese.

The whole milk and partially skimmed milk were obtained from the same lots of mixed herd milk. The milk was ripened to titratable acidities of 0.19 to 0.20 per cent, and the acidities of the whey after cutting the curd varied from 0.125 to 0.14 per cent. Except in one trial cheese were ripened at both 50° and 55° F.

After 3 months the cheese were criticized and in four trials total solids, fat and salt contents were determined. Most of the cheese ripened at 55° F. were re-examined at approximately 6 months.

The raw, partially skimmed milk cheese developed as much flavor during 3 months as raw, whole milk cheese at either 50° or 55° F. (table 3), and in some trials the cheese from partially skimmed milk had somewhat more flavor than the whole milk cheese; the improvement was particularly noticeable when the cheese were cured at 55° F. In general, the flavors were more desirable in cheese cured at 55° F. than in corresponding cheese cured at 50° F. Milk of poor quality was utilized in trials 26 and 28, and this is reflected in the flavor criticisms of the cheese.

TABLE 3. RAW, WHOLE AND RAW, PARTIALLY SKIMMED MILK CHEESE

General flavor and body and texture criticisms

Trial No.	Milk used	Curing temp. ^{o} F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
5	whole 3.55% fat	50	desirable	sl. firm, mech. holes		
		55	v. desirable	desirable, many med. eyes	v. desirable	v. desirable, few med. eyes
	part skim 2.55% fat	50	desirable	tough, firm, few sm. eyes		
		55	v. desirable	sl. firm many med. eyes	v. desirable	sl. dry, few med. eyes
6	whole 3.5% fat	50	v. desirable	sl. soft		
		55	v. sl. lacking	soft, v. few sm. eyes	v. desirable	v. desirable
	part skim 2.7% fat	50	v. desirable	soft, few sm. eyes		
		55	desirable	few mech. holes	v. desirable	sl. dry
7	whole 4.0% fat	50	desirable	soft, few sm. eyes		
		55	cons. fl., v. desirable	desirable, few sm. eyes	sl. rancid, sl. swiss	few sm. eyes
	part skim 3.0% fat	50	v. desirable	sl. soft, few med. eyes		
		55	cons. fl., v. desirable	v. desirable, many med. eyes	v. rancid	few med. eyes

TABLE 3. (Continued)

Trial No.	Milk used	Curing temp. ° F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
8	whole 3.6% fat	50	lacking	pasty, few sm. eyes		
		55	v. sl. lacking	pasty, few sm. eyes	delicate, v. desirable	few sm. eyes
	part skim 2.9% fat	50	lacking	firm, few sm. eyes		
		55	v. sl. lacking	desirable, few med. eyes	strong, sl. swiss	few med. eyes
26	whole 3.9% fat	50	fermented	soft, sl. pasty, few cabbage eyes		
		55	sl. fermented	soft, few cabbage eyes	v. unclean	desirable, gassy
	part skim 2.65% fat	50	v. sl. fermented	desirable, v. sl. dry, few cabbage eyes		
		55	v. sl. fermented	desirable, dry, few med. eyes	desirable, v. sl. unclean	sl. dry, v. gassy
28	whole 3.7% fat	50	fermented, salty	weak, few sm. eyes		
		55	fermented, salty	v. sl. weak, few sm. eyes	lacking, salty	v. few sm. eyes
	part skim 3.25% fat	50	v. sl. fermented, salty	desirable, few sm. eyes		
		55	desirable, salty	v. desirable, few sm. eyes	desirable, v. sl. unclean	v. few sm. eyes
64	whole 4.0% fat	55	v. desirable	v. desirable		
	part skim 2.8% fat	55	v. desirable	desirable, sl. firm		

After curing 3 months the body of the partially skimmed milk cheese was more firm in most trials than the body of the corresponding whole milk cheese. The body and texture of both the whole milk cheese and the partially skimmed milk cheese were better in most cases when cured at 55° F. than when cured at 50° F. Commonly, the eyes in the cheese made from partially skimmed milk were either more numerous or larger than those in the corresponding whole milk cheese.

After 6 months some of the cheese cured at 55° F. improved in flavor while others did not. In trial 7 the cheese from partially skimmed milk became very rancid, while that from whole milk was slightly rancid and slightly swiss-like. In trial 8 the partially skimmed milk cheese was criticized as strong and slightly swiss-like. With increased holding the cheese from partially skimmed milk sometimes were criticized as dry in body and texture, while the whole milk cheese improved in body and texture; loss of moisture probably explains the change in the character of the body and texture.

There were only slight differences in the total solids contents of the partially skimmed milk cheese and the whole milk cheese at 3 months (table 4), but in most cases the cheese from the partially skimmed milk was lower. The total solids contents commonly were higher in the cheese cured at 55° F. than in that cured at 50° F. The total solids contents of the whole milk cheese varied from 63.29 to 64.85 per cent, while those of the partially skimmed milk cheese ranged from 61.76 to 64.15 per cent. The fat on a dry basis varied from 46.99 to 50.53 per cent with the whole

TABLE 4. RAW, WHOLE AND RAW, PARTIALLY SKIMMED MILK CHEESE

Chemical analyses

Cheese paraffined at about 2 months

Trial No.	Milk used	Curing temp. °F.	Percentage Composition at 3 months					Values at 6 months	
			total solids	fat	fat dry basis	salt	salt dry basis	pH of cheese	acid no. on fat
5	whole	50	63.74	31.58	49.54	1.99	3.12		
		55	64.85	31.40	48.42	1.93	2.98	5.69	5.13
	part skim	50	63.72	23.14	36.32	2.01	3.15		
		55	63.71	24.13	37.87	2.20	3.45	5.82	5.80
6	whole	50	63.29	31.98	50.53	1.90	3.00		
		55	64.15	30.44	47.45	2.34	3.65	5.70	5.53
	part skim	50	62.14	25.73	41.41	2.01	3.23		
		55	62.08	26.81	43.19	2.13	3.43	5.70	6.40
7	whole	50	63.40	29.79	46.99	1.96	3.09		
		55	63.40	30.72	48.45	1.97	3.11	5.44	15.45
	part skim	50	61.76	24.92	40.35	1.71	2.77		
		55	62.85	25.96	41.30	1.76	2.80		31.52
8	whole	50	63.30	29.95	47.31	1.98	3.13		
		55	64.09	31.72	49.49	2.00	3.12	5.51	7.06
	part skim	50	63.26	26.17	41.37	1.79	2.83		
		55	64.15	27.47	42.82	1.65	2.57		9.19

milk cheese and from 36.32 to 43.19 per cent with the cheese from partially skimmed milk. The per cent of salt on a dry basis ranged from 2.98 to 3.65 per cent with the whole milk cheese and from 2.57 to 3.45 with the cheese from partially skimmed milk.

In trial 5 the whole milk cheese cured 3 months at 55° F. showed desirable body and texture and contained 64.85 per cent total solids and 48.42 per cent fat on the dry basis; in the same trial the cheese from partially skimmed milk was criticized as slightly firm and showed 63.71 per cent total solids and 37.87 per cent fat on the dry basis. In trial 8 the whole milk cheese was criticized as pasty after 3 months at 55° F., and it contained 64.09 per cent total solids and 49.49 per cent fat on the dry basis; in the same trial the partially skimmed milk cheese had a desirable body and texture and it contained 64.15 per cent total solids and 42.82 per cent fat on the dry basis.

After curing 6 months at 55° F. the cheese that were very desirable in flavor showed pH values from 5.51 to 5.82 (table 4). Acid values on the cheese fat were relatively high because the cheese was manufactured from raw milk; in each trial the acid number on the fat was the higher in the partially skimmed milk cheese, being more than twice as high in trial 7. The whole milk cheese in this trial was criticized as slightly rancid and slightly swiss-like and it had an acid number of 15.45; the partially skimmed milk cheese was criticized as very rancid and it had an acid number of 31.52. In trial 8 the flavor of the whole milk cheese was very desirable and the acid number on the fat was 7.06, whereas the cheese from partially skimmed milk was criticized as strong and slightly

swiss-like and the acid number on the fat was 9.19.

Pasteurized, whole milk and pasteurized, partially skimmed milk cheese.

The pasteurized, whole milk and pasteurized, partially skimmed milk used for the comparisons came from the same lots of mixed herd milk. The milk was set at titratable acidities of 0.185 and 0.20 per cent, and acidities of the whey after cutting the curd varied from 0.13 to 0.14 per cent. Except in one trial the cheese were ripened at 50° and 55° F.

The cheese were examined for flavor and body and texture after 3 months, and most of the cheese cured at 55° F. were re-examined after 6 months; chemical data on some of the cheese were obtained after 3 months and 6 months.

After curing 3 months at 50° or 55° F. the cheese from both whole milk and partially skimmed milk were lacking in flavor (table 5). In one trial criticisms showed a tendency for the cheese to have an unclean flavor, unlike the typical cheese flavor found in cheese of good quality. There was no distinct difference in the flavor development in cheese cured at 50° F. and at 55° F., which presumably was due to insufficient curing agents in the cheese.

In general, the cheese from partially skimmed milk exhibited a desirable body and texture after curing 3 months at either 50° F. or at 55° F., while the whole milk cheese in the same trials commonly were pasty or soft. There was a slight tendency to form more and larger eyes in the cheese from partially skimmed milk than in the cheese from whole milk.

TABLE 5. PASTEURIZED, WHOLE AND PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE

General flavor and body and texture criticisms

Trial No.	Milk used	Curing temp. °F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
9	whole 4.0% fat	50	lacking	soft, sl. pasty, few v. sm. eyes		
		55	sl. lacking	soft, few sm. eyes	v. lacking, sour, v. unclean	few large eyes
	part skim 2.7% fat	50	lacking	v. sl. soft, few v. sm. eyes		
		55	sl. lacking	desirable, few sm. eyes	lacking, sl. unclean	v. few eyes
10	whole 3.8% fat	50	lacking, sl. unclean	sl. mealy, mech. holes		
		55	lacking, sl. unclean	sl. pasty, mech. holes	lacking, v. unclean	brittle
	part skim 2.5% fat	50	lacking	desirable, few sm. eyes		
		55	lacking, unclean	v. desirable, few med. eyes	lacking, unclean	sl. brittle, mealy, few v. sm. eyes
11	whole 4.0% fat	50	lacking	pasty, few mech. holes		
		55	lacking	pasty, mech. holes	unclean, sl. lacking	weak, mech. holes
	part skim 2.7% fat	50	lacking	v. desirable, few v. sm. eyes		
		55	lacking	desirable, few sm. eyes	sl. unclean	desirable, mealy

TABLE 5. (Continued)

Trial No.	Milk used	Curing temp. °F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
12	whole 4.0% fat	50	lacking, salty	sl. weak, mech. holes		
		55	lacking, salty	pasty		
	part skim 2.8% fat	50	sl. lacking	desirable		
		55	desirable, sl. salty	firm, sl. mealy		
64	whole 4.0% fat	55	lacking	v. desirable		
	part skim 2.8% fat	55	v. lacking	desirable		

After curing 6 months at 55° F., the cheese were criticized as lacking and unclean in flavor. The changes in body and texture were not consistent.

In general, the cheese cured at 55° F. were higher in total solids than cheese from the same lots cured at 50° F. (table 6). The cheese from partially skimmed milk cured at 55° F. were regularly higher in total solids than the corresponding cheese cured at 50° F.; the increases ranged from 0.29 to 3.41 per cent. The partially skimmed milk cheese had total solids contents from 59.92 to 63.33 per cent and were desirable in body and texture. In the whole milk cheese the values varied from 60.51 to 63.93 and the cheese were criticized as pasty, soft or weak. The fat contents varied from 36.33 to 41.57 per cent on a dry basis for the partially skimmed milk cheese and from 46.43 to 51.82 per cent for the whole milk cheese.

The salt contents of the whole milk cheese on a dry basis varied from 3.36 to 4.58 per cent, while with the partially skimmed milk cheese they ranged from 2.95 to 3.64 per cent. The salt contents of the whole milk cheese were consistently higher than those of the corresponding partially skimmed milk cheese.

The pH values obtained at 6 months on 3 cheese were in the same general range as those of good quality cheese previously examined. The acid values on the fat were lower than the values for the raw milk cheese; the acid numbers on the fat obtained from the pasteurized, whole milk cheese were slightly higher than those on fat of pasteurized, partially skimmed milk cheese in the 3 comparisons made.

TABLE 6. PASTEURIZED, WHOLE AND PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE

Chemical analyses

Cheese paraffined at about 2 months

Trial No.	Milk used	Curing temp. °F.	Percentage Composition at 3 months					Values at 6 months	
			total solids	fat	fat dry basis	salt	salt dry basis	pH of cheese	acid no. on fat
9	whole	50	60.31	*28.00	46.43	2.41	4.00		
		55	62.86	*31.25	49.71	2.21	3.52	5.33	4.43
	part	50	60.19	*21.87	36.33	2.19	3.64		
	skim	55	61.61	*24.50	39.77	2.12	3.44		4.05
10	whole	50	63.10	31.40	49.76	2.40	3.80		
		55	62.85	32.57	51.82	2.11	3.36	5.43	4.67
	part	50	62.50	25.98	41.57	1.86	2.98		
	skim	55	62.79	25.05	39.89	1.96	3.12		3.70
11	whole	50	62.39			2.61	4.18		
		55	63.25			2.23	3.53	5.44	4.82
	part	50	59.92						
	skim	55	63.33			1.87	2.95		3.85
12	whole	55	63.93			2.93	4.58		3.79
	part	50	60.69						
	skim	55	62.52			2.15	3.44		

* Babcock tests

Effect on the Cheese of Addition of an Extract of Desiccated Mammary Tissue to Pasteurized Milk

Pasteurized, whole milk cheese made without and with extract of mammary tissue added to the milk.

Portions of pasteurized, whole milk were obtained from the same lots of mixed herd milk. In each trial an extract of desiccated mammary tissue was added to one portion at the rate of 15 ml. per 100 pounds of milk. The milk was ripened to titratable acidities of 0.185 to 0.195 per cent, and the acidities of the whey after the curd was cut varied from 0.12 to 0.13 per cent. The cheese were ripened at temperatures of 50° and 55° F.

After 3 months the cheese were criticized for flavor and body and texture, and the total solids and salt contents were determined on some of the lots. Cheese cured at 55° F. were re-examined after 6 months.

At 3 months the cheese manufactured from pasteurized, whole milk treated with extract of mammary tissue and cured at 55° F. tended to have more flavor than cheese from the corresponding untreated milk (table 7), and flavor defects appeared to be less noticeable in it. The apparent improvement in flavor of the cheese manufactured from milk treated with the extract was less noticeable at 50° F. In cheese made from both treated and untreated milk there was more flavor with curing at 55° F. than with curing at 50° F.

There were no significant differences at 3 months in the body and texture of the cheese manufactured without and with the extract of

TABLE 7. PASTEURIZED, WHOLE MILK CHEESE MADE WITHOUT AND WITH EXTRACT OF DESICCATED MAMMARY TISSUE ADDED TO THE MILK

General flavor and body and texture criticisms

Trial No.	Milk used	Curing temp.° F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
13	untreated	50	sour, salty	pasty, mech. holes		
		55	sl. sour, salty	pasty, mech. holes	sl. unclean, sour, salty	weak, pasty, mech. holes
4.5% fat in milk	treated	50	lacking, sl. sour, salty	pasty, mech. holes		
		55	desirable, salty	pasty, few sm. eyes	v. sl. unclean	weak, pasty, few eyes, mech. holes
14	untreated	50	sl. sour, salty	weak, mech. holes		
		55	v. sl. sour, sl. salty	desirable, mech. holes	lacking, unclean, v. sl. sour	weak, pasty
4.1% fat in milk	treated	50	v. sl. sour, sl. salty	weak, mech. holes		
		55	desirable, sl. salty, prominent	v. sl. weak, few sm. eyes	v. sl. lacking	sl. weak
15	untreated	50	sl. sour, sl. salty	weak, few cabbage eyes		
		55	v. sl. sour, sl. salty	sl. weak, few sm. cabbage eyes	lacking, sl. unclean	weak, few sm. eyes, mech. holes
4.1% fat in milk	treated	50	lacking, sl. salty	weak, few cabbage eyes		
		55	desirable	desirable, few sm. ragged eyes	lacking, sl. unclean	weak, few sm. eyes, mech. holes

TABLE 7. (Continued)

Trial No.	Milk used	Curing temp. °F.	Criticisms at 3 months flavor	Criticisms at 3 months body and texture	Criticisms at 6 months flavor	Criticisms at 6 months body and texture
16	untreated	50	desirable	sticky, mech. holes		
4.4% fat in milk		55	desirable	sl. weak, mealy, mech. holes	lacking	desirable, mech. holes
	treated	50	desirable	desirable, mech. holes		
		55	desirable	desirable, few sm. eyes	cons. fl.	desirable, few eyes

mammary tissue. Cheese cured at 55° F. tended to be more desirable in body and texture than cheese from the same lot cured at 50° F., and there also was a tendency to form more eyes.

After 6 months at 55° F. the flavor of the cheese made from milk treated with extract of mammary tissue was more desirable than the flavor of cheese from untreated milk except in trial 15, where there was no difference. Commonly, the cheese depreciated in flavor during the second 3 month period. The body and texture did not show any general improvement with the longer curing and in most cases it was less desirable than at 3 months.

The total solids contents at 3 months ranged from 61.69 to 64.28 per cent for the cheese analyzed (table 8). There were only slight differences in the total solids contents of the cheese cured at 50° and 55° F. In trial 15 cheese from treated milk ripened at 55° F. had a desirable body and texture with a total solids content of 62.26 per cent and in trial 16 cheese from treated milk ripened at 50° F. had a desirable body and texture with 62.12 per cent total solids. Some lots of cheese with slightly higher total solids contents were criticized as weak or pasty.

The salt contents on the dry basis (table 8) varied from 4.02 to 4.64 per cent for the cheese that was analyzed, and nearly all of them were criticized as salty at 3 months.

The cheese manufactured without and with the extract of mammary tissue showed only slight differences in pH values at 6 months; the values were slightly higher in the cheese from the milk treated with extract of mammary tissue in all cases except trial 15, when the difference was

TABLE 8. PASTEURIZED, WHOLE MILK CHEESE MADE WITHOUT AND WITH EXTRACT OF DESICCATED MAMMARY TISSUE ADDED TO THE MILK

Chemical analyses

Cheese paraffined at about 2 months

Trial No.	Milk used	Curing temp. °F.	% Composition, 3 months			Values, 6 months	
			total solids	salt	salt dry basis	pH of cheese	acid no. on fat
13	untreated	50	64.28	2.98	4.64		
		55	63.03	2.75	4.36	5.27	4.08
	treated	55	63.29	2.94	4.65	5.39	4.27
14	untreated	55				5.14	5.09
	treated	50	61.92	2.49	4.02		
		55	62.90	2.56	4.07	5.21	5.66
15	untreated	50	61.69				
		55	62.29	2.63	4.22	5.34	4.96
	treated	55	62.26			5.31	4.95
16	untreated	50	63.31				
		55	63.86			5.21	4.77
	treated	50	62.12				
		55				5.37	5.01

negligible. Acid numbers on the fat were higher in all the cheese manufactured from milk treated with extract of mammary tissue except in trial 15, where the difference was negligible. In trial 15 at 6 months there was no difference in flavor between the cheese made without and with the extract of mammary tissue and cured at 55° F.; although at 3 months the cheese from the treated milk was the more desirable.

Pasteurized, whole milk cheese made without extract of mammary tissue and pasteurized, partially skimmed milk cheese made with extract of mammary tissue added to the milk.

Portions of pasteurized milk (whole and partially skimmed) were obtained from the same lots of mixed herd milk. Extract of desiccated mammary tissue was added to the partially skimmed milk in each trial at the rate of 15 ml. per 100 pounds of milk. The milk was ripened to titratable acidities of 0.185 to 0.20 per cent, while the acidities of the whey after cutting the curd varied from 0.125 to 0.13 per cent. The cheese were ripened at temperatures of 50° to 55° F.

After 3 months the cheese were criticized for flavor and body and texture, and the percentages of total solids were determined with some of the cheese. Most of the cheese cured at 55° F. were re-examined at 6 months.

At 3 months the flavor of the cheese manufactured from partially skimmed milk treated with extract of mammary tissue was more desirable in 5 of 6 trials than cheese manufactured from untreated pasteurized whole milk (table 9), and there were fewer flavor defects. Flavor differences

TABLE 9. PASTEURIZED, WHOLE MILK CHEESE MADE WITHOUT EXTRACT OF DESICCATED MAMMARY TISSUE AND PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE MADE WITH EXTRACT OF DESICCATED MAMMARY TISSUE ADDED TO THE MILK

General flavor and body and texture criticisms

Trial No.	Milk used	Curing temp.° F.	Criticisms at 3 months		Criticisms at 6 months	
			flavor	body and texture	flavor	body and texture
17	untreated whole 3.65% fat	50	unclean, *foreign	v. sl. weak, few eyes		
		55	unclean, v. foreign	desirable, few mech. holes	v. sl. lacking	v. desirable, mech. holes
	treated part skim 2.95% fat	50	v. sl. unclean	desirable, few med. eyes		
		55	v. desirable, cons. fl.	desirable, few eyes	v. sl. lacking	v. desirable, few mech. holes
18	untreated whole 4.0% fat	50	desirable, v. sl. lacking	desirable, few sm. eyes		
		55	sour, salty	sl. weak, v. few eyes	v. sl. lacking, sl. foreign	desirable, v. few eyes
	treated part skim 2.6% fat	50	v. sl. lacking	desirable, sl. dry, cons. med. eyes		
		55	sl. swiss	mealy, dry, brittle, many large eyes	lacking, sl. foreign	desirable, many med.eyes
19	untreated whole 3.8% fat	50	lacking, sour, salty	dry, mealy, few mech. holes		
		55	lacking, sl. sour, salty	sl. dry, few mech. holes	lacking, foreign	sl. dry
	treated part skim 2.5% fat	50	desirable, cons. fl.	dry, mealy few mech. holes		
		55	v. desirable	dry, mealy, few mech. holes	sl. lacking, foreign	dry

TABLE 9. (Continued)

Trial No.	Milk used	Curing temp. °F.	Criticisms at 3 months flavor	body and texture	Criticisms at 6 months flavor	body and texture
20	untreated whole 4.7% fat	50	lacking	pasty, mech. holes		
		55	sl. lacking	sl. pasty, few med. eyes	sl. sour, sl. lacking	sl. pasty, few mech. holes
	treated part skim 3.5% fat	50	desirable, cons. fl.	v. desirable, mech. holes		
		55	v. desirable	v. desirable, few med. eyes	v. desirable	desirable, few mech. holes
24	untreated whole 3.7% fat	50	acidy, unclean	sl. pasty, few mech. holes		
		55	acidy, unclean	pasty, few mech. holes	sl. lacking, sl. sour	desirable
	treated part skim 2.2% fat	50	desirable, swt.	sl. weak, few mech. holes		
		55	v. desirable, swt.	sl. weak, few mech. holes	desirable, cons. fl.	v. sl. dry, few mech. holes
25	untreated whole 3.3% fat	50	unclean, salty	sl. pasty, few mech. holes		
		55	v. unclean, salty	sl. pasty, few mech. holes		
	treated part skim 2.5% fat	50	desirable, swt.	v. sl. dry, v. desirable, few mech. holes		
		55	desirable, swt.	sl. dry, desirable, few mech. holes.		

* foreign: similar to burned or caramel flavor.

between the cheese from partially skimmed milk treated with the extract and the untreated whole milk cheese were more noticeable at 55° F. than at 50° F. The flavors of the cheese cured at 55° F. were more desirable than those of corresponding cheese at 50° F. in most trials, but the improvement was not distinct in the cheese manufactured from untreated whole milk.

In general, the body and texture of the cheese manufactured from the partially skimmed milk were slightly better after curing 3 months than the body and texture of corresponding whole milk cheese cured at the same temperature.

There was no improvement in the flavor of the cheese cured an additional 3 months (total curing 6 months) at 55° F. and in some cases the flavor depreciated. At 6 months less difference occurred in the flavor of the untreated whole milk cheese and the cheese manufactured from partially skimmed milk treated with the extract. The body and texture of the cheese cured 6 months at 55° F. showed slight improvement in some cases over the body and texture at 3 months.

The total solids contents for the cheese which were analyzed at 3 months ranged from 60.78 to 64.80 per cent in the whole milk cheese and from 60.48 to 64.52 per cent in the partially skimmed milk cheese (table 10). In trial 20 the cheese manufactured from partially skimmed milk had a desirable body and texture and the total solids contents were 64.52 and 63.87 per cent (with the two curing temperatures). In trial 19 the cheese from the partially skimmed milk were criticized as dry and mealy and the total solids contents were 60.61 and 61.25 per cent. The

TABLE 10. PASTEURIZED, WHOLE MILK CHEESE MADE WITHOUT EXTRACT OF DESICCATED MAMMARY TISSUE AND PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE MADE WITH EXTRACT OF DESICCATED MAMMARY TISSUE ADDED TO THE MILK

Chemical analyses

Cheese paraffined at about 2 months

Trial No.	Milk used	Curing temp. °F.	3 months percentage total solids	Values at 6 months pH of cheese	Values at 6 months acid no. on fat
17	untreated whole	50	60.78		
		55	61.66	5.45	4.73
	treated part skim	55		5.27	4.79
18	untreated whole	50	61.94		
		55	62.98	5.49	5.86
	treated part skim	50	62.71		
		55	61.16	6.23	6.52
19	untreated whole	55	62.03	5.43	3.87
	treated part skim	50	60.61		
		55	61.25	5.60	4.36
20	untreated whole	55		5.43	3.38
	treated part skim	50	64.52		
		55	63.87	5.67	3.39

TABLE 10. (Continued)

Trial No.	Milk used	Curing temp. °F.	3 months percentage total solids	Values at 6 months pH of cheese	Values at 6 months acid no. on fat
24	untreated whole	55		5.20	3.75
	treated part skim	50 55	60.48 63.25	5.46	7.77
25	untreated whole	50	64.80		
	treated part skim	50	63.06		

partially skimmed milk used in trial 20 tested 3.5 per cent fat, while that used in trial 19 tested 2.5 per cent fat.

After curing 6 months at 55° F. the cheese manufactured from partially skimmed milk treated with extract of mammary tissue showed higher pH values than the corresponding whole milk cheese in all cases except trial 17. The acid numbers on the fat were higher in the cheese manufactured from partially skimmed milk treated with extract in all cases, but in trials 17 and 20 the differences were very slight; after 6 months the flavor of the cheese in trial 17 was criticized as very slightly lacking and in trial 20 it was very desirable.

The foreign flavor sometimes noted in both types of cheese (once at 3 months and twice at 6 months) was similar to a burned or caramel flavor.

Effect on the Cheese of Addition of an Extract of Frozen Mammary Tissue to Pasteurized, Partially Skimmed Milk

For each trial the two portions of pasteurized, partially skimmed milk were obtained from the same lot of mixed herd milk. The extract of frozen mammary tissue was added to one portion in each trial at rates varying from 6 to 25 ml. per 100 pounds of milk. The milk was ripened to titratable acidities of 0.16 to 0.195 per cent. After the curd was cut the whey acidities varied from 0.10 to 0.13 per cent. Most of the cheese were paraffined one week after salting and all of them were cured at 55° F.

The cheese were criticized for flavor and body and texture after curing 3 months and again after 6 months, except in 3 trials where other periods were used. Determinations of total solids, fat and salt contents were not made.

After curing 3 months (or 6 weeks in one trial) the cheese manufactured from partially skimmed milk treated with extract of mammary tissue was definitely better in flavor in 9 of 17 trials than corresponding cheese made without the extract (table 11); in 2 trials it was inferior, while in 6 trials there was no difference in the flavor of the cheese made without and with extract of mammary tissue. An unclean flavor was noted in some of the cheese from the treated milk as well as in some cheese from untreated milk; this probably interfered with detection of the desirable cheese flavor in some cases.

There was no consistent difference in body and texture or in eye formation of the cheese manufactured without and with extract of mammary tissue.

After curing 6 months (or 5 months in 3 trials) the flavor of most of the cheese was less satisfactory than at 3 months. The greatest depreciation occurred in cheese manufactured from the treated milk and such cheese was superior to cheese from untreated milk only in trials 34, 39 and 43. In 8 instances the cheese manufactured from treated milk developed distinct unclean flavors which were not present at 3 months. There was relatively little change in flavor of the cheese manufactured from untreated milk; most of them were criticized as lacking but in some of the trials they were criticized as unclean.

TABLE 11. PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE MADE WITHOUT AND WITH EXTRACT OF FROZEN MAMMARY TISSUE ADDED TO THE MILK

General flavor and body and texture criticisms
Cheese cured at 55° F.

Trial No.	Milk used	Curing time	Criticisms: flavor	Criticisms: body and texture	*pH of cheese	**Acid no. on fat
30	untreated	3 mo.	sour, unclean	v. desirable		
3.4% fat in milk		6 mo.	unclean	desirable	5.50	4.10
	treated 6 ml. per 100 lb.	3 mo.	v. desirable, swt.	v. desirable, v. few eyes		
		6 mo.	unclean, lacking	desirable	5.69	4.17
31	untreated	3 mo.	lacking, sl. unclean	desirable		
2.4, 2.8% fat in milk		6 mo.	sl. unclean, sl. lacking	desirable	5.94	
	treated 6 ml. per 100 lb.	3 mo.	desirable	pasty, many eyes		
		6 mo.	unclean, sl. sour	desirable	5.71	
32	untreated	3 mo.	fermented	weak, gassy		
3.0% fat in milk		6 mo.	v. sl. lacking	desirable, sl. gassy	5.56	4.44
	treated 6 ml. per 100 lb.	3 mo.	fermented	weak, gassy		
		6 mo.	sl. unclean, lacking	desirable, sl. gassy	5.78	4.53

* Determined at 6 months, except with trials 40 to 43, inclusive, and trials 49 and 50 when the values were determined at 3 months.

** Determined at 6 months.

TABLE 11. (Continued)

Trial No.	Milk used	Curing time	Criticisms flavor	Criticisms body and texture	*pH of cheese	**Acid no. on fat
33	untreated	3 mo.	lacking	v. desirable, sm. ragged eyes		
3.0% fat in milk		6 mo.	unclean, lacking	desirable, few sm. eyes	5.87	2.67
	treated 6 ml. per 100 lb.	3 mo.	sl. unclean	v. desirable, med. eyes		
		6 mo.	unclean, lacking	desirable, few sm. eyes	5.62	2.86
34	untreated	3 mo.	sl. unclean	spongy, sm. ragged eyes		
2.6% fat in milk		6 mo.	v. sl. lacking	desirable	5.57	2.37
	treated 6 ml. per 100 lb.	3 mo.	desirable	desirable, few med. eyes		
		6 mo.	v. desirable, cons. fl.	desirable	5.57	2.31
35	untreated	3 mo.	unclean, fermented	weak, gassy		
2.4% fat in milk		6 mo.	lacking, unclean	desirable, v. gassy	5.89	
	treated 10 ml. per 100 lb.	3 mo.	unclean, fermented	weak, gassy		
		6 mo.	v. sl. lacking, sl. unclean	desirable, v. gassy	6.04	
36	untreated	3 mo.	lacking	desirable, few eyes		
1.9% fat in milk		6 mo.	lacking, unclean	sl. weak	5.81	
	treated 9 ml. per 100 lb.	3 mo.	v. desirable, swt.	v. desirable		
		6 mo.	lacking, unclean	sl. weak	5.62	

TABLE 11. (Continued)

Trial No.	Milk used	Curing time	Criticisms: flavor	Criticisms: body and texture	*pH of cheese	**Acid no. on fat
37	untreated	3 mo.	lacking, bitter	pasty, few eyes		
		6 mo.	lacking	desirable, few med. eyes	5.61	4.40
3.0% fat in milk	treated 9 ml. per 100 lb.	3 mo.	desirable, sl. unclean	sl. weak, few sm. eyes		
		6 mo.	unclean, lacking	desirable, few med. eyes	5.64	4.61
38	untreated	3 mo.	acidy, sl. sour	sl. weak, few eyes		
		6 mo.	lacking, acidy	sl. weak, few sm. eyes	5.35	
2.0% fat in milk	treated 6 ml. per 100 lb.	3 mo.	acidy, sl. sour	sl. weak, few med. eyes		
		6 mo.	unclean, acidy	sl. weak, few sm. eyes	5.57	5.47
39	untreated	3 mo.	v. sl. lacking	desirable, few sm. eyes		
		6 mo.	lacking	desirable, few sm. eyes	6.11	
2.7% fat in milk	treated 12 ml. per 100 lb.	3 mo.	v. desirable, swt.	desirable, few sm. eyes		
		6 mo.	v. desirable, clean	desirable, few sm. eyes	5.56	3.57
40	untreated	3 mo.	unclean	sl. weak, v. gassy	5.60	
		6 mo.	desirable	desirable, gassy		3.22
3.05% fat in milk	treated 9 ml. per 100 lb.	3 mo.	v. sl. unclean	sl. weak, v. gassy	5.61	
		6 mo.	desirable, v. sl. unclean	desirable, v. gassy		3.27

TABLE 11. (Continued)

Trial No.	Milk used	Curing time	Criticisms flavor	body and texture	*pH of cheese	**Acid no. on fat
41	untreated	3 mo.	v. unclean	desirable, v. gassy	6.07	
		6 mo.	unclean, fermented	desirable		2.48
1.9% fat in milk	treated 25 ml. per 100 lb.	3 mo.	desirable, swt.	desirable, gassy	5.98	
		6 mo.	unclean, fermented	desirable		2.84
42	untreated	3 mo.	desirable, swiss-like, swt.	v. desirable, few large eyes	5.67	
		6 mo.	desirable	excellent		3.00
2.4% fat in milk	treated 14 ml. per 100 lb.	3 mo.	desirable, clean, swt.	v. desirable, few large eyes	5.82	
		6 mo.	cons. fl., sl. unclean	v. desirable		2.82
43	untreated	3 mo.	desirable, swt., swiss-like	v. desirable, few large eyes	5.82	
		6 mo.	desirable, sl. unclean	v. desirable		2.89
2.1% fat in milk	treated 15 ml. per 100 lb.	3 mo.	cons. fl., swt.	v. desirable, few large eyes	5.81	
		6 mo.	excellent swiss fl.	v. desirable, many large eyes		3.00

TABLE 11. (Continued)

Trial No.	Milk used	Curing time	Criticisms flavor	body and texture	*pH of cheese	**Acid no. on fat
49	untreated	6 wk.	lacking	desirable		
		5 mo.	lacking	few med. eyes	5.49	2.98
3.1% fat in milk	treated 25 ml. per 100 lb.	6 wk.	swt., cons. fl.	desirable		
		5 mo.	desirable	few med. eyes	5.41	2.87
50	untreated	3 mo.	lacking	desirable	5.66	
		5 mo.	sl. lacking	desirable		2.70
2.3% fat in milk	treated 33 ml. per 100 lb.	3 mo.	unclean	desirable, sl. weak	5.87	
		5 mo.	v. unclean	v. spongy		2.51
52	untreated	3 mo.	lacking	desirable		
		5 mo.	v. unclean	many v. large eyes		2.22
3.35% fat in milk	treated 40 ml. per 100 lb.	3 mo.	desirable, v. sl. rancid	desirable		
		5 mo.	v. unclean	many large eyes		3.09

The body and texture of the cheese manufactured from untreated and treated milks did not differ appreciably after extended curing. In 11 comparisons both types of cheese showed improvement in body and texture at 6 months, in 6 comparisons they had depreciated and in 11 comparisons there was no change; in 3 trials the cheese were not examined after 6 months.

In trials 34 and 39 the cheese manufactured from milk treated with extract of mammary tissue had a desirable flavor at 6 months and the pH values were 5.57 and 5.56, respectively; the cheese also showed desirable flavor after curing 3 months. In trial 49 the cheese made from treated milk had a desirable flavor at 5 months; when the pH value was determined at 3 months it was 5.41. In trials 30, 36, 41 and 42 the cheese from the treated milk had a very desirable sweet flavor at 3 months, and an unclean flavor was present at 6 months; the pH values were 5.69 and 5.62 at 6 months in the first two trials and 5.98 and 5.82 at 3 months in the last two trials. In trial 43 the cheese from treated milk had a sweet flavor characteristic of an excellent swiss cheese at 6 months, and the pH was 5.81 at 3 months, whereas the cheese of the same trial from untreated milk had a slight unclean flavor at 6 months with a pH of 5.82 at 3 months. Some of the pH values of cheese manufactured from untreated milk suggest a correlation between pH and an unclean flavor in the cheese. In trials 31, 33, 35, 36, 41 and 43 an unclean flavor developed in the cheese made from untreated milk at 6 months, and the pH values ranged from 5.81 to 6.07, some of the values being determined at 6 months and some at 3 months. Cheese made from untreated milk in trials 49 and 50 had not developed an

unclean flavor at 5 months, and the pH values of the cheese at 3 months were 5.49 and 5.66, respectively.

After curing 6 months the acid numbers on the fat were slightly higher with cheese manufactured from treated milk than with cheese from untreated milk in 8 of the 12 comparisons; the differences were small and ranged from 0.05 to 0.36. In trials 41 and 42 the acid numbers on the fat of cheese from treated milk were 2.84 (control 2.48) and 2.82 (control 3.00), respectively; although the cheese possessed a desirable flavor after curing 3 months, an unclean flavor was present at 6 months. Likewise, in trials 30 and 37 where the acid numbers on the fat of the cheese from treated milk were 4.17 (control 4.10) and 4.61 (control 4.40), respectively, an unclean flavor developed after 6 months. However, the acid numbers on the fat of cheese from treated milk in trials 34 and 43 and from untreated milk in trial 42 were 2.31, 3.00 and 3.00, respectively, and the cheese showed a desirable flavor at 3 months and 6 months. In trials 49 and 50 the cheese from treated milk had slightly lower acid numbers on the fat than cheese from the untreated milk, and in trial 49 the flavor of cheese from treated milk was desirable at 5 months, while in trial 50 it was criticized as unclean. An unclean flavor which developed in some cheese in the later stages of ripening interfered with the characteristic cheese flavor that resulted from earlier changes.

Variations in the amounts of extract of mammary tissue added to the milk in the different trials did not result in corresponding variations in the flavor developed in the cheese.

Effect on the Cheese of Addition of an Extract of Frozen Chicken Pancreas or of Oat Flour to Pasteurized, Partially Skimmed Milk

Extract of frozen chicken pancreas.

The two portions of pasteurized, partially skimmed milk used in each trial were obtained from the same lot of mixed herd milk. Extract of chicken pancreas was added to one portion of the milk in each trial in amounts varying from 0.25 to 2.3 ml. per 100 pounds. The milk was ripened to titratable acidities of 0.165 to 0.18 per cent and the acidities of the whey after cutting the curd ranged from 0.11 to 0.12 per cent. After removal from the brine the cheese were paraffined as soon as dry and cured at 55° F.

The cheese were criticized for flavor and body and texture in 3 trials after curing 3 and 5 months and in 2 trials only after 3 months. Determinations of total solids, fat and salt contents were not made.

Cheese manufactured from milk treated with extract of frozen chicken pancreas had a bitter flavor in 3 of the 5 trials at 3 months (table 12). In one trial the cheese showed a very desirable flavor although the cheese from the untreated milk was lacking in flavor, and in one trial both types of cheese were lacking in flavor.

There was no difference in the body and texture of cheese manufactured without and with extract of frozen chicken pancreas after curing 3 months.

TABLE 12. PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE MADE WITHOUT AND WITH EXTRACT OF FROZEN CHICKEN PANCREAS ADDED TO THE MILK

General flavor and body and texture criticisms
Cheese cured at 55° F.

Trial No.	Milk used	Curing time	Criticisms: flavor	Criticisms: body and texture	pH of cheese	Acid no. on fat
51	untreated	3 mo.	lacking	desirable		
		5 mo.	sl. lacking, unclean	desirable, many eyes	6.03	2.25
2.5% fat in milk	treated 0.25 ml. per 100 lb.	3 mo.	v. bitter	desirable		
		5 mo.	unclean, bitter	desirable	5.85	4.92
52	untreated	3 mo.	lacking	desirable		
		5 mo.	v. unclean	many v. large eyes, v. soft		2.22
3.3% fat in milk	treated 1 ml. per 100 lb.	3 mo.	v. bitter	large eyes, desirable		
		5 mo.	unclean, sl. bitter	many large eyes, v. soft		2.38
53	untreated	3 mo.	sl. lacking	desirable		
		5 mo.	v. unclean	desirable, many med. eyes	6.10	2.29
3.3% fat in milk	treated 1.75 ml. per 100 lb.	3 mo.	v. desirable	excellent		
		5 mo.	v. unclean, bitter, sl. rancid	desirable	5.85	2.99

TABLE 12. (Continued)

Trial No.	Milk used	Curing time	Criticisms flavor	body and texture	pH of cheese	Acid no. on fat
65 2.5% fat in milk	untreated	3 mo.	lacking	sl. dry, many v. sm. eyes	5.63	
	treated 1.2 ml. per 100 lb.	3 mo.	lacking	sl. dry, many v. sm. eyes	5.59	
66 2.4% fat in milk	untreated	3 mo.	desirable, v. sl. lacking	dry, firm	5.54	
	treated 2.3 ml. per 100 lb.	3 mo.	unclean, sl. bitter	dry, firm	5.77	

In general, the cheese in the 3 lots cured 5 months showed considerable depreciation in flavor with the longer curing. Both types of cheese were criticized as unclean; at 3 months none of the cheese showed this defect. In one trial the cheese manufactured from treated milk depreciated in body and texture with the longer curing.

The pH values of the cheese manufactured from treated milk were lower than those of the corresponding cheese from untreated milk in 3 of the 4 trials. The relatively high pH values of both types of cheese in trials 51 and 53 may have contributed to the development of the unclean flavors in those cheese.

In the 3 trials for which data were obtained, the acid numbers on the fat were higher for cheese manufactured from treated milk than for the corresponding cheese from untreated milk.

The intensity of the bitter flavor in cheese from treated milk was not in proportion to the amounts of extract added in the different trials. This may have been due to variations in the activities of the different preparations.

Oat flour.

For each trial 2 portions of pasteurized, partially skimmed milk were obtained from the same lot of mixed herd milk. Oat flour was added to one portion of milk in each trial in amounts of 3 or 24 gm. per 100 pounds. The milk was ripened to titratable acidities of 0.16 to 0.17 per cent and acidities of the whey after the curd was cut ranged from 0.11 to 0.115 per cent. After removal from the brine the cheese were paraffined

as soon as dry and cured at 55° F.

The cheese were criticized for flavor and body and texture after curing 6 weeks and 5 months in one trial, after 3 months and 5 months in one trial and only after 3 months in 2 trials. The cheese were not analyzed for total solids, fat and salt contents.

Cheese made from partially skimmed milk treated with oat flour was not improved by the addition (table 13). In trial 49 the cheese from treated milk was slightly bitter at 6 weeks, and in trial 50 it was slightly bitter at 3 months. In trials 65 and 66 the cheese made from treated milk was criticized as lacking in flavor; in these trials considerably less oat flour was added to the milk than in trials 49 and 50. All of the cheese manufactured from untreated pasteurized, partially skimmed milk were criticized as lacking in flavor.

There was no consistent difference in the body and texture of cheese made without and with addition of oat flour to the milk.

The flavor of the cheese examined at 5 months (trials 49 and 50) showed no improvement in the case of cheese from treated milk and very slight improvement in the case of cheese from untreated milk.

The pH values of cheese made without and with oat flour added to the milk differed very little. The acid numbers on the fat were determined for trials 49 and 50. Higher values were obtained in both cases on cheese from milk treated with oat flour than on cheese from untreated milk.

TABLE 13. PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE MADE WITHOUT AND WITH OAT FLOUR ADDED TO THE MILK

General flavor and body and texture criticisms

Cheese cured at 55° F.

Trial No.	Milk used	Curing time	Criticisms: flavor	Criticisms: body and texture	pH of cheese	Acid no. on fat
49	untreated	6 wk.	lacking	desirable		
3.1% fat in milk		5 mo.	sl. lacking	desirable	5.49	2.98
	treated 24 gm. per 100 lb.	6 wk.	desirable, sl. bitter	sl. weak		
		5 mo.	sl. bitter	desirable	5.38	3.67
50	untreated	3 mo.	lacking	desirable		
2.3% fat in milk		5 mo.	sl. lacking	desirable	5.66	2.70
	treated 24 gm. per 100 lb.	3 mo.	sl. bitter	desirable		
		5 mo.	v. bitter	v. pasty	5.67	3.17
65	untreated	3 mo.	lacking	sl. dry, many v. sm. eyes	5.63	
2.5% fat in milk	treated 3 gm. per 100 lb.	3 mo.	sl. lacking	sl. dry, few sm. eyes	5.54	
66	untreated	3 mo.	v. sl. lacking	dry, firm	5.54	
2.4% fat in milk	treated 3 gm. per 100 lb.	3 mo.	lacking	dry, firm	5.50	

Effect on the Cheese of Addition to the Curd of an Extract of Frozen Mammary Tissue, an Extract of Frozen Chicken Pancreas or Oat Flour

In each trial the portions of milk utilized were obtained from the same lot of pasteurized, whole milk. Enzyme preparations were added to the curd in 13 trials. In each of 5 trials the effects of enzyme preparations were observed with 3 types of milk, normal milk (4.0 to 4.2 per cent fat), fat enriched milk (4.65 to 6.1 per cent fat) and partially skimmed milk (1.9 to 3.45 per cent fat). In the other the milk was partially skimmed milk, except in one trial where it was whole milk.

The milk was ripened to titratable acidities of 0.17 to 0.18 per cent and the acidities of the whey when the curd was cut varied from 0.105 to 0.12 per cent. After the curd was matted and hooped, the cheese to be treated with liquid enzyme preparations were either sliced and portions added to each layer, or cut in half, incisions made in each half and enzyme preparation run into the incisions. The cheese serving as controls were not cut. Oat flour was added to the unmatted curd before hooping.

Extract of frozen mammary tissue was added to the curd in 11 trials in quantities of 3.0, 4.0, 5.0 or 6.0 ml. per cheese; extract of frozen chicken pancreas was added in 11 trials in amounts of 0.5, 1.0 or 3.0 ml. per cheese. Oat flour was employed in 8 trials in quantities of 4, 6, 12 or 24 gm. per cheese.

After salting, the cheese were paraffined as soon as sufficiently dry and cured at 55° F. In the first 6 trials the cheese were criticized at 6 weeks for flavor and body and texture, and again at 5 months. In other trials the cheese were examined at 3 and 5 months. Determinations of pH values and acid numbers on the fat were obtained in some trials after curing approximately 5 months at 55° F.

Cheese made with extract of frozen mammary tissue added to the curd and examined after curing 6 weeks had more cheese flavor than the control cheese in all trials except one where the flavor was unclean. The improvement in flavor was noted in cheese from partially skimmed milk, normal milk and fat enriched milk, but usually the improved flavor was more noticeable in cheese of higher fat contents. The flavor of the cheese was most prominent in areas near the points at which the enzyme preparation was added, and the desirable flavor was not present at some distance from such areas. The cheese showed some eye development at 6 weeks; the eyes were largest in the cheese from fat enriched milk, which cheese usually possessed a soft body, and were much smaller in cheese made from partially skimmed milk.

The flavor of partially skimmed milk cheese made from curd treated with mammary extract was inferior at 3 months to the control cheese in 3 of 5 trials, being criticized as unclean, but in 2 trials the cheese had a more desirable flavor than the control. There was an indication that gas accumulated in the areas of the enzyme activity to form cavities rather than eyes.

All the cheese were examined after curing 5 months. The flavor of the cheese made from curd treated with extract of mammary tissue was more desirable than the control cheese in 14 of 20 lots; in 6 lots it was definitely inferior. In 5 of the 6 cases where the cheese were inferior, it was criticized only as unclean. The desirable flavor in cheese made from treated curd was found to be more prominent with cheese from normal milk or fat enriched milk than with cheese from partially skimmed milk. The unclean flavors that were found in cheese (from treated curd) which were inferior to the control cheese were more prominent in the partially skimmed milk cheese. The unclean flavor in some cheese from milk of higher fat contents was less noticeable, which probably was due to the greater effect of the mammary tissue extract in developing desirable flavor. Results showed no detectable variation in flavor development with variations in amounts of extract added to the curd. Cheese examined after curing 5 months showed large cavities which seemed to form between the curd layers or in the incisions in the curd. Apparently accumulation of gas contributed to the distortion. In some cases the edges of the cavities had a somewhat honeycomb appearance.

Of the 14 lots of cheese in which at 5 months mammary tissue extract gave considerable improvement in flavor over the control, the cheese had pH values ranging from 5.40 to 5.91. Of the lots showing the more desirable flavors, 8 were slightly unclean and these had pH values varying from 5.66 to 5.91. One lot that was desirable in flavor, with no unclean flavor, had a pH of 5.91.

The control cheese commonly were criticized as lacking in flavor, but 8 lots were either unclean or slightly unclean. The pH values were obtained for most of the cheese made from untreated curd and they varied from 5.49 to 6.03. In lots of the same trial there seemed to be a tendency for the pH values to decrease with a decrease in fat content of the cheese.

Acid numbers on the fat were obtained for most of the cheese. Cheese made with extract of mammary tissue had values only slightly higher than the control cheese in 25 per cent of the comparisons, and in the remainder the differences were negligible.

Cheese made with extract of frozen chicken pancreas added to the curd and cured 6 weeks had a distinctly bitter flavor in all the trials. Areas of localized action were found where the extract had acted without penetrating throughout the mass. The areas were distinctly soft, as a result of proteolysis, and were light in color and opaque. The bitter flavor was very prominent in the areas, and the flavor was not bitter at some distance from them. The localized areas were most distinct with cheese manufactured from partially skimmed milk, but the same general effect was observed in the cheese of the same trials made from normal milk or fat enriched milk.

With the partially skimmed milk cheese examined at 3 months, the flavors were either bitter or bitter with varying degrees of rancidity. Areas of localized action were found and the body of the cheese in those areas was extremely soft. The objectionable flavor was largely limited to the local areas.

After curing 5 months the cheese showed even more extensive action of the extract of chicken pancreas. In most cases there was a very strong bitter flavor and an equally objectionable rancidity. However, there was considerable difference in the type of rancidity. In some cheese the flavor was more peppery in nature which indicated the presence of higher fatty acid. In other cases the flavor distinctly suggested butyric acid, while in still others it also was unclean. The rancid flavors seemed to be less prominent in the cheese of lower fat contents. The effect of the action of the extract of chicken pancreas was so extensive after curing 5 months that large cavities were found between the layers of curd which appeared to be due to accumulation of gas and digestion of the cheese protein. The areas were distinctly bleached with a zoning around the cavity which indicated limited penetration of the enzyme preparation.

The pH values of cheese made by treating the curd with extract of chicken pancreas were lower than for control cheese (0.03 to 0.39 pH) in nearly every comparison; this relationship applied to cheese from partially skimmed milk, normal milk and fat enriched milk. In some cases the partially skimmed milk cheese made without enzyme to serve as controls showed unclean flavors; in these the pH values were 5.69, 5.82, 6.03, 6.10 and 5.81. Other cheese were not unclean in flavor and were criticized only as lacking; these had pH values approximating 5.65. Most of the control cheese from the normal and fat enriched milk were free of the unclean flavor but usually had large eyes and a very sweet, swiss-like flavor; the pH values ranged from 5.67 to 5.74.

Cheese made from curd treated with extract of chicken pancreas and cured 5 months showed considerable variation in the acid numbers on the fat. In cheese of the same trial the acid numbers increased as the fat contents of the cheese decreased. In one trial the cheese manufactured from fat enriched milk were criticized as rancid with a peppery taste; the acid number on the fat was 3.51 compared to 2.51 for the control. In the same trial the cheese made from normal milk had the same flavor and the acid number on the fat was 4.51 compared to 2.49 for the control cheese; the partially skimmed milk cheese also showed the flavor, although less prominently, and it had an acid number on the fat of 5.13 compared to 2.61 for the control. Acid numbers on the fat of other cheese which were criticized as very bitter and rancid (butyric acid-like) were 17.38, 18.47, 27.81, 12.58, 5.70, 16.23 and 7.47; most of the values were several times those obtained for corresponding control cheese.

In one trial the cheese from treated curd of fat enriched milk were criticized as bitter without detectable rancidity; the acid number on the fat was 4.83 and on the control cheese it was 3.39. Apparently there was considerable difference in the proteolytic and lipolytic activities of the extracts; comparatively large variations in the quantities employed did not bring about corresponding differences in action on the curd.

Cheese manufactured with the addition of oat flour to the curd was very bitter in all lots examined after curing 6 weeks. The body usually was weak and slightly spongy, with numerous small gas holes distributed throughout. The bitter flavor also was very prominent in the cheese after

curing 3 months, and the flavor was extremely bitter after curing 5 months. The body and texture of the cheese seemed to become more weak and spongy as the holding increased, and the gas holes also increased. After 5 months bleached areas were found which seemed to indicate excessive enzyme action in some local areas.

The bitter flavor developed in the cheese made with oat flour added to the curd did not appear to be to be correlated with the pH values. All of the cheese were bitter and the pH values ranged from 5.49 to 6.13, whereas those of control cheese of the same lots ranged from 5.49 to 6.10. In some cases the values for treated cheese were considerably higher than for the controls, while in others they were lower.

Acid numbers on the fat were determined after 5 months for nearly all of the lots. The cheese manufactured from curd treated with oat flour showed higher acid numbers than the controls except in one case. The increases ranged from 0.23 to 3.01. Variations in amounts of flour added did not result in corresponding differences in fat hydrolysis.

Effect on the Cheese of Addition of an Unidentified *Micrococcus*, *Pseudomonas putrefaciens* and an Extract of Frozen Mammary Tissue to Pasteurized, Partially Skimmed Milk

In each trial the portions of pasteurized, partially skimmed milk were obtained from the same lot of mixed herd milk. The milk was ripened to titratable acidities of 0.16 to 0.175 per cent, and the acidities of the whey after cutting the curd varied from 0.10 to 0.12 per cent.

The milk cultures of the *Micrococcus* were incubated 48 to 72 hours at 72° F. before use. Plate counts on the cultures employed in trials 55, 56, 57, 58, 59, 60 and 61 were 138,000,000, 740,000,000, 480,000,000, 1,080,000,000, 4,370,000,000, 600,000,000 and 750,000,000 per ml., respectively; in the other trials counts on the *Micrococcus* cultures were not made. The *Micrococcus* cultures were added in the following amounts: 100 ml. to 100 pounds of milk in trials 55, 60, 67, 68 and 69; 200 ml. to 100 pounds in trials 61, 70 and 71; 130 ml. to 100 pounds in trials 56 and 58; 60 and 50 ml. per 100 pounds of milk in trials 57 and 59, respectively.

The relative numbers of organisms in the milk cultures of *Ps. putrefaciens* were not determined because growth of the organism on plating media is limited. Most of the cultures were incubated 48 to 72 hours at 72° F., as in the case of the *Micrococcus*. In each trial where *Ps. putrefaciens* was employed, the quantity of culture added to the milk was

the same as with the Micrococcus.

Extract of frozen mammary tissue was added to the milk in amounts of 30, 50 and 35 ml. per 100 pounds of milk in trials 57, 58 and 59, respectively. In all other trials mammary tissue extract was added to the milk at the rate of 25 ml. per 100 pounds.

The cheese were paraffined as soon as sufficiently dry after salting and were cured at 55° F.

The cheese were criticized for flavor and body and texture at 2 months and 4 months in trials 55, 56, 57 and 58. In the other trials the cheese were criticized only after curing 3 months. The total solids and fat contents of some of the cheese were determined at 3 months; the values were in the same general range as with previous analyses.

Cultures of Micrococcus were used in 10 of the 12 trials (table 14). At 2 months cheese manufactured from milk treated with the Micrococcus were less desirable than the corresponding controls in all 4 trials, being criticized as unclean and lacking in flavor. At 4 months cheese of the same trials were criticized as unclean and lacking in flavor in 3 of the trials, but in one trial the flavor was slightly more desirable than the control cheese. Cheese made from milk treated with the Micrococcus and criticized only at 3 months were inferior to the controls in 2 of 6 trials, the criticisms being unclean and lacking in flavor; in 2 trials the cheese from the treated milk were more desirable than the controls and in 2 trials there was no difference. The pH values of the cheese made from treated milk ranged from 5.46 to 5.98. In half of the trials there was no significant difference between the values for the

TABLE 14. PASTEURIZED, PARTIALLY SKIMMED MILK CHEESE MADE WITHOUT AND WITH AN UNIDENTIFIED MICROCOCCUS, PS. PUTREFACIENS AND AN EXTRACT OF FROZEN MAMMARY TISSUE ADDED TO THE MILK

General flavor and body and texture criticisms

Cheese cured at 55° F.

Trial No.	Added to the milk	Curing time	Criticisms: flavor	Criticisms: body and texture	*pH of cheese	**Acid no. on fat
55	nothing	2 mo.	swt., lacking	v. desirable		
		4 mo.	swt., sl. lacking	sl. dry	5.74	2.11
	Micrococcus	2 mo.	unclean, lacking	v. desirable		
		4 mo.	sl. unclean, bitter	sl. dry	5.72	2.30
	Ps. putrefaciens	2 mo.	desirable, sl. bitter	v. desirable		
		4 mo.	sl. unclean	sl. dry	5.61	2.51
56	nothing	2 mo.	swt., lacking	excellent		
		4 mo.	lacking	v. desirable	5.80	2.07
	Micrococcus	2 mo.	swt., lacking, unclean	excellent		
		4 mo.	unclean	v. desirable	5.98	
	Ps. putrefaciens	2 mo.	swt., cons. fl., sl. bitter	excellent		
		4 mo.	v. desirable	excellent	5.62	2.20

* Determined at approximately 4 months, except trials 67 to 71, inclusive, when the values were determined at 3 months.

** Determined at approximately 4 months in trials 55, 59 and 60 and at approximately 5 months in trials 56, 57 and 58. Values determined at 3 months in trial 61.

TABLE 14. (Continued)

Trial No.	Added to the milk	Curing time	Criticisms flavor	body and texture	*pH of cheese	**Acid no. on fat
57	nothing	2 mo.	swt., lacking	v. desirable		
		4 mo.	lacking	desirable	5.59	4.25
	Micrococcus	2 mo.	unclean	v. desirable		
		4 mo.	lacking, sl. unclean	desirable	5.46	4.42
	Micrococcus and mammary extract	2 mo.	sl. unclean, swt.	v. desirable		
		4 mo.	v. desirable	desirable	5.56	4.98
	mammary extract	2 mo.	desirable, swt., clean	v. desirable		
		4 mo.	desirable	desirable	5.96	4.29
58	nothing	2 mo.	lacking	desirable		
		4 mo.	lacking	desirable	5.49	2.51
	Micrococcus	2 mo.	sl. unclean	desirable		
		4 mo.	sl. lacking	desirable	5.61	2.58
	Ps. putrefaciens	2 mo.	sl. unclean	desirable		
		4 mo.	sl. lacking	desirable	5.64	2.98
	mammary extract	2 mo.	v. desirable, swt., clean	desirable		
		4 mo.	cons. fl.	desirable	5.69	2.38

TABLE 14. (Continued)

Trial No.	Added to the milk	Curing time	Criticisms flavor	body and texture	*pH of cheese	**Acid no. on fat
59	nothing	3 mo.	lacking	excellent	5.51	2.20
	Micrococcus	3 mo.	desirable, sl. bitter	desirable	5.54	2.41
	Micrococcus and mammary extract	3 mo.	v. sl. bitter	desirable, sl. dry	5.50	2.18
	mammary extract	3 mo.	swt., v. desirable	v. desirable	5.56	2.43
60	nothing	3 mo.	lacking, bitter	desirable, sl. soft, med. eyes	5.82	2.27
	Micrococcus	3 mo.	v. desirable	desirable, sl. soft, mech. holes	5.72	
	Ps. putrefaciens	3 mo.	cons. fl., bitter	desirable, sl. soft	5.74	2.84
	mammary extract	3 mo.	desirable, sl. lacking	desirable, sl. soft, v. few eyes	5.72	2.52
61	nothing	3 mo.	lacking	v. desirable, few eyes	5.50	1.97
	Micrococcus	3 mo.	unclean	desirable, many med. eyes	5.53	2.21
	Micrococcus and mammary extract	3 mo.	v. lacking	desirable, v. few eyes	5.60	2.32
	mammary extract	3 mo.	sl. lacking	desirable	5.51	2.15
67	nothing	3 mo.	lacking, v. sl. acidy	v. desirable	5.33	
	Micrococcus	3 mo.	lacking, v. sl. acidy	v. desirable, v. few mech. holes	5.64	
	Micrococcus and Ps. putrefaciens	3 mo.	v. desirable, v. sl. acidy	v. desirable	5.44	
	Ps. putrefaciens	3 mo.	cons. fl., sl. bitter, v. sl. acidy	v. desirable	5.29	

TABLE 14. (Continued)

Trial No.	Added to the milk	Curing time	Criticisms flavor	body and texture	*pH of cheese	**Acid no. on fat
68	nothing	3 mo.	sl. lacking	sl. firm, dry	5.53	
	Micrococcus	3 mo.	lacking	sl. firm, dry	5.56	
	Ps. putrefaciens	3 mo.	lacking, sl. unclean	sl. firm, dry	5.67	
	mammary extract	3 mo.	v. desirable	sl. firm, dry	5.62	
69	nothing	3 mo.	lacking	firm, sl. dry	5.63	
	Micrococcus	3 mo.	lacking	firm, sl. dry	5.60	
	Ps. putrefaciens	3 mo.	v. sl. lacking	desirable, soft	5.52	
	mammary extract	3 mo.	cons. fl.	firm, sl. dry	5.56	
70	nothing	3 mo.	desirable, v. sl. lacking	v. desirable	5.64	
	Micrococcus and Ps. putrefaciens	3 mo.	sl. unclean	v. desirable	5.59	
	Ps. putrefaciens	3 mo.	v. desirable	v. desirable	5.54	
	mammary extract	3 mo.	unclean	v. desirable	5.59	
71	nothing	3 mo.	lacking	desirable, v. sl. firm	5.52	
	Ps. putrefaciens	3 mo.	lacking	desirable, sl. firm	5.50	
	Ps. putrefaciens and mammary extract	3 mo.	desirable	desirable	5.60	
	mammary extract	3 mo.	v. desirable	desirable	5.59	

cheese from treated milk and those for cheese from untreated milk; with the significant differences the higher values sometimes were obtained on cheese from treated milk and sometimes not. In all 5 trials for which acid numbers were obtained, the values were higher for the cheese from treated milk but only very slightly so.

Cultures of Ps. putrefaciens were added to individual lots of milk in 9 of the 12 trials. At 2 months cheese made from milk treated with culture showed a more desirable flavor than the controls in 2 of 3 trials; although there was considerable flavor, a slight bitterness was present. At 4 months cheese of the same trials made from treated milk also were more desirable in 2 of the 3 trials; in one case cheese that was undesirable at 2 months had improved at 4 months, while in another trial cheese that was desirable at 2 months had decreased in quality at 4 months. When cheese were examined only at 3 months, those made from milk treated with Ps. putrefaciens were more desirable than the controls in 4 of 5 trials, and in one trial there was no difference. There was a slight bitterness in 2 lots where the flavor was desirable. The cheese made from treated milk were undesirable in one trial, being criticized as unclean and lacking in flavor. The pH values of cheese made from milk treated with Ps. putrefaciens ranged from 5.29 to 5.74; they were lower than the controls in 7 trials and higher in 2 trials. In some cases the differences were only slight. The acid numbers on the fat were higher for the cheese made from treated milk in all 4 trials for which values were obtained. The differences were not significant and ranged from 0.13 to 0.57.

Combinations of extracts of frozen mammary tissue and cultures of bacteria were employed in 4 trials; the Micrococcus was used in 3 and Ps. putrefaciens in one. The cheese made from milk with the combinations added did not show improvement over the use of the extract alone, and in most cases the flavor was less desirable. A mixture of the Micrococcus and Ps. putrefaciens was used in 2 trials and neither of them showed any definite improvement over the use of Ps. putrefaciens alone.

An extract of frozen mammary tissue was used alone in 9 of the 12 trials. In 2 trials the cheese manufactured from treated milk showed a more desirable flavor than that from untreated milk at 2 months and also at 4 months. In 6 of 7 trials the cheese made from treated milk were more desirable than the controls when examined at 3 months, and in one trial they were undesirable and were criticized as unclean. The pH values of cheese made from treated milk ranged from 5.51 to 5.96. In 6 of the 9 trials the values were higher than for corresponding control cheese, and in the other 3 trials they were lower, but in 5 comparisons the differences were very small. In the trial where the cheese from treated milk was unclean in flavor, the pH value was 5.59. Acid numbers on the fat were determined in 5 comparisons and the cheese made from treated milk showed higher values in 4 of the 5 trials, but the increases were slight, ranging from 0.04 to 0.23.

Numbers of the Micrococcus and Ps. putrefaciens organisms in the cheese.

Samples from different lots of cheese manufactured from milk inoculated with the Micrococcus were cultured on beef extract agar. Amounts of material representing 0.01 to 0.0000001 gm. of cheese were smeared on the surfaces of plates, and the plates were incubated 3 to 5 days at 72° F. Since colonies of the Micrococcus employed in the studies produced a prominent orange pigment, they were differentiated readily. The results obtained are as follows:

Trial No.	Age of cheese (weeks)	Micrococcus colonies per gm.
69	6	120,000
68	8	1,000
67	8	less than 100
61	12	4,000
60	14	20,000
59	14	less than 100
56	16	6,000
55	16	740,000

In general, only small numbers of the Micrococcus were found in the cheese which varied in age from 6 to 16 weeks.

Samples of 12 lots of cheese manufactured from milk inoculated with Ps. putrefaciens were examined for the presence of the organism at ages ranging from 4 to 14 weeks. Inoculations representing 0.01 to 0.0000001 gm. of cheese were smeared on a special gelatin agar medium (50) and the plates were incubated 3 days at 72° F. Ps. putrefaciens was not found in any of the samples.

Effect on the Cheese of Miscellaneous Factors

Size of the cheese.

The effect of the size of the cheese on the flavor, body and texture and composition was studied in 3 trials. In each trial one portion of the pasteurized, partially skimmed milk was treated with extract of frozen mammary tissue. Both large and small cheese were made from each lot of curd. Weights of the large cheese varied from about 1,200 to about 1,800 gm., while those of the small cheese ranged from about 600 to about 800 gm. Large cheese were salted 48 hours in 24 per cent brine, while the small ones were salted 24 hours. All of the cheese were paraffined about one week after salting.

In some cases at 3 months the small cheese showed slightly more flavor development than corresponding large cheese, but in most instances at 6 months the criticisms were identical (table 15). The body and texture of the small cheese were slightly better at 3 months than with corresponding large cheese; in some cases at 6 months the small cheese showed a slightly more desirable body and texture. There was a tendency for eye formation to be less extensive in the small cheese. Presumably, the difference was due to the greater surface area per unit volume with the small cheese than with the large cheese; this permitted a more rapid escape of gas with the former. Analyses indicate that, in general, the small cheese had higher total solids contents than the corresponding large cheese (table 16); undoubtedly this was due to the more rapid drying before paraffining. Although the large cheese were brine salted twice as long as the small ones, the differences in the salt contents were small.

TABLE 15. LARGE AND SMALL CHEESE FROM THE SAME LOTS OF CURD*

General flavor and body and texture criticisms

Cheese cured at 55° F.

Trial No.	Milk used	Curing time	Criticisms: flavor	Criticisms: body and texture
37 large 3.0% fat in milk	untreated	3 mo.	lacking, bitter	pasty, few eyes
		6 mo.	lacking	desirable, few med. eyes
	treated	3 mo.	desirable, sl. unclean	sl. weak, few sm. eyes
		6 mo.	unclean, lacking	desirable, few med. eyes
37 small 3.0% fat in milk	untreated	3 mo.	desirable, sl. lacking	v. sl. pasty, v. few eyes
		6 mo.	lacking	desirable, v. few eyes
	treated	3 mo.	v. desirable, clean	desirable, v. few eyes
		6 mo.	unclean, lacking	desirable, v. few eyes
38 large 2.0% fat in milk	untreated	3 mo.	acidy, sl. sour	sl. weak, many eyes
		6 mo.	acidy, lacking	sl. weak, many sm. eyes
	treated	3 mo.	acidy, sl. sour	sl. weak, few med. eyes
		6 mo.	acidy, unclean	sl. weak, few sm. eyes
38 small 2.0% fat in milk	untreated	3 mo.	sl. acidy, lacking	v. sl. weak, many sm. eyes
		6 mo.	acidy, fermented	v. sl. weak, many sm. eyes
	treated	3 mo.	sl. acidy, desirable	desirable, few sm. eyes
		6 mo.	acidy, unclean	desirable, few sm. eyes

* pasteurized, partially skimmed milk

TABLE 15. (Continued)

Trial No.	Milk used	Curing time	Criticisms: flavor	Criticisms: body and texture
39 large 2.7% fat in milk	untreated	3 mo.	v. sl. lacking	desirable, few med. eyes
		6 mo.	lacking	desirable, few sm. eyes
	treated	3 mo.	v. desirable, swt.	desirable, few sm. eyes
		6 mo.	v. desirable, clean	desirable, few sm. eyes
39 small 2.7% fat in milk	untreated	3 mo.	v. sl. lacking	v. desirable, v. few sm. eyes
		6 mo.	desirable, sl. lacking	v. desirable
	treated	3 mo.	v. desirable, swt.	v. desirable
		6 mo.	v. desirable, clean	v. desirable

TABLE 16. LARGE AND SMALL CHEESE FROM THE SAME LOTS OF CURD

Chemical analyses

Trial No.	Milk used	Composition at 3 months				
		% total solids	% fat	% fat dry basis	% salt	% salt dry basis
37	untreated	59.46	27.19	45.73	1.63	2.74
large	treated	61.73	27.55	44.63	1.62	2.62
37	untreated	61.51	27.94	45.42	1.91	3.11
small	treated	62.31	27.98	44.90	1.80	2.89
38	untreated	55.90	19.14	34.24	2.17	3.88
large	treated	58.04	20.85	35.92	2.17	3.74
38	untreated	58.05	19.81	34.13	1.84	3.17
small	treated	58.90	18.66	31.68	1.98	3.36
39	untreated	62.63	28.10	44.87	1.59	2.54
large	treated	62.89	27.86	44.30	1.78	2.83
39	untreated	63.99	27.90	43.60	1.77	2.77
small	treated	64.50	28.98	44.93	1.66	2.57

Relationship of type of milk (whole or partially skimmed) to composition of the cheese.

In order to show the effect of partially skimming the milk on the composition of the cheese, data obtained on whole milk cheese in 10 trials and on partially skimmed milk cheese in 9 trials were tabulated; in some of the trials two lots of cheese were included. The cheese in trials 37, 38 and 39 were paraffined at about one week after salting and the others at approximately 2 months. The analyses were obtained after the cheese had cured 3 months at 55° F.

The results show the relationship of the fat and solids not fat of the milk to the fat of the dry matter of the cheese (table 17). In the whole milk the ratios of fat to solids not fat ranged from 1:2.19 to 1:2.54 and the fat contents of the dry matter of the cheese ranged from 52.89 to 47.45 per cent. In partially skimmed milk the ratios of fat to solids not fat varied from 1:2.92 to 1:4.50, while the fat contents of the dry matter of the cheese varied from 45.73 to 34.24 per cent. Variations in the fat of the dry matter of the cheese were not consistent with the variations in the composition of the milk; in some cases the percentage of fat in the dry matter was relatively high in cheese made from milk having a relatively wide ratio of fat to solids not fat.

In general, the percentage of fat in the dry matter of the cheese decreased with a decrease in the fat content of the milk (Fig. 1). Presumably, variations in the casein contents of different lots of milk explain the variations from the general relationship.

TABLE 17. RELATIONSHIP OF TYPE OF MILK (WHOLE OR PARTIALLY SKIMMED) TO COMPOSITION OF THE CHEESE

Trial No.	Milk used	% Composition of milk			% Composition of cheese, 3 mo.		
		fat	solids not fat	ratio of fat to s.n.f.	total solids	fat in cheese	fat dry basis
				Whole milk			
1	raw	3.8			64.60	33.65	52.09
	past.	3.8			64.88	33.75	52.02
2	raw	3.9	9.17	1:2.35	65.74	33.59	51.10
	past.	3.9	9.17	1:2.35	66.21	33.90	51.20
3	raw	4.15	9.25	1:2.23	66.48	35.16	52.89
	past.	4.15	9.10	1:2.19	65.42	33.41	51.07
4	raw	4.0	9.01	1:2.25	66.54	34.45	51.77
	past.	4.0	8.96	1:2.24	65.26	33.73	51.69
5	raw	3.55	9.02	1:2.54	64.85	31.40	48.42
6	raw	3.50	8.84	1:2.53	64.15	30.44	47.45
7	raw	4.0	9.21	1:2.30	63.40	30.72	48.45
8	raw	3.6	8.98	1:2.49	64.09	31.72	49.49
9	past.	4.0	8.89	1:2.22	62.86	31.25	49.71
10	past.	3.8	8.77	1:2.31	62.85	32.57	51.82
				Partially skimmed milk			
5	raw	2.55	9.00	1:3.53	63.71	24.13	37.87
6	raw	2.70	8.80	1:3.26	62.08	26.81	43.19
7	raw	3.0	9.14	1:3.04	62.85	25.96	41.30
8	raw	2.9	9.04	1:3.12	64.15	27.47	42.82
9	past.	2.7	8.83	1:3.27	61.61	24.50	39.77
10	past.	2.5	8.89	1:3.56	62.79	25.05	39.89

TABLE 17. (Continued)

Trial No.	Milk used	%Composition of milk			%Composition of cheese, 3 mo.		
		fat	solids not fat	ratio of fat to s.n.f.	total solids	fat in cheese	fat dry basis
		Partially skimmed milk					
37	past.	3.0	8.76	1:2.92	59.46	27.19	45.73
	past. treated	3.0	8.76	1:2.92	61.73	27.55	44.63
38	past.	2.0	8.99	1:4.50	55.90	19.14	34.24
	past. treated	2.0	8.99	1:4.50	58.04	20.85	35.92
39	past.	2.7	8.93	1:3.31	62.63	28.10	44.87
	past. treated	2.7	8.93	1:3.31	62.89	27.86	44.30

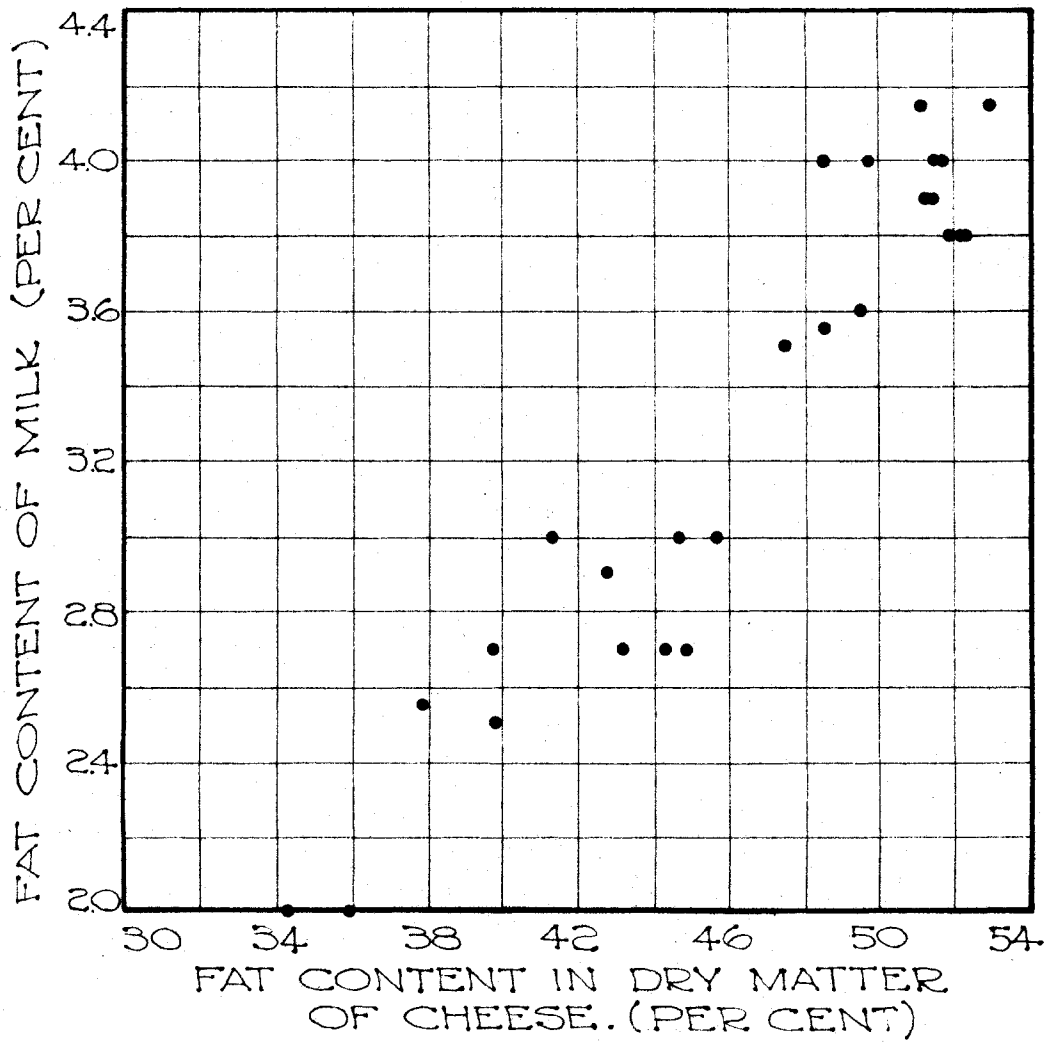


FIG. 1. RELATIONSHIP OF FAT CONTENT OF MILK TO FAT IN DRY MATTER OF CHEESE

Relationship of body and texture to composition of the cheese.

Commonly, whole milk and partially skimmed milk cheese, made with the same general methods and cured under the same conditions, differ considerably in character, with the cheese from partially skimmed milk tending to be quite firm and brittle. It was found that, in general, curd from partially skimmed milk had to be cooked at temperatures 2 to 4 degrees lower and for shorter periods of time than that from whole milk in order to obtain a desirable body. Commonly, cheese from partially skimmed milk has a lower total solids content and a lower percentage of fat on the dry basis than that from whole milk.

In order to compare the composition of cheese with the body and texture criticisms, data (many of which already have been presented) were compiled on the basis of whole milk cheese and partially skimmed milk cheese (table 18). The cheese of trials 37 to 68, inclusive, were paraffined at one week or less after salting, while the others were paraffined at about 2 months.

Whole milk cheese showed a desirable body and texture in trials 5 and 7 and the total solids contents were 64.85 and 63.40 per cent, respectively, while the fat contents on the dry basis were 48.42 and 48.45 per cent, respectively. In trials 2, 3 and 4, the body and texture were not criticized; the total solids contents were 65.74, 66.48 and 66.54 per cent, respectively, and the fat contents on the dry basis were relatively high. Most of the cheese criticized as pasty or soft had high moisture contents; in trial 1 it did not and the pasty body probably was due to a high fat content on the dry basis.

TABLE 18. RELATIONSHIP OF BODY AND TEXTURE TO COMPOSITION OF CHEESE

Trial No.	% Total solids	% Fat dry basis	Criticisms body and texture, 3 mo.
		Whole milk cheese	
1	64.60	52.09	pasty
2	65.74	51.10	none
3	66.48	52.89	none
4	66.54	51.77	none
5	64.85	48.42	desirable
6	64.15	47.45	soft
7	63.40	48.45	desirable
8	64.09	49.49	pasty
9	62.86	49.71	soft
10	62.85	51.82	sl. pasty
		Partially skimmed milk cheese	
5	63.71	37.87	sl. firm
6	62.08	43.19	none
7	62.85	41.30	v. desirable
8	64.15	42.82	desirable
9	61.61	39.76	desirable
10	62.79	39.89	v. desirable
37	59.46	45.73	pasty
38	55.90	34.24	sl. weak
39	62.63	44.86	desirable
59-1	55.30	36.16	excellent

TABLE 18. (Continued)

Trial No.	% Total solids	% Fat dry basis	Criticisms body and texture, 3 mo.
		Partially skimmed milk cheese	
59-2	56.02	34.13	v. desirable
59-3	54.86	33.48	desirable, sl. dry
59-4	53.82	32.05	desirable
60-1	56.66	44.77	desirable, sl. soft
60-2	58.51	47.20	desirable, sl. soft
60-3	58.97	46.41	desirable, sl. soft
60-4	57.02	47.77	desirable, sl. soft
56-1	56.90		desirable
56-3	56.95		soft
65-1	58.68		sl. dry
65-2	59.63		sl. dry
65-3	58.27		sl. dry
65-4	58.19		sl. dry
66-1	58.56		dry, firm
66-2	58.52		dry, firm
66-3	58.38		dry, firm
66-4	59.37		dry, firm
68-1	57.68		sl. firm, dry
68-2	57.52		sl. firm, dry
68-3	58.22		sl. firm, dry
68-4	57.62		sl. firm, dry

Partially skimmed milk cheese showed a desirable body and texture in trials 7, 8, 9, 10, 39, 59-1, 59-2 and 59-4. The total solids contents were 62.85, 64.15, 61.61, 62.79, 62.63, 55.30, 56.02 and 53.82 per cent, respectively; in general, the fat contents on the dry basis were high or low in agreement with the total solids values. The results suggest that a desirable body and texture are largely dependent on the ratio of total solids and fat. Various lots of cheese from trials 66 to 68 were criticized as slightly firm, firm or dry, with total solids contents from 57.52 to 59.37 per cent. The fat contents on these cheese were not available but presumably they were low because of the low fat contents of the milk used; the milk employed in trial 66 had 2.4 per cent fat and that used in trial 68 had 2.2 per cent.

In general, it appears that the occurrence of a weak, soft or pasty body can be corrected by decreasing either the moisture content or fat content on the dry basis, and the occurrence of a dry or firm body can be corrected by increasing either the moisture content or the fat on the dry basis.

Composition of exterior and interior of the cheese.

Cheese that were not paraffined early showed considerable drying at the surface, with apparent differences in flavor and in body and texture between the exterior and the interior. The loss of moisture probably contributed to the differences. In 2 trials both raw and pasteurized milk cheese that had been paraffined at about 2 months were analyzed at 3 months to determine the effect of surface drying on the composition. With each cheese a slice was taken through the center of the cheese and the rind was removed. The slice was then cut equidistant from the center and the edge to obtain the exterior and interior portions. Total solids, fat and salt contents were determined.

The exterior portion of each cheese was considerably higher in both total solids and fat than the interior portion (table 19). However, the exterior portion showed a lower percentage of salt in the cheese and also on the dry basis. The differences in salt contents presumably were due to differences in moisture distribution as a result of the drying at the surface of the cheese. Although the salt content was lower in the exterior portion than in the interior portion, the salt content in the moisture of the exterior portion was higher in each case.

TABLE 19. COMPOSITION OF EXTERIOR AND INTERIOR OF CHEESE

Cheese paraffined at about 2 months

Trial No.	Milk used	% Total solids	% fat	%Fat dry basis	% salt	%Salt dry basis	%Salt in moisture
			Exterior				
3	raw	60.07	35.72	51.72	2.69	3.89	8.70
	past.	67.69	34.57	51.07	2.59	3.83	8.01
4	raw	69.53			1.99	2.86	6.52
	past.	68.28			2.28	3.34	7.18
			Interior				
3	raw	64.40	33.60	52.17	2.94	4.57	8.25
	past.	62.28	31.67	50.85	2.84	4.56	7.50
4	raw	63.00			2.20	3.49	5.94
	past.	62.37			2.54	4.07	6.75

Changes in weight of cheese during salting and curing.

Cheese that are not paraffined until late in curing undergo such losses of moisture that undesirable, thick, hard rinds are formed. The losses of moisture result in cheese that vary in composition from the surface to the interior; moreover, they reduce the yield of cheese.

Observations were made on the weight losses of cheese during salting and also during curing for various periods. Weight losses were compared when cheese were paraffined at 2 weeks and at 4 weeks; unparaffined cheese were included as controls.

The losses in weight during salting for 48 hours in 24 per cent brine (tables 20 and 22) ranged from 4.23 to 6.07 per cent for small cheese (under 1000 gm.) and from 2.99 to 4.62 per cent for large cheese (over 1000 gm.). During salting for 36 hours in 24 per cent brine, the losses ranged from 2.72 to 4.88 per cent for small cheese and from 2.33 to 4.12 per cent for large cheese. With small cheese the losses in weight during salting for 24 hours in 24 per cent brine (table 21) varied from 3.80 to 5.00 per cent; while during salting for 24 hours in 12 per cent brine the losses ranged from 1.06 to 1.35 per cent.

After salting 48 hours in 24 per cent brine and curing 6 weeks at 55° F., the total losses in weight of small cheese paraffined at 2 weeks varied from 9.36 to 11.05 per cent, with those paraffined at 4 weeks the losses varied from 13.41 to 14.32 per cent, and without paraffining the losses ranged from 16.92 to 19.03 per cent. Large cheese paraffined at 2 weeks showed total losses in weight from 7.42 to 10.09 per cent, those

TABLE 20. CHANGES IN WEIGHT OF CHEESE DURING SALTING AND CURING

Cheese paraffined at 2 weeks, 4 weeks and unparaffined

Cheese salted 48 hours in 24 per cent brine

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	loss in wt. %	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
raw whole milk trial 29	841.0	803.8	37.2	4.42	767.9 *775.9	35.9	772.0	1.9	768.3	3.7	78.7	9.36
	797.4	762.1	35.3	4.43	726.2	35.9	687.2 *693.8	39.0	693.2	0.6	110.8	13.90
	770.0	737.1	32.9	4.27	699.3	37.8	663.6	35.7	639.7	23.9	130.3	16.92
past. whole milk trial 29	802.1	766.2	35.9	4.48	732.1 *737.8	34.1	731.9	5.9	725.2	6.7	82.6	10.30
	823.8	785.6	38.2	4.64	754.9	30.7	706.2 *712.4	48.7	712.0	0.4	118.0	14.32
	899.2	861.2	38.0	4.23	824.7	36.5	776.1	48.6	745.1	31.0	154.1	17.14
raw whole milk trial 29	1613.6	1557.8	55.8	3.46	1498.8 *1512.6	59.0	1511.2	1.4	1507.7	3.5	119.7	7.42
	1368.1	1317.6	50.5	3.69	1264.8	52.8	1207.9 *1219.8	56.9	1218.8	1.0	161.2	11.78
	1023.6	984.3	39.3	3.84	942.8	41.5	895.1	47.7	862.2	32.9	161.4	15.77
past. whole milk trial 29	1046.0	1003.6	42.4	4.05	960.6 *967.0	43.0	962.3	4.7	955.3	7.0	97.1	9.28
	1125.8	1080.8	45.0	4.00	1034.8	46.0	980.6 *989.1	54.2	988.3	0.8	146.0	12.97
	1087.1	1043.9	43.2	3.97	993.7	50.2	942.2	51.5	908.9	33.3	178.2	16.39

* weight after paraffining

TABLE 20. (Continued)

Cheese salted 48 hours in 24 per cent brine

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	%	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
past. part skim	509.4	478.4	31.0	6.07	459.2 *465.6	19.2	464.9	0.7	459.5	5.4	56.3	11.05
and mammary	602.6	569.9	32.7	5.43	545.1	24.8	522.8 *528.2	22.3	527.1	1.1	80.9	13.43
extract trial 30	543.9	512.1	31.8	5.84	490.6	21.5	469.1	21.5	440.4	28.7	103.5	19.03
past. part skim	825.2	784.0	41.2	4.99	743.2 *751.2	40.8	750.2	1.0	744.9	5.3	88.3	10.70
and mammary	925.6	878.9	46.7	5.05	830.4	48.5	803.5 *811.2	26.9	809.2	2.0	124.1	13.41
extract trial 30	1228.1	1174.7	53.4	4.35	1126.4	48.3	1078.0	48.4	1026.2	51.8	201.9	16.44
past. part skim	655.1	620.2	34.9	5.33	593.6 *599.7	26.6	599.1	0.6	594.9	4.2	66.3	10.12
	590.4	556.6	33.8	5.72	533.4	23.2	508.4 *513.7	25.0	512.6	1.1	83.1	14.08
trial 30	1210.1	1154.2	55.9	4.62	1111.2	43.0	1069.2	42.0	1010.4	58.8	199.7	16.50
past. part skim	1136.4	1085.7	50.7	4.46	1030.0 *1039.1	55.7	1038.5	0.6	1030.8	7.7	114.7	10.09
	1315.1	1258.9	56.2	4.27	1212.4	46.5	1169.7 *1180.9	42.7	1178.9	2.0	147.4	11.21
trial 30	1218.6	1167.0	51.6	4.23	1121.9	45.1	1080.6	41.3	1022.9	57.7	195.7	16.06

TABLE 20. (Continued)

Cheese salted 36 hours in 24 per cent brine

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	loss in wt. %	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
past.	685.3	653.3	32.0	4.67	609.5	43.8	616.2	0.9	614.6	1.6	78.3	11.43
part skim	687.6	645.5	33.1	4.88	*617.1 602.4	43.1	573.5	28.9	580.3	0.5	105.6	15.56
							*580.8					
trial 31	1063.8	1020.3	43.5	4.07	958.2	62.1	914.2	44.0	877.9	36.3	185.9	17.48
past.	984.1	945.7	38.4	3.90	891.5	54.2	901.6	0.9	901.1	0.5	94.0	9.55
part skim	1015.8	973.9	41.9	4.12	*902.5 922.0	51.9	877.6	44.4	887.1	0.1	138.3	13.61
							*887.2					
trial 31	993.8	952.8	41.0	4.13	903.2	49.6	860.6	42.6	826.1	34.5	167.7	16.87
past. part skim	570.2	543.1	27.1	4.75	511.0	32.1	516.7	0.7	515.4	1.3	61.2	10.73
and	620.8	593.4	27.4	4.41	*517.4 556.0	37.4	531.2	24.8	537.2	+0.3	89.6	14.43
mammary							*536.9					
extract	623.6	594.5	29.1	4.67	558.2	36.3	531.9	26.3	513.0	18.9	110.6	17.74
trial 31												
past. part skim	1293.5	1248.1	45.4	3.51	1186.2	61.9	1199.9	1.3	1198.6	1.3	109.9	8.50
and	1241.8	1199.2	42.6	3.43	*1201.2 1139.2	60.0	1092.2	47.0	1105.1	0.3	149.9	12.07
mammary							*1105.4					
extract	1183.6	1140.2	43.4	3.67	1082.9	57.3	1038.2	44.7	999.4	38.8	184.2	15.56
trial 31												

TABLE 20. (Continued)

Cheese salted 36 hours in 24 per cent brine

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	loss in wt. %	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
past. part skim	717.5	695.4	22.1	3.08	648.9 *656.4	46.5	656.1	0.3	655.1	1.0	69.9	9.74
and mammary	771.0	747.5	23.5	3.05	698.6	48.9	680.2 *688.3	18.4	687.1	1.2	92.0	11.93
extract trial 32	728.6	706.4	22.2	3.05	658.1	48.3	640.4	17.7	611.4	29.0	117.2	16.09
past. part skim	1265.0	1235.3	29.7	2.35	1164.6 *1177.9	70.7	1177.6	0.3	1176.6	1.0	101.7	8.04
and mammary	1288.3	1257.9	30.4	2.36	1191.8	66.1	1164.2 *1178.9	27.6	1177.4	1.5	125.6	9.75
extract trial 32	1263.9	1232.7	31.2	2.47	1167.4	65.3	1139.6	27.8	1087.6	52.0	176.3	13.95
past. part	763.6	741.1	22.5	2.95	690.4 *696.8	50.7	696.7	0.1	695.4	1.3	74.6	9.77
skim	765.4	743.9	22.0	2.87	693.8	50.1	673.5 *681.6	20.3	681.2	0.4	92.8	12.12
trial 32	628.2	611.1	17.1	2.72	566.3	44.8	549.6	16.7	523.8	25.8	104.4	16.62
past. part	1321.5	1290.7	30.8	2.33	1218.4 *1231.0	72.3	1230.4	0.6	1229.4	1.0	104.7	7.92
skim	1273.6	1243.4	30.2	2.37	1171.9	71.5	1144.4 *1160.2	27.5	1158.9	1.3	130.5	10.25
trial 32	1229.1	1199.8	29.3	2.38	1130.1	69.7	1102.3	27.8	1058.1	44.2	171.0	13.91

TABLE 20. (Continued)

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	%	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
Cheese salted 24 hours in 24 per cent brine												
past. part skim	772.8	742.0	30.8	3.99			667.0 *679.2	75.0	679.1	0.1	105.9	13.70
trial 35	812.3	781.4	30.9	3.80			701.7 *716.6	79.7	716.3	0.3	110.9	13.65
	776.3	746.1	30.2	3.89			670.9	75.2	637.1	33.8	139.2	17.93
past. part skim and mammary extract trial 35	762.8	731.9	30.9	4.05			656.6 *667.4	75.3	667.1	0.3	106.5	13.96
	773.2	742.2	31.0	4.01			666.2 *677.6	76.0	677.0	0.6	107.6	13.92
	680.4	653.9	26.5	3.89			584.6	69.3	554.5	30.1	125.9	18.50
Cheese salted 48 hours in 24 per cent brine												
past. part skim	1825.9	1754.4	71.4	3.91			1631.8 *1644.7	122.6	1641.6	3.1	197.1	10.79
trial 35	1702.8	1635.2	67.6	3.97			1518.6 *1530.8	116.6	1528.4	2.4	186.6	10.96
	1718.3	1647.1	71.2	4.14			1527.1	120.0	1457.3	69.8	261.0	15.19
past. part skim and mammary extract trial 35	1721.9	1654.4	67.5	3.92			1536.9 *1548.2	117.5	1545.8	2.4	187.4	10.88
	1846.8	1773.9	72.9	3.95			1650.8 *1666.4	123.1	1664.6	1.8	197.8	10.71
	1752.4	1683.7	68.7	3.92			1562.4	121.3	1494.6	67.8	257.8	14.71

TABLE 20. (Continued)

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	%	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
Cheese salted 24 hours in 24 per cent brine												
past. part skim	676.6	642.8	33.8	5.00	598.4 *603.9	44.4	603.8	0.1	601.4	2.4	80.7	11.93
and mammary extract trial 36	784.1	747.9	36.2	4.62	696.8	41.1	679.3 *687.4	17.5	687.4		94.8	12.09
	711.6	680.4	31.2	4.38	633.1	47.3	614.9	18.2	584.1	30.8	127.5	17.92
past. part skim	674.6	644.2	30.4	4.51	597.9 *605.2	46.3	605.1	0.1	604.2	0.9	77.7	11.52
and mammary extract trial 36	720.8	689.2	31.6	4.38	643.1	46.1	626.3 *634.2	16.8	633.9	0.3	94.8	13.15
	658.2	627.9	30.3	4.60	586.5	41.4	570.5	16.0	542.6	27.9	115.6	17.56
Cheese salted 60 hours in 24 per cent brine												
past. part skim	1108.6	1043.1	65.5	5.91	990.1 *1001.3	53.0	1001.2	0.1	999.9	1.3	119.9	10.82
and mammary extract trial 35	1199.4	1131.2	68.2	5.69	1076.8	54.4	1047.7 *1060.1	29.1	1059.7	0.4	152.1	12.68
	1396.1	1322.4	73.7	5.28	1259.3	63.1	1228.5	30.8	1178.3	50.2	217.8	15.60
past. part skim	1338.8	1272.4	66.4	4.96	1212.9 *1228.9	59.5	1228.8	0.1	1227.9	0.9	126.9	9.48
and mammary extract trial 36	1440.0	1369.4	70.6	4.90	1302.6	66.8	1275.1 *1293.1	27.5	1292.6	0.5	165.4	11.49
	1375.8	1306.8	69.0	5.02	1242.7	64.1	1216.6	26.1	1169.8	46.8	206.0	14.97

TABLE 20. (Continued)

Cheese	Into brine	After salting			After 2 wk.		After 4 wk.		After 6 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	%	wt. gm.	loss in wt.	wt. gm.	loss in wt.	wt. gm.	loss in wt.	gm.	%
Cheese salted 40 hours in 24 per cent brine												
past.	798.9	768.6	30.3	3.79	727.3	41.3	736.9		736.2	0.7	72.3	9.05
part skim	759.1	729.2	29.9	3.94	*736.9 695.5	33.7	677.7	17.8	690.4	0.3	81.7	10.76
							*690.7					
trial 39	747.3	719.4	27.9	3.73	686.9	32.5	666.7	20.2	631.2	35.5	116.1	15.54
past.	731.2	704.1	27.1	3.71	665.7	38.4	673.7	0.1	673.4	0.3	65.9	9.01
part skim and	756.3	730.5	25.8	3.41	*673.8 693.0	37.5	675.8	17.2	687.6	1.2	81.7	10.80
mammary							*688.8					
extract trial 39	806.7	775.9	30.8	3.82	739.9	36.0	716.4	23.5	681.9	34.5	124.8	15.47
Cheese salted 48 hours in 24 per cent brine												
past.	1367.8	1323.8	44.0	3.22	1265.2	58.6	1285.1	+0.2	1284.7	0.4	102.8	7.52
part skim	1375.2	1334.1	41.1	2.99	*1284.9 1281.4	52.7	1238.3	43.1	1257.2	0.9	137.8	10.02
							*1258.1					
trial 39	1565.1	1516.3	48.8	3.12	1449.9	66.4	1407.6	42.3	1355.9	51.7	209.2	13.37
past.	1299.9	1259.1	40.8	3.14	1205.4	53.7	1217.4	0.4	1217.1	0.3	95.2	7.32
part skim and	1388.8	1344.9	43.9	3.16	*1217.8 1293.8	51.1	1249.4	44.4	1268.8	0.6	140.0	10.08
mammary							*1269.4					
extract trial 39	1565.4	1515.5	49.9	3.19	1450.6	64.9	1406.1	44.5	1357.9	48.2	207.5	13.26

TABLE 21. CHANGES IN WEIGHT OF CHEESE DURING SALTING AND CURING

Cheese paraffined immediately after salting

Cheese salted 24 hours in 12 per cent brine

Cheese	Into brine	After salting			After	After 4 wk.		Total loss	
	wt. gm.	wt. gm.	loss in wt. gm.	loss in wt. %	paraf-fining	wt. gm.	loss in wt.	gm.	%
past. part skim milk	670.1	661.6	8.5	1.27	672.8	670.6	2.2	10.7	1.60
trial 43	640.4	632.4	8.0	1.25	644.4	642.6	1.8	9.8	1.53
	642.2	633.7	8.5	1.32	643.2	638.9	4.3	12.8	1.99
past. part skim milk and mammary extract	653.9	645.6	8.3	1.27	655.7	653.0	2.7	11.0	1.68
trial 43	657.1	648.2	8.9	1.35	657.6	652.9	4.7	13.6	2.07
	716.2	708.6	7.6	1.06	720.1	717.2	2.9	10.5	1.47

TABLE 22. CHANGES IN WEIGHT OF CHEESE DURING SALTING

Trial No.	Into brine wt. gm.	After salting wt. gm.	Loss in wt. gm.	Loss in wt. %
Cheese salted 24 hours in 24 per cent brine				
51-1	1608.1	1559.9	48.2	3.00
2	1498.9	1458.0	40.9	2.73
3	1458.0	1417.6	40.4	2.77
4	1534.0	1491.4	42.6	2.78
5	1692.2	1613.1	79.1	4.67
6	1553.5	1513.1	40.4	2.60
53-1	1005.6	968.1	37.5	3.73
2	1176.7	1131.4	45.3	3.85
3	1377.8	1324.8	50.0	3.63
4	1167.6	1127.8	39.8	3.41
5	1363.8	1318.2	45.6	3.34
6	1459.4	1406.5	52.9	3.62
Cheese salted 48 hours in 24 per cent brine				
59-1	1306.0	1251.0	55.0	4.21
2	1427.6	1371.0	56.6	3.96
3	1316.6	1263.7	52.9	4.02
4	1378.4	1319.8	58.6	4.25
5	1252.3	1197.2	55.1	4.40
6	1206.0	1153.0	53.0	4.39
7	1131.4	1081.2	50.2	4.44
8	1479.8	1420.3	59.5	4.02

paraffined at 4 weeks showed losses from 10.02 to 12.97 per cent, while unparaffined cheese showed losses from 13.26 to 16.50 per cent.

After salting 36 hours in 24 per cent brine and curing 6 weeks at 55° F., small cheese that were paraffined at 2 weeks showed total weight losses from 9.55 to 11.43 per cent, those paraffined at 4 weeks showed losses from 11.93 to 15.56 per cent, while the unparaffined cheese showed losses from 16.09 to 17.74 per cent. Large cheese paraffined at 2 weeks showed total losses in weight from 7.92 to 8.50 per cent, those paraffined at 4 weeks showed losses from 9.75 to 13.61 per cent, and the unparaffined cheese showed losses from 13.91 to 17.48 per cent.

Cheese manufactured from fat enriched milk.

Cheese made from pasteurized, fat enriched milk, without and with an extract of frozen mammary tissue added to the milk, were compared in 2 trials. In each trial the milk was ripened to titratable acidities of 0.165 per cent, and the acidities of the whey after the curd was cut were 0.10 per cent. The fat contents of the milk used were 5.5 and 6.0 per cent. Extract of frozen mammary tissue was added to the milk in quantities of 15 and 25 ml. per 100 pounds. The salted cheese were paraffined as soon as sufficiently dry and were cured at 55° F. The cheese were criticized at 3 months and again at 6 months. Total solids, fat and salt contents were not determined.

After curing 3 months the cheese had considerably more flavor in both trials than the cheese from untreated milk. Cheese from both untreated and treated milk were slightly bitter; the body was very soft and buttery and no eyes were formed.

After curing 6 months the cheese made from milk treated with extract of mammary tissue had an excellent flavor and they were much more desirable than the controls. The cheese made from untreated milk lacked flavor and were slightly bitter.

After curing 3 months the pH value of the cheese made from treated milk was 5.36 in one trial and 5.62 in the other; the pH values of the control cheese were 5.42 and 5.50. After curing 6 months the differences in the acid numbers on the fat were negligible; in one trial the value obtained for cheese from treated milk was 4.08 (control 4.42), while in the other it was 3.35 (control 3.40).

Cheese cured in oil.

In 2 trials both raw and pasteurized, whole milk cheese were ripened in mineral oil at 55° F. for 8 months. During the entire period the cheese were submerged in oil.

Oil penetrated the cheese and was very evident at more than one-quarter inch from the surface of the cheese. The body of the cheese was very soft in all cases and very large eyes regularly were present. Some of the eyes were more than 1 inch in diameter. In both trials the cheese manufactured from raw milk had an excellent delicate flavor that was much more desirable than the flavor of corresponding cheese made from pasteurized milk. Both the raw and pasteurized milk cheese were very sweet, and there was no undesirable flavor.

At 8 months the pH values of the raw milk cheese were 5.98 and 5.90, while those of the corresponding pasteurized milk cheese were 5.95 and

5.73. Acid numbers on the fat were 6.50 and 6.17 for the cheese made from raw milk and 3.35 and 4.70 for corresponding cheese made from pasteurized milk.

Gassy cheese.

Occasionally, edam cheese develop defects which are referred to as gassy. They usually are attributed to organisms of the Escherichia-Aerobacter group which have gained entrance to the milk or curd in sufficient numbers to produce considerable quantities of gas under favorable growth conditions. The gassy defect caused by Escherichia-Aerobacter organisms is not only objectionable because of injury to body and texture but also because a very undesirable unclean flavor may be produced. The growth of the organisms may be so rapid that the damage to the body and texture of the cheese has been done before the cheese are placed in the brine.

The cheese of trial 35 were examined after curing 3 months at 55° F., and the gassy defect was very conspicuous. Samples of the cheese were taken aseptically near the rind and also from the interior. One gm. portions were weighed aseptically on sterile paper and macerated in sterile mortars, using sterile 2 per cent sodium citrate solution for emulsification. Dilutions from 1:10 to 1:1,000,000 were prepared for plating with eosin-methylene-blue agar to obtain total counts and for inoculation with fermentation tubes of lactose broth; dilutions of 1:100, 1:1,000 and 1:10,000 also were smeared on poured plates of eosin-methylene-blue agar.

After incubating 24 hours at 37° C. the fermentation tubes showed gas formation in dilutions as high as 1:100,000 with cheese from near the rind and in dilutions as high as 1:1,000,000 with cheese from the interior.

Both Escherichia and Aerobacter organisms were found on the eosin-methylene-blue agar plates. Average total counts of Escherichia-Aerobacter organisms on eosin-methylene-blue agar were 290,000 per gram for cheese from near the rind and 1,425,000 per gram for cheese from the interior. Typical colonies of Escherichia-Aerobacter organisms also were found on plates of eosin-methylene-blue agar smeared with dilutions of the cheese.

The very gassy condition of the cheese in trial 35 is shown in Fig. 2. The numerous, small, ragged holes are typical of the action of Escherichia-Aerobacter organisms. One of the cheese illustrated was paraffined as soon as sufficiently dry and shows very little rind, while the other was not paraffined until after 1 month and considerable rind is evident.

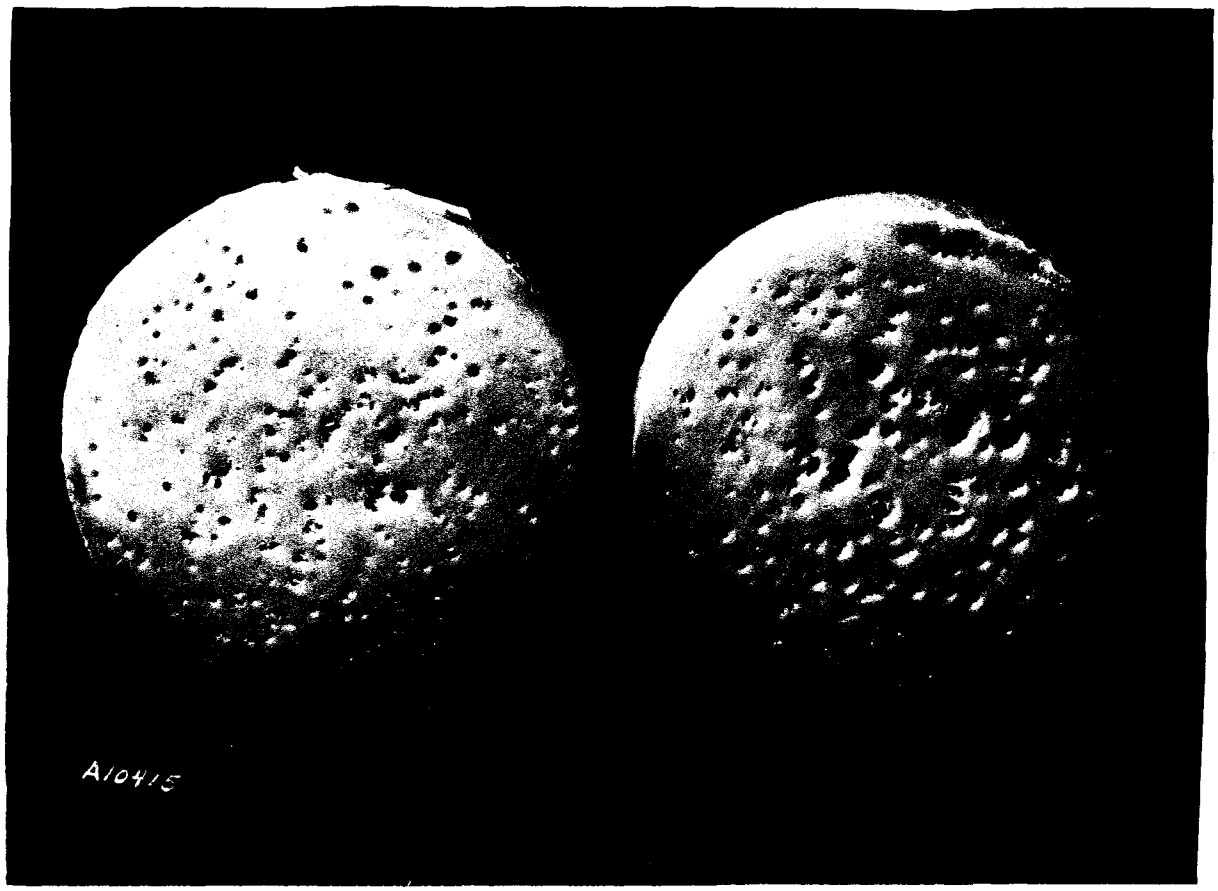


FIG. 2. GASSY CHEESE DUE TO ESCHERICHIA-AEROBACTER ORGANISMS

The cheese on the left was paraffined early and shows little rind; the one on the right was paraffined at about one month and shows considerable rind.

DISCUSSION

The greater flavor development in edam cheese manufactured from raw milk than in corresponding cheese from pasteurized milk is in agreement with the relationship found in cheddar cheese. Also, the higher acid numbers on the fat of raw milk edam cheese than on the fat of corresponding pasteurized milk cheese agree with investigations on cheddar cheese. Lane and Hammer (46) stated that the relatively rapid hydrolysis of the fat of raw milk cheddar cheese during the ripening, when compared to the fat of pasteurized milk cheese, shows that there is a difference in the factor or factors which influence the hydrolysis. Apparently, the agents which contribute to the fat hydrolysis are partially destroyed by pasteurization of the milk. Lane (47) demonstrated that cheddar cheese made from 90 per cent pasteurized milk and 10 per cent raw milk was similar in flavor to cheese made from raw milk.

Cheese manufactured from raw, partially skimmed milk and from raw, whole milk showed relatively high acid numbers on the fats compared to the values for pasteurized, partially skimmed milk cheese or pasteurized, whole milk cheese. The raw, partially skimmed milk cheese showed higher acid numbers on the fat than corresponding whole milk cheese, which is the reverse of what might be expected. However, if the amount of fat hydrolyzed is the same in the two types of cheese, the fatty acids liberated in the partially skimmed milk cheese would be contained in the smaller volume of fat, and the acid number on the fat would be higher.

The enzymes normally present in milk as well as the bacterial flora have been considered important contributors to flavor development in various cheeses. Babcock and Russell (2) suggested, in 1897, that the ripening of hard cheese was due to the joint action of enzymes and bacteria. Lipase, the enzyme capable of hydrolyzing fat, has been considered an important ripening agent with certain cheeses, and its presence in milk has been demonstrated by Palmer (52), Rice and Markley (53), Sharp and deTomasi (58) and others. The relationship of fat hydrolysis to the ripening of cheddar cheese was studied by Lane and Hammer (49). They found that addition of desiccated mammary tissue, or an extract of it, to pasteurized milk commonly had a desirable effect on the flavor of the cheese, and also increased the fat acidity. As in the case of cheddar cheese, edam cheese made from pasteurized, whole milk treated with an extract of desiccated mammary tissue tended to have more flavor than cheese made from untreated milk. Cheese made from pasteurized, partially skimmed milk treated with an extract of desiccated mammary tissue also tended to have more flavor. The fact that the fat in cheese made from treated milk showed higher acidities than the fat in cheese from untreated milk suggests that the increased fat hydrolysis is related to the flavor development. Retarded fat hydrolysis in cheese made from pasteurized milk without added extract probably was due to destruction of the lipase in the milk.

An extract of frozen mammary tissue was used in the studies in order to compare its effectiveness with an extract of desiccated mammary tissue. It was considered that an extract of frozen tissue might be more active

in the cheese than an extract of desiccated tissue. Although the extracts of frozen mammary tissue tended to have beneficial effects on the flavor, an unclean flavor frequently was found in the cheese made with them. Unclean flavors were noted only occasionally after the first 3 months of curing but were present in most cases after curing an additional 3 months. Micro-organisms or proteolytic enzymes in the extract may have been responsible for the unclean flavors.

Extracts of frozen chicken pancreas were both proteolytic and lipolytic and the flavors produced in the cheese by them commonly were bitter or rancid. In cases where the extracts were added to the curd the fat acidities were increased markedly and the rancid flavor was especially noticeable. The fact that the rancidity sometimes suggested fatty acids higher than butyric acid indicates that lipase activities probably differ considerably. When oat flour was employed in the manufacture of cheese, bitter flavors also were developed. In most cases the cheese made with oat flour showed higher fat acidities than corresponding control cheese; this suggests that oat flour also possesses lipolytic properties.

Certain cultures of bacteria show proteolytic properties and have been considered influential in flavor development in cheese. The unclean flavor resulting from addition of the unidentified Micrococcus probably was due to proteolytic action. The desirable effect obtained in some instances with Ps. putrefaciens, even when the organism could not be recovered from the cheese, suggests that enzymes produced by the organism may have been active in the cheese.

A desirable flavor was obtained in small cheese as well as in large cheese and this indicates that the reduced size of the cheese did not interfere with the flavor development. Early paraffining of the cheese prevented the injurious effects of drying.

The use of fat enriched milk resulted in the desirable flavors being especially prominent, which in itself suggests that much of the flavor in edam cheese is carried by the fat. The body and texture of such cheese was very desirable for some consumers. However, the increased sale price necessary because of the higher fat content would limit the demand for the cheese.

Cheese cured in mineral oil had a very soft body. The formation of extremely large eyes probably was due to the plasticity of the cheese and confinement of the developed gas.

CONCLUSIONS

1. Raw milk cheese commonly developed more flavor than corresponding pasteurized milk cheese cured under the same conditions. More eyes were formed in the raw milk cheese. Acid numbers on the fat of the raw milk cheese were distinctly higher.
2. Raw, partially skimmed milk cheese developed as much flavor as corresponding raw, whole milk cheese cured under the same conditions. Commonly, the eyes in the former cheese were either more numerous or larger than in the latter cheese. Acid numbers on the fat were higher with the former cheese.
3. Pasteurized, partially skimmed milk cheese and corresponding pasteurized, whole milk cheese cured under the same conditions were equally lacking in flavor.
4. Cheese manufactured from pasteurized, whole milk and pasteurized, partially skimmed milk treated with an extract of desiccated mammary tissue tended to develop more desirable flavor than pasteurized, whole milk cheese made without the extract. Usually the flavor depreciated during the second 3 months of curing, and then there was less difference in flavor between the two types of cheese. The improvement in flavor of the cheese manufactured from treated milk was more noticeable at 55° F. than at 50° F. In most cases the acid numbers on the fat of cheese from treated milk were slightly higher than those on the fat of cheese from untreated milk.

5. Cheese manufactured from pasteurized, partially skimmed milk treated with an extract of frozen mammary tissue tended to develop more flavor than cheese made from untreated milk. Some of the cheese from treated milk showed a slight unclean flavor after 3 months, and in many instances distinct unclean flavors were present after 6 months. In general, acid numbers on the fat were slightly higher with cheese from treated milk, but the differences were small.
6. Cheese manufactured from pasteurized, partially skimmed milk treated with an extract of frozen chicken pancreas or with oat flour tended to develop bitter flavors.
7. Enzyme preparations added to curd did not diffuse to any extent and acted primarily in areas immediately adjacent to the points of addition. At the points of addition the effects of various enzymes were much the same as the effects when the enzymes were added to the milk.
8. A Micrococcus culture added to pasteurized, partially skimmed milk tended to produce an unclean flavor in the cheese; when examined after curing 6 to 16 weeks, only small numbers of the Micrococcus were found in the cheese. Use of Ps. putrefaciens tended to give a more desirable flavor, although a slight bitterness was sometimes encountered; when examined after curing 4 to 14 weeks, the organism was not recovered from the cheese.
9. In some cases at 3 months, small cheese (about 600 to 800 grams) showed slightly more flavor development than corresponding large cheese (about 1200 to 1800 grams), but in most instances at 6 months the

flavor criticisms were identical. There was a tendency for eye formation to be less extensive in the small cheese.

10. Whole milk cheese cured at 55° F. contained from 47.45 to 52.89 per cent fat on the dry basis, while partially skimmed milk cheese had from 34.24 to 45.73 per cent.

11. The relationships between body and texture and composition of cheese suggest that a weak, soft or pasty body can be corrected by decreasing either the moisture content or the fat content on the dry basis, while a dry or firm body can be corrected by increasing either the moisture content or the fat content on the dry basis.

12. In cheese that were paraffined late, the exterior portion of the cheese was considerably higher in both total solids and fat than the interior portion but showed a lower percentage of salt in the cheese and also on the dry basis.

13. Some lots of cheese made from fat enriched milk had an unusually fine flavor.

14. Cheese cured in mineral oil were penetrated by the oil. With the few cheese cured in oil, the body was very soft and large eyes developed.

15. Gassy cheese obtained in one of the trials contained relatively large numbers of Escherichia-Aerobacter organisms.

LITERATURE CITED

1. Association of Official Agricultural Chemists
   1935. Methods of analysis. Fourth edition.
   p. 291. Washington, D. C.

2. Babcock, S. M. and Russell, H. L.
   1897. Unorganized ferments of milk; a new factor in the ripening of cheese. Wisc. Agr. Exp. Sta., Fourteenth Annual Report, p. 161-192.

3. Babcock, S. M. and Russell, H. L.
   1897. Influence of temperature on the ripening of cheese. Wisc. Agr. Exp. Sta., Fourteenth Annual Report, p. 194-210.

4. Babcock, S. M., Russell, H. L. and Vivian, Alfred
   1898. Properties of galactase: a digestive ferment of milk. Wisc. Agr. Exp. Sta., Fifteenth Annual Report, p. 77-86.

5. Babcock, S. M., Russell, H. L. and Vivian, Alfred
   1898. Distribution of galactase in cow's milk. Wisc. Agr. Exp. Sta., Fifteenth Annual Report, p. 87-92.

6. Babcock, S. M., Russell, H. L., Vivian, A. and Hastings, E. G.
   1899. The action of proteolytic ferments on milk with special reference to galactase the cheese ripening enzyme. Wisc. Agr. Exp. Sta., Sixteenth Annual Report, p. 157-174.

7. Babcock, S. M., Russell, H. L., Vivian, A. and Hastings, E. G.
   1901. Influence of sugar on the nature of the fermentations occurring in milk and cheese. Wisc. Agr. Exp. Sta., Eighteenth Annual Report, p. 162-176.

8. Babel, F. J. and Hammer, B. W.
   1939. Bacteriology of cheese. IV. Factors affecting the ripening of swiss-type cheese made from pasteurized milk. Iowa Agr. Exp. Sta., Res. Bul. 264.

9. Boekhout, F. W. J. and Ott de Vries, J. J.
   1899. Untersuchungen über den Reifungsprozess des Edamer Käses. Centbl. Bakt. u. Par., 2. Abt., 5, No. 9: 304-307.

10. Boekhout, F. W. J. and Ott de Vries, J. J.
    1905. De la maturation des fromages d'Edam. Revue Générale du Lait, 5: 59-64.

11. Boekhout, F. W. J. and Ott de Vries, J. J.
1906. De la maturation du fromage d'Edam.
Revue Générale du Lait, 6: 1-10.

12. Boekhout, F. W. J.
1907. Ueber die Reifung der Edamer Käse.
Milchzeitung, 36: 506-509.

13. Boekhout, F. W. J. and Ott de Vries, J. J.
1907. Sur la maturation du fromage d'Edam.
Revue Générale du Lait, 6: 248-254.

14. Boekhout, F. W. J. and Ott de Vries, J. J.
1909. Sur le fromage "court".
Revue Générale du Lait, 7: 418-423.

15. Boekhout, F. W. J. and Ott de Vries, J. J.
1910. Sur deux défauts du fromage d'Edam.
Revue Générale du Lait, 8: 347-356.

16. Boekhout, F. W. J. and Ott de Vries, J. J.
1913. De la structure de la pâte du fromage d'Edam.
Revue Générale du Lait, 9: 313-319.

17. Boekhout, F. W. J. and Ott de Vries, J. J.
1913. Sur le défaut "Knijpers" dans le fromage d'Edam.
Revue Générale du Lait, 9: 442-448.

18. Bradley, H. C.
1912. The problem of enzyme synthesis: 1. Lipase and fat of animal tissue. Jour. Biol. Chem., 13: 407-418.

19. Breazeale, D. F. and Bird, E. W.
1938. A study of methods for the determination of acidity in butter fat. Jour. Dairy Sci., 21: 335-344.

20. Bryant, H. W.
1937. The effect of Penicillium roqueforti on some lower fatty acids. Hammer Panegyric, Collegiate Press, Ames, Iowa, p. 119-122.

21. Collier, Peter (director of station; no author listed.)
1893. Experiments in the manufacture of cheese. Part 1. The manufacture of Edam cheese. N. Y. (Geneva) Agr. Exp. Sta., Bul. 56, p. 361-379.

22. Conn, H. W., Thom, Charles, Bosworth, A. W., Stocking, W. A. and Issajeff, T. W.
1905. The camembert type of cheese in the United States. U. S. D. A., Bureau An. Ind., Bul. 71, p. 7-29.

23. Coulter, S. T. and Combs, W. B.
1939. The use of steapsin in the manufacture of blue cheese. Jour. Dairy Sci., 22: 521-525.

24. Currie, J. N.
1914. Flavor of roquefort cheese.
Jour. Agr. Res., 2: 1-14.

25. Davies, W. L., Davis, J. G., Dearden, D. V. and Mattisch, A. T. R.
1934. Studies in cheddar cheese. III. The role of rennin, pepsin and lactobacilli. Jour. Dairy Res., 5: 144-152.

26. Decker, J. W.
1898. Investigations on the effect of salt (NaCl) on rennet action. Wisc. Agr. Exp. Sta., Fifteenth Annual Report, p. 37-41.

27. Doane, C. F. and Lawson, H. W.
1918. Varieties of cheese: description and analyses.
U. S. D. A., Bul. 608, p. 18; 65.

28. Dox, Arthur W.
1908. Proteolytic changes in the ripening of camembert cheese.
U. S. D. A., Bureau An. Ind., Bul. 109, p. 5-22.

29. Eugling-Weigmann
1923. Handbuch der praktischen Käserei. p. 333-342. dritte auflage. Berlin, Verlagsbuchhandlung Paul Parey.

30. Evans, Alice C., Hastings, E. G. and Hart, E. B.
1914. Bacteria concerned in the production of the characteristic flavor in cheese of the cheddar type. Jour. Agr. Res., 2: 167-192.

31. Freeman, T. R. and Dahle, C. D.
1938. Rate of ripening in cheddar cheese.
Pa. Agr. Exp. Sta., Bul. 362.

32. Funder, Ludvig
1919. De to Typer av Goudaost og Edamerost.
Maelkeritidende, 32: 607-613; 627-635.

33. Gorini, Constantin
1910. Recherches sur les coccus producteurs d'acide et de présure du fromage. Revue Générale du Lait, 8: 337-346.

34. Haecker, T. L.
1893. Manufacture of sweet curd cheese.
Minn. Agr. Exp. Sta., Bul. 35, p. 104-128.

35. Hammer, B. W. and Bryant, H. W.
1937. A flavor constituent of blue cheese (roquefort type). Iowa State College Jour. Sci., 11: 281-285.

36. Hansen, H. C.
1936. Influence of certain bacteria on the ripening of cheddar cheese made from pasteurized milk. Unpublished Ph.D. Thesis, Library, Iowa State College.

37. Harding, H. A. and Prucha, M. J.
1908. The bacterial flora of cheddar cheese. N. Y. (Geneva) Agr. Exp. Sta., Tech. Bul. 8.

38. Harned, H. H.
1939. Classification of proteolytic micrococci isolated from dairy products. Unpublished Ph.D. Thesis, Library, Iowa State College.

39. Harris, W. C. and Hammer, B. W.
1940. Effect of various bacteria on flavor of cheese made from pasteurized milk. Jour. Dairy Sci., 23: 701-709.

40. Hart, E. B., Hastings, E. G., Flint, E. M. and Evans, Alice C.
1914. Relation of the action of certain bacteria to the ripening of cheese of the cheddar type. Jour. Agr. Res., 2: 193-216.

41. Harvey, Wm. Clunie and Hill, Harry
1937. Milk products, p. 214. London, H. K. Lewis and Co., Ltd.

42. Hastings, E. G., Evans, Alice C. and Hart, E. B.
1912. Studies on the factors concerned in the ripening of cheddar cheese. Wisc. Agr. Exp. Sta., Res. Bul. 25.

43. Hindriko, J.
1940. Laabi hulga mõju edami juustule. Agronoomia, No. 7: 531-542.

44. Hucker, G. J.
1922. Review of the bacteriological aspects of cheese ripening. N. Y. (Geneva) Agr. Exp. Sta., Tech. Bul. 89.

45. Hucker, G. J.
1922. Types of bacteria found in commercial cheddar cheese. N. Y. (Geneva) Agr. Exp. Sta., Tech. Bul. 90.

46. Lane, C. B. and Hammer, B. W.
1939. Studies on the fat of cheddar cheese. Iowa State College Jour. Sci., 13: 149-155.

47. Lane, C. Bronson
1934. The effect of certain bacteria on the ripening of cheddar cheese made from pasteurized milk. Unpublished Ph.D. Thesis, Library, Iowa State College.

48. Lane, C. B. and Hammer, B. W.
1935. Bacteriology of cheese. I. Effect of pasteurizing the milk on the nitrogenous decomposition in cheddar cheese. Iowa Agr. Exp. Sta., Res. Bul. 183.

49. Lane, C. B. and Hammer, B. W.
1941. Bacteriology of cheese. VI. Relationship of fat hydrolysis to the ripening of cheddar cheese. Iowa Agr. Exp. Sta., Res. Bul. 291.

50. Long, H. F. and Hammer, B. W.
1941. Classification of the organisms important in dairy products. III. Pseudomonas putrefaciens. Iowa Agr. Exp. Sta., Res. Bul. 285.

51. Orla-Jensen, Sigurd
1931. Dairy bacteriology. Trans. from Danish. Second English edition. p. 144-145; 147. Philadelphia, P. Blakiston's Son & Co.

52. Palmer, L. S.
1922. Bitter milk of advanced lactation. A lipase fermentation. Jour. Dairy Sci., 5: 201-211.

53. Rice, F. E. and Markley, A. L.
1922. Proof of the presence of lipase in milk and a new method for the detection of the enzyme. Jour. Dairy Sci., 5: 64-82.

54. Russell, H. L.
1896. The rise and fall of bacteria in cheddar cheese. Wisc. Agr. Exp. Sta., Thirteenth Annual Report, p. 95-111.

55. Sammis, J. L. and Bruhn, A. T.
1912. The manufacture of cheddar cheese from pasteurized milk. Wisc. Agr. Exp. Sta., Res. Bul. 27, p. 137-248.

56. Sammis, J. L.
1914. Cheesemaking tests with homogenized milk. Wisc. Agr. Exp. Sta., Bul. 241, p. 16-19.

57. Sammis, J. L.
1930. Cheese making. Eighth edition of Decker's cheesemaking, p. 197-199. Madison, The Cheese Maker Book Co.

58. Sharp, P. F. and deTomasi, J. A.
1932. Increase in non-lactic acidity in raw cream and its control. International Assoc. Milk Dealers, Laboratory Section, 25: 3-20.

59. Sherwood, I. R. and Whitehead, H. R.
1934. The influence of lactic streptococci on the ripening of cheddar cheese. Jour. Dairy Res., 5: 208-222.

60. Sirks, H. A.
1937. Over de verandering van het melksuikergehalte der wrongel na de watertoevoeging bij de Edammerkaasbereiding. Verslag. Landb. Onderzoek. Rijkslandbouwproefsta., 43: 175-188.

61. Stocking, William A.
1922. Manual of milk products. p. 359-368. New York, The Macmillan Company.

62. Suzuki, S. K., Hastings, E. G. and Hart, E. B.
1910. The production of volatile fatty acids and esters in cheddar cheese and their relation to the development of flavor. Wisc. Agr. Exp. Sta., Res. Bul. 11, p. 127-154.

63. Thom, Charles and Fisk, Walter W.
1921. The book of cheese. p. 174-180. New York, The Macmillan Company.

64. Van Beynum, J., Van Dam, W. and Holwerda, B. J.
1933. Over het gebrek "witte rand" bij Edammerkazen. Verslag. Landb. Onderzoek. Rijkslandbouwproefsta., 39: 25-38.

65. Van Dam, W.
1910. Recherches sur le processus de maturation du fromage d'Edam. Revue Générale du Lait, 8: 145-155; 169-178.

66. Van Dam, W.
1912. De la structure de la pâte du fromage d'Edam. Revue Générale du Lait, 9: 151-158.

67. Van Dam, W.
1912. On the influence of different factory methods on the water content of the curd of Edam cheese. (In Dutch, English summary). Verslag. Ver. Exploit. Proefzuivelboerderij Hoorn, p. 84-91. (Original not seen; abstracted in Exp. Sta. Record, 30: 179. 1914).

68. Van Dam, W.
1928. The influence of pasteurization of cheese milk on the decomposition of the protein substances in Edam cheese. (In Dutch, English summary). Verslag. Landb. Onderzoek. Rijkslandbouwproefsta., No. 33: 187-200. (Original not seen; abstracted in Chem. Abstr., 24: 169. 1930).

69. Van Rijn, J. J. L.
1915. The composition of dutch cheese, and the system of control for whole-milk dutch cheese. The Analyst, 40: 391-398.

70. Van Slyke, L. L. and Hart, E. B.
1903. The relation of carbon dioxide to proteolysis in the ripening of cheddar cheese. N. Y. (Geneva) Agr. Exp. Sta., Bul. 231.

71. Van Slyke, L. L., Harding, H. A. and Hart, E. B.
1903. Rennet-enzyme as a factor in cheese ripening. N. Y. (Geneva) Agr. Exp. Sta., Bul. 233.

72. Van Slyke, L. L. and Hart, E. B.
1903. Conditions affecting chemical changes in cheese ripening. N. Y. (Geneva) Agr. Exp. Sta., Bul. 236.

73. Van Slyke, L. L. and Hart, E. B.
1903. IV. The relation of carbon dioxide to proteolysis in the ripening of cheese. Am. Chem. Jour., 30: 1-24.

74. Van Slyke, L. L. and Hart, E. B.
1904. VI. Chemical changes in cheese ripening as affected by different conditions. Am. Chem. Jour., 31: 45-61.

75. Van Slyke, Lucius L. and Publow, Charles A.
1918. The science and practice of cheesemaking. p. 406-415. New York, Orange Judd Company.

76. Weigmann, H.
1932. Handbuch der Praktischen Käserei. vierte auflage. p. 305-312. Berlin, Verlag. Paul Parey.

77. Weigmann, H.
1932. Lehrbuch der Milchwirtschaft. siebente auflage. p. 777-778. Berlin, Verlag. Paul Parey.

ACKNOWLEDGMENTS

The author sincerely appreciates the advice and valuable direction of Dr. B. W. Hammer in conducting these studies and his helpful suggestions in writing the manuscript; the assistance of Dr. F. J. Babel and Mr. V. H. Nielsen in the manufacture of the cheese and examination of the finished products; the assistance of Dr. H. F. Long and Dr. W. H. Hoecker; and many helpful suggestions from members of the staff of the Department of Dairy Industry, Iowa State College.