5-1986

Manufacture of White Soft Cheese from Ultrafiltered Whole Milk Retentate

Khalid Mohamed Shammet
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/etd

Recommended Citation
Shammet, Khalid Mohamed, "Manufacture of White Soft Cheese from Ultrafiltered Whole Milk Retentate" (1986). All Graduate Theses and Dissertations. 5334.
https://digitalcommons.usu.edu/etd/5334

This Thesis is brought to you for free and open access by the Graduate Studies at DigitalCommons@USU. It has been accepted for inclusion in All Graduate Theses and Dissertations by an authorized administrator of DigitalCommons@USU. For more information, please contact dylan.burns@usu.edu.
MANUFACTURE OF WHITE SOFT CHEESE FROM
ULTRAFILTERED WHOLE MILK RETENTATE

by
Khalid Mohamed Shammet

A thesis submitted in partial fulfillment
of the requirements for the degree
of
MASTER OF SCIENCE
in
Nutrition and Food Sciences

Approved:

UTAH STATE UNIVERSITY
Logan, Utah
1986
To my parents
ACKNOWLEDGEMENTS

I owe deep gratitude to Dr. C.A. Ernstrom for his thorough guidance and benevolence. I am also grateful to Dr. Deloy Hendricks for his ever willingness to help. Sincere appreciation goes to Dr. R.J. Brown and Dr. J.C. Batty for their willingness to serve on my committee. I would like also to express my appreciation to Dr. D. Turner for his help with statistical analysis and Ms. C. Brennand for her help with sensory evaluation.

I am appreciative of the Sudan government, African American Institute and Utah State University, which provided the needed financial support for me to pursue the degree.

My deepest thanks to Ms. Gail Baker for her help and sincere friendship.

I am deeply grateful to my sisters and brothers for their continued support and encouragement.

This work is dedicated to my parents Mohamed Shammet and El Tagwa Ali for their love, support and encouragement throughout my life and my education.

Khalid M. Shammet
TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....................................................  ii
LIST OF TABLES .......................................................... v
LIST OF FIGURES .......................................................... vii
ABSTRACT .................................................................. viii
INTRODUCTION ................................................................. 1
LITERATURE REVIEW .......................................................... 3
   Advantages of Using Ultrafiltration in Cheese Making. 4
       Cheese Yield .......................................................... 4
       Rennet Saving ....................................................... 5
       Quality of the Cheese ............................................. 6
       Pollution .............................................................. 6
       Operation Cost ..................................................... 6
   Acidification .............................................................. 7
   Diafiltration .............................................................. 9
   Heat Treatment of Retentate ....................................... 10
   Buffer Capacity and Acid Development ....................... 12
   White Soft Cheese ................................................... 13
   The Manufacture of Soft Cheese Using UF Techniques ... 18
MATERIALS AND METHODS .................................................. 22
   Milk ................................................................. 22
   Acidification ......................................................... 22
   Ultrafiltration and Diafiltration ................................ 22
   Heat Treatment of Retentates for Cheese Making .......... 28
   Cheese Making Procedure .......................................... 29
   Chemical Analysis .................................................... 29
       Moisture ........................................................... 29
       Fat ................................................................. 30
       Protein ............................................................ 30
       Calcium ........................................................... 31
       pH ................................................................. 31
   Taste Panel Sessions .................................................. 31
   Statistical Analysis ................................................... 32
<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td>4</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>7</td>
<td>63</td>
</tr>
<tr>
<td>8</td>
<td>66</td>
</tr>
<tr>
<td>9</td>
<td>67</td>
</tr>
<tr>
<td>10</td>
<td>79</td>
</tr>
<tr>
<td>11</td>
<td>81</td>
</tr>
<tr>
<td>12</td>
<td>82</td>
</tr>
<tr>
<td>13</td>
<td>83</td>
</tr>
<tr>
<td>14</td>
<td>84</td>
</tr>
<tr>
<td>15</td>
<td>85</td>
</tr>
</tbody>
</table>

The pH of retentates during ultrafiltration

Effect of acid and temperature on the pH of white soft cheese from ultrafiltered whole milk

Chemical analysis of retentate and permeate from ultrafiltered whole milk (1)

Chemical analysis of retentate and permeate from ultrafiltered whole milk (2)

Chemical composition of finished cheeses from ultrafiltered whole milk (1)

Chemical composition of finished cheeses from ultrafiltered whole milk (2)

Correlation coefficients of flavor, texture and appearance to overall acceptability for soft cheese

Means of taste panel parameters for cheese samples (1)

Means of taste panel parameters for cheese samples (2)

Analysis of variance of sensory evaluation for appearance of cheese samples (1)

Analysis of variance of sensory evaluation for appearance of cheese samples (2)

Analysis of variance of sensory evaluation for texture of cheese samples (1)

Analysis of variance of sensory evaluation for texture of cheese samples (2)

Analysis of variance of sensory evaluation for flavor of cheese samples (1)

Analysis of variance of sensory evaluation for flavor of cheese samples (2)
16 Analysis of variance of sensory evaluation for overall acceptability of cheese samples (1) .. 86
17 Analysis of variance of sensory evaluation for overall acceptability of cheese samples (2) .. 87
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The general basic steps for manufacture of white brined cheese (Jibna Baida) in the Sudan</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>3-module test ultrafiltration unit</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>Manufacture of white soft cheese from ultrafiltered whole milk retentates</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>The effect of the storage temperature on the total solid of the finished cheeses</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>Means of sensory evaluation for appearance of cheese samples (1)</td>
<td>48</td>
</tr>
<tr>
<td>6</td>
<td>Means of sensory evaluation for appearance of cheese samples (2)</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Means of sensory evaluation for texture of cheese samples (1)</td>
<td>52</td>
</tr>
<tr>
<td>8</td>
<td>Means of sensory evaluation for texture of cheese samples (2)</td>
<td>54</td>
</tr>
<tr>
<td>9</td>
<td>Means of sensory evaluation for flavor of cheese samples (1)</td>
<td>56</td>
</tr>
<tr>
<td>10</td>
<td>Means of sensory evaluation for flavor of cheese samples (2)</td>
<td>58</td>
</tr>
<tr>
<td>11</td>
<td>Means of sensory evaluation for overall acceptability of cheese samples (1)</td>
<td>60</td>
</tr>
<tr>
<td>12</td>
<td>Means of sensory evaluation for overall acceptability of cheese samples (2)</td>
<td>62</td>
</tr>
</tbody>
</table>
ABSTRACT

Manufacture of White Soft Cheese
from Ultrafiltered Whole Milk Retentate

by

Khalid Mohamed Shammet, Master of Science
Utah State University, 1986

Major Professor: Dr. Carl Anthon Ernstrom
Department: Nutrition and Food Sciences

Manufacture of white soft cheese from ultrafiltered whole cows' milk involved acidification of pasturized homogenized whole milk to pH 6.0 with phosphoric or citric acid. The preacidified milk was ultrafiltered at 54°C until 60% of original milk weight was removed as permeate, diafiltered with deionized water equal to 38.5% of the original milk and concentrated by UF (4.8 fold) to pre-cheese (38% total solid). The pre-cheese was heated to 76.7°C/16 sec, 71.1°C/16 sec (HTST) and 71.1°C/15 min (controlled water bath), inoculated with 2% starter culture (Streptococcus cremoris), renneted (10 ml/100 lb retentate) and placed in one pound plastic containers in which coagulation took place (8-10 min). Salt (1.5%) was added on the top of parchment paper placed under the lid, and the curd was incubated at 85°F. The most acceptable cheese was from ultrafiltered retentate heated for 16 sec at 76.7°C before cheese making. Organoleptic tests showed that samples highest in calcium content ranked highest in acceptability. Acidification with citric acid removed more calcium than phosphoric acid and resulted in softer cheese than the control cheese (non-acidified). Slight
bitterness was observed when excessive starter and low salt (NaCl) concentration were used. Addition of salt to the retentate prior to heating caused thickening of the retentate before 70°C was reached. Extending the heating time increased the tendency toward mealiness in the cheese.
INTRODUCTION

White soft cheese is considered the best means of utilizing low quality milk in tropical and Middle East countries. It is characterized by either high acidity and/or high salt content (29). Under warm atmospheric conditions when keeping quality of milk is poor and cheese deteriorates before it ripens, salt becomes one of the practices necessary for cheese preservation.

The simplest method for making bacteriologically safe cheese is to follow Arabian (Bedouin) procedures: Rennet-curd is pressed, salted, piled, placed in a wire basket, boiled for few seconds in brine (10%) and stored in saturated brine (22%). Pickling makes heat treatment of milk or curd unnecessary (65).

The most important varieties of soft cheese in Balkan and Middle East countries are: Feta, Teleme (Greece), Salamora (Bulgaria and Yugoslavia) Brandza de Braila (Romania) Domiati (Egypt) and Jibna Baida (Sudan) (25).

A great deal of research has been conducted to improve the quality and manufacturing procedures of soft cheeses and to increase the yield and extend the shelf life.

Recently, ultrafiltration (UF) revolutionized manufacturing processes of cheese. Concentration of milk by UF is used as the first step in manufacture of soft cheese since it substitutes for whey drainage in conventional cheese making (23). It is also used as a base for cheese processing (24). Pre-cheese (retentate) containing fat and protein at the concentration required in the
finished soft cheese, is prepared and subsequently set by addition of rennet and starter. Increase in yields (due to retention of soluble proteins in the curd), and reduction in enzyme requirements, manufacturing time, work space and labor may be realized by utilization of UF techniques.

The objectives of the present investigation were to determine the effect of acidification of milk prior to UF and heat treatment of retentate on the quality of finished white soft cheese. A further objective was to manufacture white soft cheese (Middle Eastern type) that appeals to the American taste, by reducing the salt content to 1.5% and controlling the pH (5.1) of the final product.
LITERATURE REVIEW

Ultrafiltration (UF) is a sieving process by which water and low molecular weight solutes such as sugars and inorganic salts are separated from macromolecules such as protein through a molecular sieve. The practical application of ultrafiltration (UF) in the manufacture of various types of cheese was reported by Maubois and Mocquot (53); they also stated many advantages of UF in cheese making such as an increase in yield due to retention of soluble protein in the curd, use of much less rennet and less space required for equipment.

The ultrafiltration technique is now successfully used as the main step in manufacture of soft cheeses such as Feta, Domiati, Bulgarian and Italian cheese. It actually substitutes for most of the curd syneresis that is responsible for whey separation in conventional methods of cheese making. It also is used as a first step in the manufacture of several cheese varieties such as Cheddar cheese and Cottage cheese (23).

Cheese production by ultrafiltration (UF) can be divided into 3 types (41):

(1) Concentration of milk by a factor of not more than 2, followed by cheese making on traditional equipment.

(2) Concentration by a factor of 3-6, followed by cheese making on modified equipment.

(3) Concentration to the final dry matter (DM) content using new techniques and equipment.
The first method is used in certain soft cheeses such as cottage cheese, and also can be used on dairy farms to reduce the volume of the milk and hence save cooling, heating and transport costs. The second method, used for almost all types of cheese, offers attractive financial savings (due to a reduction in cost, time, labor and increase in yield) which allow rapid recovery of the cost of the UF plant. The third method gives the highest yield, because all the fat and whey proteins go into the cheese, but it is more difficult to achieve acceptable quality with this method, especially when it is used for hard or semi-hard cheese.

Advantages of Using Ultrafiltration in Cheese Making

Cheese Yield

The major advantage of using UF for cheese making is improved yield that comes from better recovery of the milk fat and protein and better utilization of whey proteins.

Hansen (36) stated that in the best production of Feta cheese by conventional methods it takes 7.3 kg of milk/kg cheese, while UF takes only 5.3 kg of milk/kg cheese, thereby saving 27% of the milk compared with traditional methods, or produces an extra yield of 37%. Mohmoud and Kosikowski (49) reported that the protein losses dropped from 37% to 9% for Domiati cheese and from 13% to 3% for Feta cheese by using UF. Hansen (35) reported a 30% increase in the yield of Feta cheese by using UF as compared with the traditional methods. Kessler and Baurle (42) claimed a 20% increase in yield of Feta cheese by using UF. These data agree with results
of other authors (28) and (35). Anis and Ernstrom (7) claimed that the fat recovery in UF samples of Domiati cheese was 100% compared to 95% in traditional cheese, and nitrogen recovery was nearly 98% in UF cheese as opposed to 75% in traditional Domiati cheese.

In some cheese varieties no yield improvement has been experienced over traditional cheese making. Starting from a 2-fold concentration and making Cheddar cheese in the traditional way, cheese of acceptable quality was produced but without improvement in the yield (14). Ernstrom (23) reported that no improvement in yield can be expected by making Cheddar cheese from 2X concentrated milk, since the soluble whey proteins were expelled in a concentrated form into the whey during curd syneresis.

**Rennet Saving**

Maubois and Mocquot (53) reported that UF may save up to 80% of the quantity of the rennet usually needed for a preparation of a given amount of cheese. This results in decreased processing costs for the cheese maker. Babella and Jansco-Ivady (9) studied the enzyme requirement and setting time in cheese made from ultrafiltered skim-milk. He concluded that the setting time of samples concentrated by UF remained unchanged while enzyme requirement decreased with increased ultrafiltering degree. Veinogluo et al. (71) confirmed a considerable saving in rennet by using UF techniques. Hansen (36) used an amount of rennet for making Feta cheese by UF which was about 0.2 of the amount used by the traditional method. Yan et al. (72) stated that a considerable
cost saving is expected in cheese manufacture using UF, because of a 50-80% reduction in rennet and starter requirement.

Quality of the Cheese

Hansen (36) emphasized that Feta cheese produced by UF has a quality equal to or superior to that of the traditional product at official evaluations of cheese in Denmark. Scores of texture, body and color were higher than for traditional Feta. The quality of the finished cheese is easier to control, and is less dependent on the activity of the starter (40). Hard cheese such as Cheddar cheese has not yet been made satisfactorily with ultrafiltered milk concentrates (30). Defects in flavor (sweet flavor), texture (woody texture) of Cheddar cheese made from ultrafiltered retentates were observed after several months of ripening (18,44).

Pollution

Ultrafiltration produces a permeate with a lower biological oxygen demand (BOD) than normal whey. The permeate contains less protein; its polluting power, therefore, represents only 80% that of traditional whey (53).

Operation Cost

Ultrafiltration requires less space for equipment than cheese vats in conventional methods because membrane areas can be held within a small volume. The number of cubic meters necessary for accommodation of an UF apparatus is smaller than for a corresponding draining room. Also this technique can be controlled automatically
and avoids many of the manipulations of traditional technology. A reduction in labor also can be expected (53). Siapantas (64) claimed that a cost reduction of 20% could be achieved when making Feta cheese using UF in comparison to natural Feta cheese by standard techniques. Modification of the cottage cheese process by using UF can reduce energy usage to as low as 733 Btu/lb product depending on the process (13). Yan et al. (72) observed a 50% decrease in making time of medium-soft cheese from ultrafiltered whole milk. Ultrafiltration can be used on dairy farms to reduce the fluid milk volume and save cooling, heating and hauling expenses.

**Acidification**

Some properties of cheese are associated with the amount of calcium (Ca) retained in the curd. In cheese made by conventional methods the calcium retained in the curd is much less than in cheese made by ultrafiltered milk. This is due to elimination of calcium by decreasing the pH through starter action which causes some of the insoluble calcium-phosphate to go into solution where it is drained with the whey. If milk is acidified to pH 5.8-6.2 prior to UF, part of the calcium-phosphate associated with caseinate micelles goes into solution, and it will be more easily removed in the permeate (23). Another way of reducing amount of Ca in the retentate is by adding a calcium-chelated agent such as sodium citrate (32).
Green et al. (32) reported that if the milk is acidified or citrated, part of the Ca, Mg and P is solubilized and a smaller proportion is retained by the membrane during UF, and the concentration in the retentate is lower than with non-acidified milk. They pointed out that most minerals are concentrated to a lesser extent in milk when citrate or acid are added indicating that they were partly solubilized from the micelles by these treatments. She claimed that in one 2.7-fold concentration of milk acidification to 5.98 causes partial precipitation of casein.

Ernstrom et al. (24) demonstrated that removal of Ca during UF of whole milk could be enhanced by ultrafiltering at pH 5.7. However, decreased flux rate was a problem associated with UF of acidified milk.

Brule and Fauquant (12) showed that concentration by UF increased the colloidal Ca and P in proportion to the amount of protein. He found that the ratio of Ca to total protein decreased with pH. But at any given pH the higher the protein concentration the higher was the ratio of colloidal Ca to total protein. During acidification of milk and milk retentate there was a solubilization of bound Ca and the ratio of colloidal Ca to total protein decreased with pH. At fixed pH values below 6.6 the higher the protein concentration the higher was the ratio of colloidal Ca to total protein. Reducing the pH solubilized relatively more Ca from milk than from retentate. For instance, the ratio of colloidal Ca to total protein in a retentate (with a total N (TN) content of 112
g/kg and a concentration factor of 3.5) at pH 6.2 was similar to the ratio in milk at pH 5.6 which was 1.49.

The influence of citrate ion on the solubilization of Ca was studied by Brule and Fauquant (12). They concluded that the effect of citrate concentration on the amount of soluble Ca was reduced by the simultaneous increase in pH, especially above pH 7.4. He also found that the casein micelles are less dispersed in retentate than in milk at any given pH.

Sutherland and Jameson (68) reported that milk acidified to pH 6.2-6.4 prior to UF produced retentate with a mineral composition suitable for Cheddar cheese manufacture.

**Diafiltration**

Ultrafiltration of whole milk leaves too much lactose in the retentate which leads to high acidity in the final product (such as Cheddar cheese and yogurt) due to the fermentation of the lactose.

Peri et al. (58) used the principle of membrane dynamics called diafiltration to describe a method of adjusting lactose levels in retentate. The process involves bleeding deionized water into the UF holding tank at the same rate permeate is removed. The effect is "washing out" of lactose to levels that are consistent with those of the desired product. Diafiltration carried out at constant volume in order to maintain a proper balance between low retentate viscosity and high lactose concentration in the water phase.

Sutherland and Jameson (68) investigated effects of diafiltration rate and milk pH on cheese making. Whole milk was
preacidified to various extents at 4°C with 10% hydrochloric acid, and ultrafiltered to 4.8 fold with various diafiltration rates. Analysis of retentate revealed a direct relationship between diafiltration rate and residual lactose concentration, with higher diafiltration rates resulting in lower lactose levels. Similarly, the degree of milk acidification directly affected Ca and P levels in retentates. Retentates derived from highly concentrated milk retained the salts. Calcium retention was more markedly affected in this regard than phosphorus.

Peri et al. (58) and Ernstrom et al. (24) reported that the decrease in lactose concentration during diafiltration causes a significant increase in permeate rate.

Heat Treatment of Retentate

Much research has been conducted to elucidate the effects of heat treating retentate. Green et al. (32) studied the effects of subjecting milk and concentrate to heat treatment at 100°C for 15 min, 119°C for 15 min and 140°C for 4 sec. They found that milk retentates acidified before UF to pH 6.0 gelled under all heat treatment conditions and those acidified to pH 6.4 before UF gelled during treatment at 119°C in all instances. Concentrates of milk treated with citrate before UF sometimes gelled during heat treatment at 119°C. They concluded that when heated at 100°C or 119°C for 15 min the whey protein tended to be denatured as the milk became more concentrated, but heating at 140°C for 4 sec caused less denaturation of individual whey proteins in any samples. They
stated that the rate of denaturation of the major whey proteins is affected by protein concentration to a small extent in the range between 1 and 3 times the normal milk concentration.

Maubois and Mocquot (53) reported that when ultra high temperature (UHT) milk is ultrafiltered its curd forming ability, ordinarily lost as a result of heat treatment, is restored. Similarly, the retentate prepared by UF of normal milk will keep its clottability with rennet even after treated by UHT. Heat treatment of retentate will improve the texture and the body of the final product due to the partial denaturation of whey proteins (50). Pasteurization of ultrafiltered milk concentrate at 77°C for 1 min reduced bacterial numbers and partly denatured the proteins which improved the body and texture of cheese. However, very high pasteurization temperatures (90°C-95°C) of pre-cheese reduces the cheese quality (10).

Robyn et al. (62) studied the factors affecting gel formation of whey proteins when heated at 80°C, and the nature of the covalent bonds cross-linking the individual polypeptide chains. The gels were formed by disulphide cross-links from one polypeptide chain to another. This is supported by the ease of solution of the gels in the presence of excess sulphhydryl compounds and by the inhibiting effect of p-chloro-mercuribenzoic acid (PCMB) and N-ethylmaleimide (NEM) as reagent specific for -SH groups on the rate of gel formations. They also found that at any pH above 5.5 gelation was accelerated by heating in the absence of air. This is inconsistent with one possible reaction mechanism for gel formation, in which
pairs of -SH groups present in separate molecules are oxidized by \( O_2 \) to disulphide bonds. They also reported that gels form more slowly at alkaline pH. A plausible explanation for the pH dependence lies in the fact that the close approach of two different protein molecules will be inhibited if they carry similar electrostatic charges: the higher the pH, the larger the repulsive force will be.

Anis and Ernstrom (7) studied the effects of heat treatment of retentate on the manufacture of Domiati cheese. He found that samples heated to 82.2°C for 30 min were typical and had the best body and texture. They stated that as the heat treatment increased, the tendency toward mealiness decreased. Furthermore, the tendency for whey expulsion also decreased.

**Buffer Capacity and Acid Development**

The buffer constituents concentrate in the retentate from two to five times their normal concentration in milk. This means acid production must be several times greater in retentate than in normal milk in order to obtain the same pH in the final product. Also if lactose is not adjusted to a certain level this will result in high concentration of lactate ion production which retards the growth of the starter. The rate of fermentation can be increased only by increasing the size of the inoculum (23).

Ernstrom (23) found that high-solids skimmilk retentates never did reach the pH level achieved in the normal milk when cultured with lactic starters.
Covacevich and Kosikowski (17) reported that the buffer capacity of retentates increased exponentially with increasing total solids. They found that skimmilk concentrated 5X by UF exhibited buffer capacity approximately six times greater than milk.

The increased buffer capacity has been attributed principally to protein in retentates.

White Soft Cheese

White soft cheese is a traditional dairy product manufactured throughout the Middle East. All the white cheese varieties of which Feta and Domiati cheese are probably the best known, are characterized by either high acidity and/or high salt content. Both these factors have a preservative effect and are critical in ensuring cheese quality considering the prevailing climatic condition in the Middle East.

Domiati cheese is one of the most important dairy products made in Egypt. The best quality Domiati cheese is made from buffaloes' milk, though it can be made from bovine milk. A detailed description of the manufacture of Domiati cheese was given by Fahmi and Sharara (25). A relatively high percentage of salt (6-15%) is added to the milk prior to renneting depending on the season and period of storage intended. It is increased with higher atmospheric temperature, lower quality milk and longer storage periods. The salted milk is usually warmed to 35-37°C followed by addition of 0.12-0.25° lactic acid starter and 15-20 ml rennet per 45 kg milk. The curd is ladled out into metallic molds, wooden forms or frames
and allowed to drain for 2-3 h after which time it is wrapped in cheese cloth, covered by wooden lids and left to settle for about 3 h. Drainage is encouraged by placing a weight, equal to 50% of the weight of the milk used, on the wooden cover for approximately 2 days (2). The cheese is then removed from the cloth, divided into cubes 10 x 10 x 10 cm and packed in tins of 1, 2 or 20 kg. The tin is filled with salted whey then soldered and stored at room temperature. Domiati cheese may be consumed fresh, but may be ripened for 4-8 months or longer. In the latter case, this usually is done domestically in earthenware vessels, after which the cheese is called Jibna Jedima (which means old cheese).

Sudanese cheese is a soft white brined cheese known as Jibna Baida (Jibna = cheese and Baida = white in colloquial Arabic). It is similar to the white brined cheeses made in many countries of Eastern Europe, the Eastern Mediterranean region and North Africa. The cheese is made mainly in small factories spread throughout the country (Sudan), but more particularly in the district of El Douim which produces 60% of the total cheese production in Sudan. Jibna Baida is a very suitable variety for manufacture in Sudan because the bacteriological quality of the milk is usually poor and the addition of salt (6-20%) to the raw milk inhibits bacterial growth. Khalid and Harrigan (43) reported that the salt concentration of 8.5% used in the preparation of Jibna affected growth of Staphylococcus aureus markedly. The process of Jibna requires little practice; it is simple and no elaborate equipment is required. The sharp salted taste appeals to the majority of
Sudanese consumers. The flow chart of the general basic steps for manufacture of white brined cheese (Jibna Baida) in the Sudan (Fig. 1) was given by Khalid and Harrigan (43).

Feta cheese is a cheese of Greece, manufactured mainly from goat's and sheep's milk but in recent years also from cow's milk (19).

The cheese tastes and smells salty and a little acid. This cheese is today a basic foodstuff throughout the Balkan countries and in many Middle East countries. The milk is pasteurized at 72°C for 10 min before cooling to the setting temperature of 30-32°C. After addition of 0.1-0.2% starter and 21 ml rennet per 100 L milk and a setting period of 60-90 min, the curd is cut and allowed to stand in the whey for up to 60 min with occasional gentle stirring before scooping into cloth-lined molds. The molds are turned several times before pressing lightly for a period ranging from 4-5 h to overnight (45).

Cheeses are salted on the table with salt the size of rice grains and not with fine salt. After 12 h the cheeses are turned and salted on the other surface. The salting is continued every 12 h, until each side has received two saltings. If the weather is hot, then salting time is shortened and if cold, it is done every 24 h.

The total amount of salt used does not exceed 6% of the weight of the cheese. Depending on the season, the cheese should remain on the table and be turned for 8-12 days, this period is necessary for development of the typical microflora of feta cheese. The cheese is then washed with cold water and packed in wooden barrels, cans or in
Figure 1. The general basic steps for manufacture of white brined cheese (Jibna Baida) in the Sudan.
Raw Milk + Salt (6-20%)

Rennet tablets, crushed, dissolved in a little water, and added to the milk, mixed and left for 4-6 hours at ambient temperature (22-45°C)

Coagulum poured into molds lined with cheese cloth, covered with cheese cloth and left overnight

Drained whey collected if cheese is not submerged. Boiled or unboiled whey is used as packing solution with or without additional salt.

Curd is cut into cubes and placed in plastic or metal containers.

Cheese is submerged in excess whey draining from the cheese after packing in containers. Containers sealed.

Transportation to areas of consumption and storage normally at ambient temperatures up to 43°C.
bags. If the cheese is not sold soon after packing, it is transferred to an underground ripening room with sufficient humidity to prevent evaporation and loss of weight (19).

The Manufacture of Soft Cheese Using UF Techniques

Moubois and Mocquot (53) reviews several methods of soft cheese manufacture using ultrafiltered milk. They stated that yield increases in production of high moisture cheeses are easily achieved by UF techniques over conventional methods. Milk can be concentrated directly to the solid content of the soft cheese being produced. Whey proteins are incorporated into the product rather than drained with the whey. It was suggested that UF of milk proceed for no longer than 5 h at UF temperature of 50°C - 54°C in order to preserve milk quality. Ultrafiltration for longer periods at these temperatures may promote the growth of thermophilic bacteria and cause protein damage.

Hansen (35) described the basic process of Feta cheese manufacture by UF. Milk was pasteurized, partly homogenized, standardized, and preheated to 50°C, then ultrafiltered to a concentration of 39.5% dry matter (DM). The concentrate was then pasteurized at 77°C, cooled to 27°C, inoculated with starter, coagulated with rennet, cut, packed and salted. He found that the cheese yield was increased by 30%.

Qvist and Nielsen (60) developed a procedure for making Feta cheese. Ultrafiltration of whole milk combined with diafiltration obtained retentate of 30% TS. The retentate was heated to 90°C for
1 min, homogenized, inoculated with 1-2% cheese type starter for 60 min, and coagulated with rennet. The curd was molded, placed in cans, and the permeate was added and the cheese soured and salted.

Hansen (36) described a method for manufacture of Feta cheese. Milk concentrated by UF to 5X was pasteurized, homogenized, inoculated, renneted, cut into cubes and packed into tins. Brine was added and the cheese was ripened for 5-8 weeks. The first factory to employ this method is producing Feta cheese from 200,000 kg milk/day with a savings of 27% of the milk compared with the traditional methods.

Birkkjaer (10) confirmed that UF is now successfully used in Denmark for production of Feta cheese, giving improvements in cheese yields by better utilization of whey proteins.

Feta cheese is now easily produced from milk retentate in many countries in Europe. In Denmark it is estimated that almost all Feta cheese is produced using UF techniques, with nine Danish Feta cheese plant operations in production at the end of 1980 (36).

Mahmoud and Kosikowski (48) reported that addition of .001% microbial lipase to liquid Feta pre-cheese prepared by UF of whole cow's milk at 10°C resulted in cheese with excellent body and texture and typical flavor.

Excellent quality Domiati cheese and Feta cheese were produced without whey drainage using highly concentrated retentates (47). Abd-El-Salam et al. (5) reported that cheese stored without salting showed lower losses than cheese stored in brine or salted permeate. He also made Domiati cheese from 3.5X retentate. The final product
was softer and had slightly higher acidity than traditional cheese. Abd-El-Salam et al. (3) developed a new method for making Domiati cheese based on blending ultrafiltered reconstitute milk and lipolized recombined cream. They found that the flavor intensity increased with the amount of lipase added. El-Shibiny et al. (22) found that the type of packaging material had no apparent effect on cheese texture or flavor. He also reported that cheese with 10% fat had better texture than that with 12% fat. Abd-El-Salam et al. (4) concluded that aging of the milk had only a slight effect on chemical composition and quality of the cheese; therefore, aging of the milk is considered not to be necessary when making Domiati cheese by UF. Abd-El-Salam and Shibiny (1) studied the effect of rennet and starter in the manufacture of Domiati cheese by UF. They found no significant effect due to type of rennet or starter on the composition or quality of the cheese. They stated that adult bovine rennet can be used to make Domiati cheese by UF. Peri and Lucisano (59) reported that cheese was obtained by UF of whole raw milk acidification to pH 6.1, diafiltration and addition of rennet and 5% starter cream. Cutting the curd and significant drainage of whey were essential for obtaining a typical soft texture in Italian soft cheese. Gilles (29) showed that Domiati-type flavor was obtained in the cheese through the addition of a salt-tolerant Lactobacillus strain isolated from a traditional Domiati cheese.

An illustrated description was given (70) of a complete production line for Feta cheese manufacture using UF techniques. It is highly automated and is designed for continuous round-the-
clock operation. The UF plant with an output of 7000-14000 L of milk/h. Concentrates whole milk to a ratio of 5:1. Producing, for instance, at an output of 10000 L whole milk/h, 2000 L retentate with 38% TS was homogenized, heated, cooled, starter and rennet were added. Then the mixture was filled into cans and coagulum was cut and the cans were filled with brine, sealed and palletized.

Pasilac has developed processes involving UF for production of number of cheese varieties including Feta cheese (54). The UF plant is a new DDS module 37 giving retentate with up to 50% total solids and processing 2000 L/h into 270 kg cheese in a continuous operation. Increases of over 20% in cheese yields are claimed compared with the traditional method.

Many research workers have reported a general basic method for the manufacture of Feta cheese from whole cow's milk concentrated by UF (26,10,11,15,27,33,34,39,40,42,46,51,52,57,63).
MATERIALS AND METHODS

Milk

Raw, whole milk was obtained from the Utah State University Dairy farm.

The milk was pasteurized at 74°C for 16 sec, homogenized at 2500 psi (17,225 kpa) and stored at 4°C for acidification and/or ultrafiltration.

Acidification

Milk in this study was divided into three parts:

1. Control - without acidification
2. Acidified with saturated citric acid
3. Acidified with concentrated phosphoric acid.

Acidification of milk with citric or phosphoric acid was carried out at 2°C to prevent localized coagulation of protein. Addition of 38 ml of concentrated phosphoric acid and 65 ml saturated citric acid per 100 pound milk resulted in a pH of approximately 6.00 to 6.01.

The preacidified milks were stored overnight at 35°F to attain equilibrium.

Ultrafiltration and Diafiltration

All experiments in this research involved a 3-module test ultrafiltration unit (Ladish Co., Tri-Clover Division, Kenosha, WI 53141). It was spiral wound, polysulfone membrane (Figure 2). A holding tank and centrifuge pump (Tri-Clover pump model no. C218HD
Figure 2. 3-module test ultraraffitation unit.
2115) were used for recirculation. An inlet pressure of 420 kpa (60 psi) and outlet pressure of 280 kpa (40 psi) were used throughout the process. The milk was pumped out of a holding tank into the membrane module using a high-speed centrifugal pump. Operating pressures and the flow rates were adjusted to the desired values by manipulating the inlet and outlet pressure valves. Feed temperature was controlled by circulating cold water or steam through the double jacket of the holding tank.

The pasteurized homogenized milk (control or preacidified) was ultrafiltered at 54°C until 60% of the original milk weight was removed as permeate.

The retentate was then diafiltered by adding deionized water at 54°C until an amount of deionized water equivalent to 38.5% of original milk was added. Water entered the system at the same rate permeate was removed (58). At that point, the diafiltration water was turned off and UF was continued to approximately 40% total solids (TS). The total solids were checked using microwave method (CEM-Corporation Model AVC-80).

Samples of retentate were collected immediately following UF in plastic bags (Nasco Whirl Pak Bags) and stored at 4°C until analyzed.

The retentate was then collected from the system and cooled immediately in an ice-water bath 2°C in order to avoid browning and to minimize bacteriological growth in the retentate.

The retentate was then placed in a cold room (4°C) overnight for cheese making.
Figure 3. Manufacture of white soft cheese from ultrafiltered whole milk retentates.
Whole Milk

Pasteurization and homogenization

control (pH 6.67)  citric acid (pH 6.0)  phosphoric acid (pH 6.0)

Ultrafiltration (60%)

Diafiltration (38.5%)

Ultrafiltration (20%)

Retentate (38% TS)

Heat treatment
71.1°C/15 min, 71.1°C/16 sec, 76.7°C/16 sec (CWB)

(starter (2%) rennet (10ml/100 lb retentate)

salting (1.5%)

incubation 85°F(29°C) 48 hr

Cold room 40°F (4.4°C)
Membranes were cleaned as follows: water rinse; caustic wash (NaOH pH 10.5-11.5) and chlorine 200 ppm (optimum temperature was 120°F) - 30 min; water rinse; acid wash (H3PO4, pH 1.5-2) - 30 min; water rinse. Equipment was sanitized immediately before use with water containing 200 ppm chlorine. All water used for washing and sanitizing the UF membrane was deionized.

Heat Treatment of Retentates for Cheese Making

The control and preacidified retentates (citric and phosphoric) were adjusted to 38% total solids (TS).

Citrated and phosphated retentates were divided into three parts. The first and second parts were heated at 71.1°C and 76.7°C for 16 sec respectively using a high temperature short time (HTST) system.

The HTST pasteurizer (plate heat exchanger) (Pasilac Therm A/S. DK6000 Kolding, Denmark) consists of a regeneration unit and heating section heated by circulating hot water from a control water bath controlled by a steam thermo device.

Retentates were first heated to 26°C in a water bath to reduce the viscosity of the retentates and to reach a suitable temperature required for incubation at the collecting point.

The third part and the control retentates were heated at 71.1°C for 15 min in a control water bath; the retentates were stirred manually. Then they were cooled to 30°C.
Cheese Making Procedure

Retentates were inoculated with a single strain (D-70), *Streptococcus cremoris*, frozen concentrate starter culture (Biolac, 300 S Main, Millville, UT 84326). A large inoculum (2%) was used (because acid development in retentate inoculated at lower levels was too slow to reach the suitable pH required and to inhibit contaminating spoilage organisms), followed by addition of single strength calf chymosin (New Zealand Milk Products, Inc., 1269 N McDowell Blvd., Petaluma, CA 94952). The cultured renneted retentate was placed into one-pound plastic containers in which coagulation took place. The time required for coagulation varied from 8-10 min.

Dried salt equal to 1.5% of the retentate was placed on parchment paper under the lid. This was to delay the absorption of the salt into the cheese until the starter had had a chance to reduce the desired pH (7).

All containers were inoculated at 29°C until the pH stabilized. The time required to reach the pH of 5.1 varied from 24-36 h.

The cheese was transferred to a cold room (4.4°C) when it reached pH 5.0-5.1, and was held for one week before the chemical analysis and sensory evaluation.

Chemical Analysis

Moisture

Moisture was determined as weight loss from 2.5 to 3.0 g of milk and permeate, or 2.0 to 2.5 g of retentate and cheese. Samples
were weighed in an aluminum pan, evaporated on a steam bath, and
dried 3 h at 100 ± 2°C in a forced draft oven (Thelco model 28 - GCA
Precision Scientific) (61). All samples were cooled in a glass
dessicator prior to final weighing. Moisture determinations were
made at least in duplicate.

Samples revealing discrepancies were repeated until close
agreement was achieved.

Fat

Fat was estimated by the Mojonnier method (55) using samples of
approximately 10 g for milk and permeate and 2.5 g for retentate and
cheese.

Method of homogenizing samples before weighing depended upon
samples' consistency. Milk and permeate samples were warmed and
shaked in the plastic bags. Retentate samples were warmed and mixed
with a spatula. Cheese samples were chopped and mixed with a
spatula.

Protein

Protein was estimated by a semi-micro kjeldahl procedure for
nitrogen (38) using automatic Kjeltec equipment (Kjeltec Auto 1030
Analyzer, Fischer Scientific Co.). Determinations were made in
tripli cate and protein content was calculated by multiplying the
nitrogen content of the sample by 6.38.
Calcium

Calcium was determined by the atomic absorption method using atomic absorption model 457 AA/AE spectrophotometer (Instrumentation Laboratory Inc.) (8).

Samples were digested using wet ashing procedure (16), by adding 10 ml concentrated nitric acid (16 M) to 1 g of all samples and digesting for 48 h at 100°C or until a clear pale yellow solution was obtained.

Salts were dissolved in distilled deionized water and made up to 50 ml.

pH

pH values of whole milk before and after acidification, at the time of UF, retentate and cheese were determined with a glass electrode potentiometer (Model 811, Orion Research, Cambridge, MA 02139).

Taste Panel Sessions

Four consumer taste panel sessions (70-77 judges per session) were devoted to tasting and rating the white soft cheeses. The judges evaluated the finished cheese on: appearance, texture, flavor and overall acceptability, using a Hedonic scale from 1-9 (1 = disliked the most and 9 = liked the most - Appendix B).
Statistical Analysis

The taste panel parameters were analyzed by a one-way analysis of variance to determine source of variation (21). Treatment means were compared by the Least Significant Difference (LSD) method (66) for those treatments which had significant F-ratios.
RESULTS AND DISCUSSION

Figure 4 shows effect of storage temperature on the total solid (TS) content of finished cheeses. Expelling of slight amounts of cheese serum during incubation at 29°C resulted in increasing the total solid of all cheeses. However, all cheese made with preacidified milk prior to ultrafiltration maintained a higher moisture (lower solid in the curd). At cold room 4°C temperature the exudate reabsorbed again resulted in lower TS in all cheese and the cheese body became softer. This agrees with Abou Dawood (6) who found that storage temperature of the cheese has a significant effect on moisture loss. He reported an increase in moisture (and hence cheese weight) with cheese stored in brine at less than 10°C. Similar results were observed by Gilles (29). At higher storage temperatures (22-30°C) the cheese stored in brine lost 6% of its weight. Gilles (29) reported that when cheese was stored in brine at 7°C it increased in weight up to 4% by absorbing moisture from the brine. Similar results are reported by Mahmoud and Kosikowski (49).

The effect of storage temperature on the moisture content of soft cheese may be due to the hydrophobicity which is temperature dependent. At high temperature the hydrophobic bond between casein micelles becomes very strong and water is expelled. At lower temperatures the bond becomes weak and water is reabsorbed.

A storage temperature of 22°C was optimum for maintaining cheese weight.
Figure 4. The effect of the storage temperature on the total solid of the finished cheeses.

(A) The finished cheese at zero time (26°C).

(B) The finished cheese held at incubation temperature (29°C). (pH 5.2.)

(C) The finished cheese at 4°C. (The cold room temperature.)
Salting the Cheese

A preliminary experiment investigated the effect of salting prior to heat treatment of acidified and non-acidified retentates. The retentates were first warmed to 26°C, samples of 150 g were placed in glass beakers. Salt equal to 1.5% of the retentate was added and the beakers heated with stirring in controlled water bath at 93°C. All samples became too viscous to handle before reaching 68°C - 70°C.

Addition of salt (1.5%) to retentates prior to heating and renneting caused many problems. It slowed pH changes although it eventually reached pH 5.1 after 15 days (7). Addition of salt followed by heating caused a thickening of the retentates before 70°C was reached. Possible reasons are as follows:

1. Addition of salt followed by heating may dehydrate the layer of water surrounding the casein micella resulting in precipitation of the milk proteins.

2. Addition of salt while heating accelerated the replacement of the calcium ions by sodium ions. Calcium ions may have rearranged and formed calcium-protein bonds that hold the protein compactly together and coagulation occurs. In this study the same method described by Anis and Ernstrom (7) was used in which salt equal to 1.5% of the retentate was placed on the parchment paper under the lid. This was to delay the penetration of the salt into the cheese until the starter had had a chance to reduce the pH. This prevented thickening of the retentate by direct salting and
formed a thin layer of sodium chloride at the top of the cheese which minimized the outside contamination.

When the desired pH (5.1) was reached, enough cheese serum had been expressed to dissolve the salt. The salted exudate was reabsorbed into the curd when the cheese was placed in a cold room (4°C) and a good distribution of the salt into the curd was obtained.

**Heat Treatment of the Retentates**

A preliminary experiment was performed to determine the effect of heating the retentates on the texture and body of the white soft cheese. It was impossible to heat 5X retentate (non-acidified) 40% total solid (TS) above 78°C using controlled water bath at 90, 94, and 96.7°C. At these temperatures the viscosity of the retentate increased markedly and sudden coagulation occurred. Heating (water bath) retentates (40% TS) acidified by phosphoric or citric acid before UF to pH 6.0, coagulated before 70°C was reached. This observation agrees with the findings of Green et al. (32) who found that concentrates of milks (2.8 fold) acidified before UF to pH 6.0 gelled under all heat treatments of 100 and 119°C for 15 min. The temperature they used was relatively high; however, only 2.8X concentration was used. This does not support Anis and Ernstrom (7) who stated that heating retentates (40% TS) at 82.2°C for 30 min improved the texture and the body of Domiati cheese.
Coagulation occurs due to the formation of stable gels when whey proteins solutions are heated at 80°C (62); the gels consist of polypeptide chains cross-linked by disulfide bonds.

By decreasing the total solids of the retentate to 38%, it became possible to heat (controlled water bath) the non-acidified and preacidified retentates to 76.7°C for 15 min and 71.1°C respectively. Also, preacidified retentates (pH 6.0) could be heated to 76.7°C for 16 sec using high temperature short time (plate exchange) system.

Table 1 illustrates the pH of retentates during ultrafiltration. The acidified samples showed a slight increase in pH while setting overnight to establish equilibrium. The pH of all samples decreased when heated from 4°C to 54°C and increased during diafiltration.

The effect of acidification and heat treatment on rate of pH change during incubation of the white soft cheese is shown in Table 2. All samples that were preacidified by phosphoric acid achieved the desired pH (5.1) within 36 h, while the control and citrated samples never did reach this pH even after 48 h. Heat treatments of retentates had no effect on the rate of pH change during fermentation.
Table 1. The pH of retentates during ultrafiltration.

<table>
<thead>
<tr>
<th>Steps</th>
<th>Phosphoric Acid</th>
<th>Citric Acid</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh whole milk (4°C)</td>
<td>6.76</td>
<td>6.76</td>
<td>6.76</td>
</tr>
<tr>
<td>Acidification (2°C)</td>
<td>6.00</td>
<td>6.00</td>
<td>6.76</td>
</tr>
<tr>
<td>Equilibrium time (4°C)</td>
<td>6.01</td>
<td>6.04</td>
<td>6.75</td>
</tr>
<tr>
<td>Heating to 54°C</td>
<td>5.79</td>
<td>5.88</td>
<td>6.65</td>
</tr>
<tr>
<td>Ultrafiltration 60%</td>
<td>5.88</td>
<td>5.92</td>
<td>6.66</td>
</tr>
<tr>
<td>Diafiltration 50%</td>
<td>5.95</td>
<td>5.98</td>
<td>6.69</td>
</tr>
<tr>
<td>Diafiltration 100%</td>
<td>5.98</td>
<td>5.99</td>
<td>6.70</td>
</tr>
<tr>
<td>Ultrafiltration 80%</td>
<td>6.09</td>
<td>6.16</td>
<td>6.72</td>
</tr>
</tbody>
</table>
Table 2. Effect of acid and temperature on the pH of white soft cheese from ultrafiltered whole milk.

<table>
<thead>
<tr>
<th>Incubation Time</th>
<th>Control 71.1°C/15 min</th>
<th>Phosphoric Acid 76.7°C/16 sec</th>
<th>71.1°C/16 sec</th>
<th>71.1°C/15 min</th>
<th>Citric Acid 76.7°C/16 sec</th>
<th>71.1°C/16 sec</th>
<th>71.1°C/15 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>12 AV</td>
<td>6.33</td>
<td>5.49</td>
<td>5.51</td>
<td>5.49</td>
<td>5.80</td>
<td>5.84</td>
<td>5.79</td>
</tr>
<tr>
<td>SD</td>
<td>0.03</td>
<td>0.01</td>
<td>0.04</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>24 AV</td>
<td>5.54</td>
<td>5.28</td>
<td>5.29</td>
<td>5.24</td>
<td>5.47</td>
<td>5.49</td>
<td>5.44</td>
</tr>
<tr>
<td>SD</td>
<td>0.01</td>
<td>0.04</td>
<td>0.04</td>
<td>0.06</td>
<td>0.02</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>36 AV</td>
<td>5.42</td>
<td>5.09</td>
<td>5.12</td>
<td>5.06</td>
<td>5.28</td>
<td>5.26</td>
<td>5.24</td>
</tr>
<tr>
<td>SD</td>
<td>0.03</td>
<td>0.04</td>
<td>0.09</td>
<td>0.01</td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>48 AV</td>
<td>5.28</td>
<td>5.01</td>
<td>5.04</td>
<td>5.00</td>
<td>5.26</td>
<td>5.24</td>
<td>5.21</td>
</tr>
<tr>
<td>SD</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>

AV = average  
SD = standard deviation
Chemical Analysis

The compositional analysis of milk, retentates and permeates is shown in Tables 3 and 4. The calcium content of retentates were significantly different. Concentration of calcium in the preacidified retentates was lower than with non-acidified-retentate (control) which confirms the findings of Green et al. (32) who stated that addition of citrate or acid decreased the mineral (such as Ca and Mg) content of ultrafiltered milk, indicating that they were partly solubilized from the micelles by acidification. Similar results are reported in the literature (12,24,34). Acidification by citric acid removed more calcium from micelles than by phosphoric acid.

There were no significant differences in the chemical composition of permeates. The fat was retained completely in the retentates as validated by permeate analysis. The average fat content in all permeates was zero which agrees with several researchers (7,23,24).

Tables 5 and 6 show the chemical analysis of white soft cheese made from ultrafiltered retentates. A slight decrease was observed in the moisture content of all cheese compared with retentates. This was due to exudation of a slight quantity of cheese serum during incubation at 29°C. Cheese with low moisture content had exuded more serum. The cheese varied slightly in composition with respect to the major components. Calcium content of the citric acid
### Table 3. Chemical analysis of retentate and permeate from ultrafiltered whole milk. (1)

<table>
<thead>
<tr>
<th>%</th>
<th>Whole Milk</th>
<th>Control</th>
<th>Phosphoric Acid</th>
<th>Citric Acid</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retentate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>87.54</td>
<td>62.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>61.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62.74&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.09</td>
</tr>
<tr>
<td>Protein</td>
<td>3.13</td>
<td>15.47&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.07</td>
</tr>
<tr>
<td>Fat</td>
<td>4.09</td>
<td>19.95&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.1</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.107</td>
<td>0.464&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.369&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.269&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Permeate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>94.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>94.17&lt;sup&gt;b&lt;/sup&gt;</td>
<td>93.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0.017&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.022&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.024&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

Values in the same row with the same letter are not significantly different (p = 0.05)

NS = not significantly different
Table 4. Chemical analysis of retentate and permeate from ultrafiltered whole milk. (2)

<table>
<thead>
<tr>
<th>%</th>
<th>Whole Milk</th>
<th>Control</th>
<th>Phosphoric Acid</th>
<th>Citric Acid</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Retentate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>87.37</td>
<td>61.84(^a)</td>
<td>62.33(^b)</td>
<td>62.36(^b)</td>
<td>0.37</td>
</tr>
<tr>
<td>Protein</td>
<td>3.21</td>
<td>15.78(^b)</td>
<td>15.75(^b)</td>
<td>15.51(^a)</td>
<td>0.06</td>
</tr>
<tr>
<td>Fat</td>
<td>3.99</td>
<td>19.90(^c)</td>
<td>18.95(^a)</td>
<td>19.38(^b)</td>
<td>0.09</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.097</td>
<td>0.420(^c)</td>
<td>0.351(^b)</td>
<td>0.298(^a)</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Permeate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>94.09(^a)</td>
<td>94.04(^a)</td>
<td>93.83(^a)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>0.27(^a)</td>
<td>0.26(^a)</td>
<td>0.29(^a)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>0.00(^a)</td>
<td>0.00(^a)</td>
<td>0.00(^a)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0.020(^a)</td>
<td>0.025(^ab)</td>
<td>0.032(^b)</td>
<td>0.008</td>
<td></td>
</tr>
</tbody>
</table>

Values in the same row with the same letter are not significantly different (p = 0.05)

NS = not significantly different
Table 5. Chemical composition of finished cheeses from ultrafiltered whole milk. (1)

<table>
<thead>
<tr>
<th>%</th>
<th>Control 71.1°C/15 min</th>
<th>Phosphoric Acid 76.7°C/16 sec</th>
<th>71.1°C/16 sec</th>
<th>71.1°C/15 min</th>
<th>Citric Acid 76.7°C/16 sec</th>
<th>71.1°C/16 sec</th>
<th>71.1°C/15 min</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>60.17b</td>
<td>60.06a</td>
<td>60.55c</td>
<td>61.16e</td>
<td>62.38g</td>
<td>61.09d</td>
<td>61.69f</td>
<td>0.05</td>
</tr>
<tr>
<td>Protein</td>
<td>15.30b</td>
<td>14.84a</td>
<td>15.22b</td>
<td>14.95a</td>
<td>14.92a</td>
<td>14.97a</td>
<td>14.77a</td>
<td>0.24</td>
</tr>
<tr>
<td>Fat</td>
<td>19.13a</td>
<td>19.71bc</td>
<td>19.51b</td>
<td>20.25e</td>
<td>19.56b</td>
<td>19.98d</td>
<td>19.86cd</td>
<td>0.22</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.465f</td>
<td>0.389e</td>
<td>0.388e</td>
<td>0.365d</td>
<td>0.266a</td>
<td>0.277b</td>
<td>0.299c</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Values in the same row with the same letter are not significantly different (p = 0.05).
Table 6. Chemical composition of finished cheeses from ultrafiltered whole milk. (2)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Phosphoric Acid</th>
<th>Citric Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>71.1°C/15 min</td>
<td>76.7°C/16 sec</td>
<td>71.1°C/16 sec</td>
</tr>
<tr>
<td>%</td>
<td>60.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>61.91&lt;sup&gt;d&lt;/sup&gt;</td>
<td>61.81&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moisture</td>
<td>15.34&lt;sup&gt;d&lt;/sup&gt;</td>
<td>15.19&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein</td>
<td>19.43&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>19.11&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat</td>
<td>0.421&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.356&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.354&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values in the same row with the same letter are not significantly different (<i>p</i> = 0.05).
group was the lowest, and resulted in a softening of the texture of the cheese.

Effect of Heat Treatment on the Quality of Finished Soft Cheeses

Figures 5, 6, 7 and 8 show the effect of heat treatment on the appearance and texture of soft cheese. Samples heated to 76.7°C for 16 sec (HTST) ranked the highest, while samples heated to 71.1°C (using HTST and controlled water bath) scored lowest. High-temperature short-time gave better texture and appearance of finished cheeses. This may have been due to part denaturation of proteins, by which a smooth retentate and curd were obtained. Extending the heating time increased tendency toward mealiness.

Differences in flavor due to heat treatment was insignificant (Fig. 9). However, in the second experiment citric acid samples were scored slightly lower than phosphoric acid samples (Fig. 10).

The effect of heat treatment on the overall acceptance is shown in figures 11, 12. Samples heated at 76.7°C for 16 sec received the highest scores. Simple line regressions were performed using the cheese sensory evaluation data. Correlation coefficients were calculated for flavor, appearance and texture against overall acceptance. All parameters contribute in the overall acceptability; however, flavor had the greatest effect on overall acceptability of soft cheese made from ultrafiltered whole milk (Table 7).
Figure 5. Means of sensory evaluation for appearance of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 186 responses (1).
ControL 71.1°C, 15 min

Phosphoric acid, 76.7°C, 16 sec

Phosphoric acid, 71.1°C, 16 sec

Phosphoric acid, 71.1°C, 15 min

Citric acid, 76.7°C, 16 sec

Citric acid, 71.1°C, 16 sec

Citric acid, 71.1°C, 15 min

Appearance score

0 2 4 6 8
Figure 6. Means of sensory evaluation for appearance of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 121 responses (2).
Appearance score

Control, 71.1°C, 15 min
Phosphoric acid, 76.6°C, 16 sec
Phosphoric acid, 71.1°C, 16 sec
Phosphoric acid, 71.1°C, 15 min
Citric acid, 76.7°C, 16 sec
Citric acid, 71.1°C, 16 sec
Citric acid, 71.1°C, 15 min

Appearance score

0 2 4 6 8 10

e

d

e

a

cd

c

b
Figure 7. Means of sensory evaluation for texture of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 186 responses (1).
Texture score

Control, 71.1°C, 15 min
Phosphoric acid, 76.7°C, 16 sec
Phosphoric acid, 71.1°C, 16 sec
Phosphoric acid, 71.1°C, 15 min
Citric acid, 76.7°C, 16 sec
Citric acid, 71.1°C, 16 sec
Citric acid, 71.1°C, 15 min
Figure 8. Means of sensory evaluation for texture of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 121 responses (2).
Phosphoric acid, 76.7°C, 16 sec

Phosphoric acid, 71.1°C, 16 sec

Citric acid, 76.7°C, 16 sec

Citric acid, 71.1°C, 16 sec

Citric acid, 71.1°C, 15 min

Texture score

0 2 4 6 8 10
Figure 9. Means of sensory evaluation for flavor of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 186 responses (1).
Flavor score

Control, 71.1°C, 15 min

Phosphoric acid, 76.7°C, 16 sec

Phosphoric acid, 76.7°C, 16 sec

Phosphoric acid, 71.1°C, 15 min

Citric acid, 76.7°C, 16 sec

Citric acid, 71.1°C, 16 sec

Citric acid, 71.1°C, 15 min
Figure 10. Means of sensory evaluation for flavor of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 121 responses (2).
Control, 71.1°C, 15 min

Phosphoric acid, 76.7°C, 16 sec

Phosphoric acid, 71.1°C, 16 sec

Phosphoric acid, 71.1°C, 15 min

Citric acid, 76.7°C, 16 sec

Citric acid, 71.1°C, 16 sec

Citric acid, 71.1°C, 15 min
Figure 11. Means of sensory evaluation for overall acceptability of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 186 responses (1).
Overall acceptance score

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control, 71.1°C, 15 min</td>
<td>de</td>
</tr>
<tr>
<td>Phosphoric acid, 76.7°C, 16 sec</td>
<td>e</td>
</tr>
<tr>
<td>Phosphoric acid, 71.1°C, 16 sec</td>
<td>bd</td>
</tr>
<tr>
<td>Phosphoric acid, 71.1°C, 15 min</td>
<td>a</td>
</tr>
<tr>
<td>Citric acid, 76.7°C, 16 sec</td>
<td>cde</td>
</tr>
<tr>
<td>Citric acid, 71.1°C, 16 sec</td>
<td>bc</td>
</tr>
<tr>
<td>Citric acid, 71.1°C, 15 min</td>
<td>bd</td>
</tr>
</tbody>
</table>
Figure 12. Means of sensory evaluation for overall acceptability of cheese samples. Bars with the same letter are not significantly different (p=0.05). Each bar represents an average of 121 responses (2).
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Overall acceptance score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control, 71.1°C, 15 min</td>
<td>e</td>
</tr>
<tr>
<td>Phosphoric acid, 76.7°C, 16 sec</td>
<td>de</td>
</tr>
<tr>
<td>Phosphoric acid, 71.1°C, 16 sec</td>
<td>cd</td>
</tr>
<tr>
<td>Phosphoric acid, 71.1°C, 15 min</td>
<td>a</td>
</tr>
<tr>
<td>Citric acid, 76.7°C, 16 sec</td>
<td>bc</td>
</tr>
<tr>
<td>Citric acid, 71.1°C, 16 sec</td>
<td>b</td>
</tr>
<tr>
<td>Citric acid, 71.1°C, 15 min</td>
<td>a</td>
</tr>
</tbody>
</table>
Effect of Acidification on the Quality of the Finished Soft Cheeses

Acidification (pH 6.0) was used in order to remove part of the calcium from the retentate, to improve the texture of the cheese and to minimize the bitterness that may be caused by high content of calcium in the retentate.

Table 7. Correlation coefficients of flavor, texture and appearance to overall acceptability for soft cheese.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation coefficient with overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experiment 1</td>
</tr>
<tr>
<td>Appearance</td>
<td>0.635</td>
</tr>
<tr>
<td>Texture</td>
<td>0.768</td>
</tr>
<tr>
<td>Flavor</td>
<td>0.860</td>
</tr>
</tbody>
</table>

Figures 5, 6, 7 and 8 show that calcium content in the finished cheese had an effect on the appearance and the texture of cheeses. The control and phosphoric acid (76.7°C for 16 sec) samples scored the highest in texture and appearance among all samples as compared to citric acid (76.7°C for 16 sec) samples (Tables 5, 6). It was concluded that the lower the calcium content, the softer the cheese.

There was no evidence that partial removal of the calcium by acidification (pH 6.0) decreased bitterness in soft cheeses (Fig. 9, 10). All samples were criticized for slight bitterness by some of the judges. Bitterness could be possibly increased by any of the following conditions (20):
1. Low ripening temperature (below 12°C)
2. Excessive starter, rennet or CaCl₂
3. Insufficient salt (less than 2.5%) in the ripened cheese

In this experiment only 10 mL rennet/100 lb retentate (38% TS) was used which represented only 20% of the amount of rennet usually required for cheese made by conventional methods (10-15 mL/100 lb milk) (25). However, all the rennet added remained in the curd, which may accelerate proteolysis of the milk proteins, resulting in the bitterness.

In Cheddar cheese, curd contains only 6% of the original rennet activity following pressing (37,73). In this experiment all the rennet added remained in the curd (20%) and with no heat treatment after renneting. This increased the possibility of the rennet being the main factor causing the bitterness in soft cheese made by UF.

The amount of the salt added was less than 2%. This enhances the activity of the proteolytic enzymes. Milk protease activity was stimulated by low concentrations of sodium chloride (NaCl), maximum activity being observed near 2% NaCl. At higher salt concentrations (8%) caseins became less degraded (56). The amount of salt (1.5%) used in this experiment may be the other factor that caused bitterness in the white soft cheese made using UF techniques.

Starter bacteria possess a number of proteinases and peptidases which act in concert to hydrolyse milk protein (69). Investigations have shown that starter enzymes contribute to proteolysis during ripening of various cheese types (67). They were responsible for an increased level of small peptides. It was found by Gordon and
Speck (31) that strains of *Streptococcus cremoris* are capable of producing bitter peptide in milk culture. More intense bitter flavor is observed in the cheese when a higher amount (1.5%) of the starter has been added. It was concluded that growth to high cell densities in cheese led to a high concentration of starter proteinase and an elevated level of bitter peptides (69). The large inoculum (2%) used in this study to increase the rate of the pH changes may have contributed to the bitterness of soft cheeses.

**Soft Cheeses Evaluation**

In rating of the cheese samples the consumer taste panel judges used a Hedonic scale (1 = disliked the most and 9 = liked the most - Appendix B). Therefore, those samples scoring 5 and above (Tables 8, 9) were liked and show promise for commercial use in the U.S.
Table 8. Means of taste panel parameters for cheese samples. (1)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Appearance</th>
<th>Texture</th>
<th>Flavor</th>
<th>Overall*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71.1°C/15 min</td>
<td>6.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.73&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.69&lt;sup&gt;de&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76.7°C/16 sec</td>
<td>6.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.73&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.1°C/16 sec</td>
<td>5.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.51&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.43&lt;sup&gt;bd&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.1°C/15 min</td>
<td>3.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.87&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Citric Acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76.7°C/16 sec</td>
<td>5.95&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.94&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.64&lt;sup&gt;cde&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.1°C/16 sec</td>
<td>5.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.58&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.39&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.1°C/15 min</td>
<td>5.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.36&lt;sup&gt;bd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means in the same column with the same letter are not significantly different (p = 0.05). Each mean is an average of 184 responses.

Product was rated on a hedonic scale of 1-9 (1 = disliked the most and 9 = liked the most).

* Overall Acceptability
Table 9. Means of taste panel parameters for cheese samples. (2)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Appearance</th>
<th>Texture</th>
<th>Flavor</th>
<th>Overall*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71.3°C/15 min</td>
<td>6.65&lt;sup&gt;ce&lt;/sup&gt;</td>
<td>6.26&lt;sup&gt;ce&lt;/sup&gt;</td>
<td>5.98&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.29&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76.7°C/16 sec</td>
<td>6.64&lt;sup&gt;e&lt;/sup&gt;</td>
<td>6.42&lt;sup&gt;de&lt;/sup&gt;</td>
<td>5.99&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.16&lt;sup&gt;de&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.3°C/16 sec</td>
<td>6.25&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.09&lt;sup&gt;bcde&lt;/sup&gt;</td>
<td>5.62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.83&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.3°C/15 min</td>
<td>4.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.66&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Citric Acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76.7°C/16 sec</td>
<td>6.22&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>5.89&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.50&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.3°C/16 sec</td>
<td>6.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.72&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.25&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>71.3°C/15 min</td>
<td>5.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.82&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means in the same column with the same letter are not significantly different (p = 0.05). Each mean is an average of 121 responses.

Product was rated on a hedonic scale of 1-9 (1 = disliked the most and 9 = liked the most).

* Overall Acceptability
CONCLUSIONS

The goals of this study was to determine the effect of heat treatment and acidification on the quality of the finished soft cheeses, and to manufacture white soft cheese (Middle Eastern type) that appeals to the American taste. These objectives were achieved by developing a satisfactory method of making soft white cheese from ultrafiltered retentates, whereby the final product at pH 5.1 contained 1.5% salt.

The following conclusions can be drawn:

1. Retentates (preacidified to pH 6.0) can be heated to 76.7°C/16 sec, 71.1°C/16 sec (HTST) without thickening when their total solids are adjusted to 38%.

2. Extending the heating time of retentates increased the tendency toward mealiness of finished soft cheeses.

3. Acidification to pH 6.0 removed part of the calcium from casein micelles. However, using citric acid removed more calcium than phosphoric acid removed.

4. Cheeses made from preacidified retentates had softer body compared with that made from nonacidified retentates. This was due to partial removal of calcium by acidification.

5. Salting retentates prior to heating causes thickening of the retentate before 70°C is reached.

6. pH of cheese could be decreased rapidly by using large inoculum (2%) and acidification.
7. Cheese made from ultrafiltered milk heated for 16 sec at 76.7°C before cheese making was preferred by all judges.

8. Differences in flavor due to acidification were insignificant within acid groups. However, citric acid samples scored slightly lower than phosphoric acid samples.
REFERENCES


39. In Denmark over 15% of cheese is produced by ultrafiltration (MMV) process. 1980. Technique Laitiere 946:15.


Worldwide 4:78.


50. Manufacture of feta cheese by the MMV process at the cooperative at Kirkeby. 1980. Technique Laitiere 946:19.


### Table 10. Analysis of variance of sensory evaluation for appearance of cheese samples. (1)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>1</td>
<td>20.91</td>
<td>N.S. d</td>
</tr>
<tr>
<td>Judge</td>
<td>184</td>
<td>10.78</td>
<td>-</td>
</tr>
<tr>
<td>Cheese</td>
<td>6</td>
<td>164.28</td>
<td>***</td>
</tr>
<tr>
<td>Day X Cheese</td>
<td>6</td>
<td>4.97</td>
<td>*</td>
</tr>
<tr>
<td>Error</td>
<td>1104</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1301</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[a\] Source of variation  
\[b\] Degree of freedom  
\[c\] Mean sum of square  
\[d\] Not significant  
*Significant at 0.1  
**Significant at 0.05  
***Significant at 0.01
Table 11. Analysis of variance of sensory evaluation for appearance of cheese samples. (2)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day (D)</td>
<td>1</td>
<td>3.88</td>
<td>N.S.</td>
</tr>
<tr>
<td>Judge (J) (Error)</td>
<td>119</td>
<td>9.85</td>
<td>*</td>
</tr>
<tr>
<td>Cheese (C)</td>
<td>6</td>
<td>69.70</td>
<td>***</td>
</tr>
<tr>
<td>Day X Cheese (DC)</td>
<td>6</td>
<td>1.58</td>
<td>N.S.</td>
</tr>
<tr>
<td>Error</td>
<td>714</td>
<td>1.89</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>846</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a Source of variation  
*b Degree of freedom  
*c Mean sum of square  
*d Not significant  
*Significant at 0.1  
**Significant at 0.05  
***Significant at 0.01
Table 12. Analysis of variance of sensory evaluation for texture of cheese samples. (1)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>DF</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>1</td>
<td>21.78</td>
<td>N.S.</td>
</tr>
<tr>
<td>Judge</td>
<td>184</td>
<td>7.85</td>
<td></td>
</tr>
<tr>
<td>Cheese</td>
<td>6</td>
<td>103.08</td>
<td>***</td>
</tr>
<tr>
<td>Day X Cheese</td>
<td>6</td>
<td>1.61</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>1104</td>
<td>2.33</td>
<td>N.S.</td>
</tr>
<tr>
<td>Total</td>
<td>1301</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Source of variation  
\(^b\) Degree of freedom  
\(^c\) Mean sum of square  
\(^d\) Not significant  
*Significant at 0.1  
**Significant at 0.05  
***Significant at 0.01
Table 13. Analysis of variance of sensory evaluation for texture of cheese samples. (2)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day (D)</td>
<td>1</td>
<td>1.28</td>
<td>N.S.</td>
</tr>
<tr>
<td>Judge (J)</td>
<td>119</td>
<td>9.23</td>
<td>-</td>
</tr>
<tr>
<td>Cheese (C)</td>
<td>6</td>
<td>66.39</td>
<td>***</td>
</tr>
<tr>
<td>Day/Cheese (DC)</td>
<td>6</td>
<td>3.79</td>
<td>N.S.</td>
</tr>
<tr>
<td>Error</td>
<td>714</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>846</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source of variation
Degree of freedom
Mean sum of square
Not significant
*Significant at 0.1
**Significant at 0.05
***Significant at 0.01
Table 14. Analysis of variance of sensory evaluation for flavor of cheese samples. (1)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>Mean Sum of Squares</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>1</td>
<td>4.29</td>
<td>N.S.</td>
</tr>
<tr>
<td>Judge</td>
<td>184</td>
<td>9.32</td>
<td></td>
</tr>
<tr>
<td>Cheese</td>
<td>6</td>
<td>38.34</td>
<td>***</td>
</tr>
<tr>
<td>Day X Cheese</td>
<td>6</td>
<td>2.75</td>
<td>*</td>
</tr>
<tr>
<td>Error</td>
<td>1104</td>
<td>2.35</td>
<td>N.S.</td>
</tr>
<tr>
<td>Total</td>
<td>1301</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) Source of variation  
\(^{b}\) Degree of freedom  
\(^{c}\) Mean sum of square  
\(^{d}\) Not significant  
* Significant at 0.1  
** Significant at 0.05  
*** Significant at 0.01
Table 15. Analysis of variance of sensory evaluation for flavor of cheese samples. (2)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>DF</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day (D)</td>
<td>1</td>
<td>16.56</td>
<td>N.S. d</td>
</tr>
<tr>
<td>Judge (J)</td>
<td>119</td>
<td>9.47</td>
<td>-</td>
</tr>
<tr>
<td>Cheese (C)</td>
<td>6</td>
<td>25.26</td>
<td>***</td>
</tr>
<tr>
<td>Day/Cheese (DC)</td>
<td>6</td>
<td>6.14</td>
<td>N.S.</td>
</tr>
<tr>
<td>Error</td>
<td>714</td>
<td>3.01</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>846</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Source of variation  
b Degree of freedom  
c Mean sum of square  
d Not significant  
* Significant at 0.1  
** Significant at 0.05  
*** Significant at 0.01
Table 16. Analysis of variance of sensory evaluation for overall acceptability of cheese samples. (1)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degree of freedom</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>1</td>
<td>18.43</td>
<td>N.S.</td>
</tr>
<tr>
<td>Judge</td>
<td>184</td>
<td>8.20</td>
<td>-</td>
</tr>
<tr>
<td>Cheese</td>
<td>6</td>
<td>78.26</td>
<td>***</td>
</tr>
<tr>
<td>Day X Cheese</td>
<td>6</td>
<td>3.32</td>
<td>N.S.</td>
</tr>
<tr>
<td>Error</td>
<td>1104</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1301</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aSource of variation
bDegree of freedom
cMean sum of square
dNot significant
*Significant at 0.1
**Significant at 0.05
***Significant at 0.01
Table 17. Analysis of variance of sensory evaluation for overall acceptability of cheese samples. (2)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day (D)</td>
<td>1</td>
<td>3.71</td>
<td>N.S. d</td>
</tr>
<tr>
<td>Judge (J)</td>
<td>119</td>
<td>8.54</td>
<td>-</td>
</tr>
<tr>
<td>Cheese (C)</td>
<td>6</td>
<td>48.32</td>
<td>***</td>
</tr>
<tr>
<td>Day/Cheese (DC)</td>
<td>6</td>
<td>4.22</td>
<td>N.S.</td>
</tr>
<tr>
<td>Error</td>
<td>714</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>846</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Source of variation  
b Degree of freedom  
c Mean sum of square  
d Not significant  
*Significant at 0.1  
**Significant at 0.05  
***Significant at 0.01
Appendix B
Form Used for Taste Panel Sessions

SOFT CHEESE EVALUATION

Please score using the following scale:

9 = like extremely
8 = like very much
7 = like moderately
6 = like slightly
5 = neither like nor dislike
4 = dislike slightly
3 = dislike moderately
2 = dislike very much
1 = dislike extremely

<table>
<thead>
<tr>
<th>Sample</th>
<th>Appearance</th>
<th>Texture</th>
<th>Flavor</th>
<th>Overall Quality</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>675</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>898</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>659</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>523</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>070</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>952</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>