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Studies on a Newly Developed White Cheese.

Edward Halim Youssef

Louisiana State University and Agricultural & Mechanical College

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STUDIES ON A NEWLY DEVELOPED
WHITE CHEESE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Dairy Science

by

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August, 1971
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ABSTRACT

The first phase of this investigation was to study the possibility of developing a new or modified cheese product. The manufacturing procedure is based on the traditional methods of making "Feta Cheese", a popular white cheese in the Near East countries. Pilot scale experiments revealed that traditional make procedures could be modified to produce an acceptable product for the American consumer. Results of consumer evaluation showed that 78% would buy this new cheese at a reasonable price. It is characterized by its smooth, creamy, sliceable body, slight acid and salty taste, and mild, savory, piquant type flavor. The new cheese can be consumed as a mild fresh product 5-7 days after manufacture, or as a more flavorful product after 4-5 weeks of ripening at 7-10°C.

The second phase was a study of the chemical and bacteriological composition of the fresh product and the changes during ripening of this cheese, with special emphasis on flavor. The average composition after three weeks of ripening was as follows: 62.13% moisture, 21.61% fat (57.06% on dry basis), 11.57% total protein, 2.45% soluble protein, 0.64% titratable acidity, pH 6.27 and 3.25% salt with standard plate count of 46 x 10^6/g, coliform count 7/g, yeast and mold 21 x 10^5/g, psychrophilic count of 58 x 10^4/g and proteolytic count 20 x 10^5/g.

From this study, it appears that volatile fatty acids (C_2 to C_5) and the nonvolatile long chain fatty acids (C_6 and higher) specifically
C_{14}, C_{16} and C_{18} as well as some free amino acids, namely phenylalanine, leucine, proline, glutamic acid, lysine and ammonia, constitute the major components of this white cheese that undoubtedly contribute to its characteristic flavor.
INTRODUCTION

There are many varieties of cheese made throughout the world today. Some hundred of names are in use, although all can be classified into about twenty groups or types. Many modern varieties still utilize the same principles of manufacture established many centuries ago.

Names have been derived from different sources, i.e. region of manufacture, town in a region, type of milk used,...etc. Sometimes a name has been made up, and occasionally some characteristic stage in making or ripening gives its name to a cheese. These names may refer to a type of cheese such as Pasta Filata (plastic curd) in Italy and Pickled (highly salted) such as Domiati in Egypt (7).

White cheese, by the name Feta is currently manufactured extensively in the Balkan and Near East countries. It is a soft cheese, not artificially colored; hence its common name, white cheese. It may be eaten fresh or ripened. The fresh product is similar to a highly salted domestic pot cottage type; the ripened product is substantially different, since the curing occurs in a brine solution. This highly salted or pickled product is characterized by its smooth, creamy texture, sliceable body and pleasant acid, salty, and slight rancid, or piquant flavor (8).

The manufacturing procedure for this type of cheese has not been uniform. It has varied with locality, climatic conditions, and tradition. Several varieties cited by Fahmi and Sharara (14) are as follows: Feta and Teleme (Greece), Salamora (Bulgaria and Yugoslavia),
Brandza de Braila (Rumania) and Domiat and Karish (Egypt). Other similar cheeses are Brinza (Israel) and Queso Blanco (South and Central America).

According to Efthymiou and Mattick (8), Feta cheese, as traditionally manufactured, was often lacking in uniformity and quality. Moreover, high rejection rates due to wide ranges of flavor abnormalities, gassiness and excessive extraneous matter have been reported. Feta has usually been made from sheep milk, although blends of sheep's, goats' and cows' milk have been used. Unblended goats' or cows' milks have received only limited usage, since goats' milk cheese develops typical hardness and dryness, whereas cows' milk imparts an objectionable yellow color and a characteristic cowy odor in the cheese (60). Also, according to Fahmi and Sharara (14) Domati cheese has been traditionally manufactured from buffalos' milk, cows' milk, or a mixture of both.

Regardless of its origin, this white cheese has usually been made without the use of added starter cultures and controlled cooling. Pasteurization of the milk has not been generally practiced. Therefore, the fermentations which occur during the making and curing have been unpredictable.

Since the traditional methods of manufacturing this white cheese has many limitations, some investigation was made to develop a controlled and readily duplicatable process, using pasteurized cows' milk, suitable starters and selected lipolytic enzyme preparations, (8, 14, 18, 52, 59). This investigation was made to:
(1) Examine the possibility of developing a new type of cheese based on the traditional method of making "White cheese", acceptable to the American market.

(2) Determine the chemical composition of the fresh product and the changes during ripening of this cheese, with special reference to flavor.

(3) Determine the number and general classes of microorganisms present as well as the proteolytic and total lipolytic activity of microorganisms in the fresh and ripened cheese.

In this project, pilot scale experiments were carried out to evaluate a new modified white cheese for the American market, which is striving continuously for new dairy products.
Due to the localized nature of naming the varieties of white cheese and the similarities in manufacturing procedures, this review will be directed toward those varieties mentioned by Fahmi and Sharara (14), namely Feta, Teleme, Salamore, Brandza de Braila, Domiati and Karish.

Technological Improvements of White Pickled Cheese in the United States

Limited work by Efthymiou and Mattick (8) has been conducted to improve the traditional method of making white cheese by using cows' milk, suitable starters, and selected lipolytic enzyme preparations. Their method involved pasteurized milk, *Streptococcus lactis* and *Lactobacillus casei* cultures, a pregastic esterase (capalase - KL) and liquid rennet. They produced a cheese having a salty, pleasant acetic acid, and mild characteristic rancid flavor, and a smooth, creamy, and sliceable body.

Zerfiridis and Kristoffersen (59) reported that Feta Cheese, traditionally manufactured from untreated sheeps' milk, was made successfully from pasteurized (73°C for 17 sec.) cows' milk using 0.5% of a commercial mixed *S. Lactis* and *S. Cremoris* culture. A commercial lipase preparation was added to the milk at the rate of 7.5 g/500 kg to give the cheese its characteristic flavor.

In the same study, they reported that bleaching of the cream with 2.4 g/500 kg of benzol peroxide, was without harmful effect on the flavor quality and resulted in a whiter cheese. No beneficial
flavor effect has been noted by adding additional milk solids not fat, homogenization of the cream, or use of single strain cultures of *S. lactis* and *L. casei*.

Work on Domlati cheese, which is very similar to Feta cheese has been reported by Sirry and Kosikowski (52). They mentioned that pasteurization of milk produced Domlati cheese with a firm body but without flavor. The use of enterococci starters (*Streptococcus faecalis* strains) did not overcome the flavor deficiency. Hydrogen peroxide applications to the milk by these workers resulted in a high reduction in original bacterial count of the milk. The cheese had a firm body and typical flavor usually associated with good raw-milk Domlati cheese, but a slight chemical after taste was evident within some of the cheese.

Ibrahim (18) studied the changes during the ripening of Domlati cheese made from raw milk, pasteurized milk and pasteurized milk plus starter *Micrococcus* and/or *Lactobacillus* (species not specified). Initial bacterial counts were highest in raw milk cheese, but decreased during ripening in all types, with a predominance of *Lactobacillus* sp. in the mature cheese, all of which were similar in body, texture and acidity. The use of either of the starter species alone resulted in a weak flavor in the early stages of ripening, however this improved with age. Undesirable flavors frequently occurred in the raw milk cheese. He concluded that the most satisfactory Domlati cheese resulted from pasteurized milk plus a mixed strain starter.
Technological Improvements of Pickled Cheese Outside the United States

A detailed description for the processing and pickling of Domiati cheese has been prepared by Fahmi and Sharara (14). They reported that it has been made from whole buffalos' or cows' milk or from a mixture of whole and separated milk. It differed from other pickled varieties of cheese in that 5-15% of salt was added to the milk before renneting. After rennet was added, then the milk was allowed to coagulate and set for 2-3 hours at 35-37.8°C. The curd was ladled into metallic molds, wooden forms or frames. Whey drainage lasted 1-5 days in the metallic molds and 12-48 hours in the wooden receptacles. The moisture content of the fresh cheese was about 60%. It was either sold fresh or pickled in brine air tight metal containers which were stored in a cool place. The brine used for pickling was usually prepared from the expelled whey.

The same investigators (14) mentioned that with increased addition of salt, rennet coagulation was retarded, a softer curd was formed and the rate of whey drainage decreased, acidity development was also retarded and fat losses were increased. Observations were also made on the fat, sodium chloride, and nitrogen distribution between cheese and whey as well as average composition and respective yields of cheese.

Sharara (50) studied the effect of milk pasteurization and the addition of starter on the yield and composition of Domiati cheese. His study revealed that pasteurization increased the moisture, fat in dry matter, phosphorous, total protein, soluble protein, non-protein and ammonia nitrogen, and decreased the calcium. The addition of starter resulted in an increased level of fat in the dry matter,
total protein, soluble protein and non-protein nitrogen and a
decreased level of ammonia nitrogen and calcium.

Babad and Hadass (3) have outlined the manufacturing process
used in Israel for white cheese, which included: treatment of the
finished product, salting, grinding, packing and distribution.
Suggestions were also made for mechanization of the process.

Kerimov (23) studied the maintenance of optimal acidity in
brine as a factor for improving the quality of brine cheeses, but his
work did not give any positive results. Mocguot and Bejambes (34)
reviewed the manufacturing techniques for white pickled cheese and
other similar varieties using ewes' and goats' milk. El Koussy (10)
reported two techniques for manufacturing of Domati cheese. She used
pasteurized milk while in the other, raw milk with traditional make
methods was used. The effects of delayed salting after processing
was also studied in order to produce an unsalted whey utilizable in
dry poultry feed, for extraction of lactose as well as other products
where the presence of salt is a determinent. The new technique of
delayed salting gave satisfactory results in composition and yield of
cheese.

Low Fat Pickled White Cheese

Separated or skim milk cheese by the name "Karish", a white
cheese, was studied by Fahmi (13) in an attempt to improve its
quality through improved manufacturing techniques. In addition to
recommending technical processing changes for improvement of quality,
he also studied the effect of different salt concentrations on the
chemical composition of the cheese. From his work, a new and
simplified technique has been developed using the acid-rennet method which offers a good basis for speedy and satisfactory making.

El Sadek and Abdel Motteleb (11) found that heating milk to 76.7°C for 15 minutes before making into Karish cheese resulted in a higher yield of cheese with a materially improved quality compared with that of cheese from raw skim milk. The same workers (12) in later work, again reported on the effects of heating milk prior to cheese manufacture together with the effects of storage temperature upon the quality and yield of this type of cheese. They reported the yield, flavor, body and texture were improved by both low temperature storage (4-6°C) and pasteurization of milk prior to cheese making.

Chemical Composition of White Cheese

Fahmi and Sharara (14) reported on the average composition of fresh and ripened Domiati cheese made from cows' and buffalos' milk. The moisture content was 59% and 55% for the fresh and ripened (4-6 months) product made from cows' milk. The corresponding values for buffalos' milk cheese were 55% and 52%, respectively. These results would be expected from the larger amount of water in the original cows' milk which contained 87.18% as compared to 84.12% in buffalos' milk. Conversely the total solids were lower in cows' milk than buffalos' milk, namely 41 and 45% for the former and 45 and 48% for the later.

The same investigators (14) stated that with increased addition of salt to milk, there was a decrease in the acidity developed in both the cheese and whey. This was apparently due to the inhibitory action of salt on the lactic acid bacteria. Salt content was given as
4.5% and 4.9% for fresh and ripened cows' milk and 4.5% and 4.8% for buffalos' milk, respectively. Accordingly, the yield from both milks increased with increasing addition of salt, being most pronounced at 2.5% and 5% salt in buffalos' milk which resulted in yield of 20.33% and 28.49%, respectively. In cows' milk containing 2.5% and 7.5% salt, the yields were 13.08% and 24.71%, respectively. This was expected because salt affects the yield directly by being incorporated into the cheese, and indirectly by causing formation of salt curd which retains a greater percentage of moisture.

The above results were in agreement with Zerfiridis and Kristoffersen (59) who reported an average composition of 2 month old Feta cheese, as 57% moisture and 4.8% salt. Sirry and Kosikowski (52) reported on the effects of salt concentration, pH of 1 and 30 days cheese made from pasteurized milk and from hydrogen peroxide treated milk. Salt percentage in the fresh cheese from pasteurized milk was 6.2% and 5.8% after 30 days of ripening. The corresponding figures for salt percentage was 6.4% and 6.0% in hydrogen peroxide treated milk. The pH was 6.4, 6.2, 5.9 for untreated milk using lactic starter after 1, 7 and 30 days of ripening, respectively. The corresponding pH figures for hydrogen peroxide treated milk using lactic starter were 6.4, 6.2 and 6.0, respectively.

Hofi et al. (17) results were in agreement with the above reviewed work. But Kaloyereas (20) listed a lower figure for water and salt percentages, namely 50.02% and 3.24%, respectively for Greek Feta cheese found in the American market. The titratable acidity was reported as high as 2.4%. This was probably due to the unknown age of the cheese samples analyzed.
Sadek and Hamed (45) examined market samples of Domiati cheese, in relation to moisture, fat, sodium chloride, acidity and formol titration number. In this brief report correlation coefficients were calculated between acidity, moisture, salt, fat percentage on dry basis and the solids not fat content of cheese. Sharara (49) gave the composition of cows' and buffalos' milk with 7 lb and 10 lb salt added to 100 lb milk for making Domiati cheese. He emphasized that fat and solids not fat contents in the milk directly affected the composition of the cheese. The ratio of casein to fat was slightly higher in the cheese than in milk and as the casein to fat ratio increased, the percentage dry matter in cheese decreased.

Sabry and Guerrant (43) looking at other aspects of chemical composition, examined the effect of production and ripening on the vitamin content of the pickled cheeses, Domiati and Karish. The retention of Vitamin A, ascorbic acid, thiamine, riboflavin and niacin was determined during the production and subsequent storage of the two varieties. Vitamin A was retained almost quantitatively in both cheeses during preparation and also during anaerobic ripening. During the preparation of both cheeses most of the ascorbic acid, thiamine, riboflavin, and the niacin was lost to the whey. The amounts of thiamine and riboflavin retained by the curd decreased during the ripening of the cheese, whereas the amount of niacin increased markedly.

Fat, Free Fatty Acids and Its Relation to Flavor

Fahmi and Sharara (14) gave the fat percentage of fresh and ripened Domiati cheese as 18% and 20%. Sadek and Hamed (45) reported 22.86% as the mean fat percentage of 100 market samples of Domiati
cheese, which ranged from 5.55% to 33.85%. The average fat on a dry basis of these market samples was 51.63% and ranged from 17.73% to 72.37% with standard deviation of 4.4.

Hofi et al. (17) listed fat percentages as 14.2, 18.7, 18.7 and 22.7% for fresh, 1, 2 and 3 month old cheese, respectively made from cows' milk. The average fat on a dry basis was 40.7, 48.6, 48.8 and 51.6%, respectively for the same periods. These same workers assumed that the pronounced characteristic flavor of cheese, made from buffalos' milk at the end of the storage periods, was influenced by total volatile acidity rather than soluble nitrogen content. They expressed the total volatile fatty acids as ml N/10 acid per 100 g cheese in fresh, 1, 2 and 3 month old cows' milk cheese as 8.90, 15.4, 20.65 and 22.15, respectively.

Zerfiridis and Kristoffersen (59) found an average of fat 57% on a dry basis for Feta cheese stored 2 months. The ranges and averages for $\geq C_4$ fatty acids were as follows:

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<tr>
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<th>Range mg/g</th>
<th>Average mg/g</th>
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<tbody>
<tr>
<td>7 days</td>
<td>0.6 - 23.0</td>
<td>5.3</td>
</tr>
<tr>
<td>2 months</td>
<td>3.0 - 31.0</td>
<td>7.9</td>
</tr>
</tbody>
</table>

Similar values for acetic acid were given as follows:

<table>
<thead>
<tr>
<th></th>
<th>Range mg/g</th>
<th>Average mg/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days</td>
<td>2.2 - 12.0</td>
<td>6.8</td>
</tr>
<tr>
<td>2 months</td>
<td>2.2 - 6.1</td>
<td>3.8</td>
</tr>
</tbody>
</table>

They concluded that cheese which contained approximately 15 mg/g of $\geq C_4$ fatty acids at 2 months possessed the most desired flavor.

Efthymiou and Mattick (8) indicated that the rancid flavor in Feta cheese was associated with the free fatty acids (FFA) $C_2$ through
C_{10}. Objectionable rancid flavor developed in cheese with high levels of C_{12} and higher fatty acids. This was in agreement with other workers (30, 48) who emphasized that the short chain fatty acids, especially acetic acid, were the dominant volatile acid in cheddar cheese.

In another study Efthymiou (9) reported a low total FFA value in the Teleme cheese samples analyzed. This was expected in this cheese which normally has a very mild flavor. The dominant acetic acid ranged from 25 to 46\% of the total FAA.

In the mild flavored Feta cheese samples analyzed by Efthymiou and Mattick (8), the FFA varied considerably but their total value was generally low. The acetic acid which ranged from 28-43\% comprised a large portion of the total acids. In the sharp flavored samples, moderate to excessive amounts of FFA were detected. The acetic acid content did not change but its ratio to the total showed a sharp decrease and ranged between 5 and 12\%.

The above findings relative to Feta cheese flavor were in agreement with Patton (37) who indicated that volatile acids were of primary importance in the aroma of cheddar cheese. His results tend to confirm that milk fat was the source of cheddar aroma formation and that lipolysis of the fat was the mechanism by which it occurred. Moreover, he observed as had Mabbitt (33), that cheddar cheese made from skim milk was completely devoid of typical cheddar flavor characteristic. In addition, Patton's (37) findings supports earlier workers (32, 36, 38) that free fatty acids were important in cheddar flavor. The identification procedures of the FFA and the natural volatile constituents have been reviewed by Bills, Willits and Day (4).
Total, Soluble Protein and Free Amino Acids

Hofi et al. (17) reported the average total protein content of Domlati cheese made from cows' milk to be 10.45, 11.65, 12.2 and 14.25% for fresh cheese and after 1, 2 and 3 months storage, respectively. The corresponding soluble protein for 1, 2 and 3 months were 3.29, 3.10 and 3.69%, respectively. Sharara (50) emphasized that pasteurization resulted in an increase in total yield as well as total protein, soluble protein, non-protein nitrogen and ammonia N. Moisture and fat in dry matter increased but calcium decreased. While the addition of starter resulted in increases in fat, total protein, soluble protein and non-protein nitrogen on a dry matter basis, decreases were noted in total yield and ammonia N. However, results listed by Kaloyereas (20) for total protein and soluble protein were higher than reported by Sharara (50), namely 17.29 and 5.57%, respectively.

According to Prodanski's study (40) on the breakdown of paracasein in ewes' milk white cheese and Feta cheese, after 45, 90 and 180 days of ripening, total nitrogen content was higher throughout the period for Feta cheese than for white pickled cheese. The main differences were noted in the amino acid content which was about twice as high for Feta cheese as for white cheese. The general amino acid patterns of the 2 cheese varieties were similar, both containing 14-19 free amino acids, but the concentration of individual free amino acids present were significantly higher for Feta cheese.

During the ripening of cheese, amino acids and peptides are formed. These free amino acids are important to the development of cheese flavor. The report of Kosikowski (26) revealed that many free
amino acids appeared very rapidly in both raw and pasteurized milk cheese. At the end of 2 days at 15.5°C, 40% of the number of free amino acids that ultimately were found in the cheese had already appeared. In a further comparison between the use of raw and pasteurized milk, glutamic acid, leucine, methionine, basic amino acids, valine, and phenylalanine were noted to have the highest concentrations in the raw milk cheese over the 180-day ripening period. In the pasteurized milk cheese however, glutamic acid, basic amino acids and phenylalanine and asparagine were found to be present in the highest concentrations. On the other hand, glutamine, serine, threonine, proline and \( \alpha \) - amino - butyric acid were formed in low concentrations in raw milk cheese, while aspartic, alanine, glutamine, threonine and glycine were in low concentrations in the pasteurized product. Proline and \( \alpha \) - amino - butyric acid were detected in raw milk cheese but not in the pasteurized milk cheese. Asparagine was present in large quantities in pasteurized product but was not observed in raw milk cheese. The same author (25) listed the free amino acids found in a number of commercial cheddar cheeses. A number of the cheeses studied did not contain all the above mentioned compounds. Kosikowski and Dahlberg (27) estimated the free amino acids and related compounds in 30 commercial foreign type cheeses. They revealed that free amino acids were present in concentrations from a trace to more than 6 mg per gram of cheese with glutamic acid, leucines, valine, and basic acids predominating. They stated that, although some differences were observed, no foreign cheese type could be solely identified by its chromatographic amino acid pattern. Koning (24) examined Edam, Camembert and Kernhem cheese and reported that the free
amino acids in the three cheeses had certain similarities. He added that every type of cheese investigated had its particular peptide pattern, and theorized that a particular type may be identified by its peptide pattern.

Bacteriological Studies on White Pickled Cheeses

Sadek and Eissa (47) studied coliform organisms present in Domiat cheese and their relation to the salt content and acidity. They showed that at least a 9.5% salt concentration was needed to be effective in suppressing these organisms. Further, the relation between acidity and coliform count revealed that a titratable acidity of 1.2% or higher had inhibitory effects on the growth of the organisms.

The same workers (46) reported on the incidence of coliforms and their relation to the cheese quality. They concluded that the presence of these organisms materially affect both its flavor and texture. Other workers, Chalmers (5) and Kelly (22) obtained similar results regarding the detrimental effect of these organisms on the flavor and texture of other varieties of cheese.

Zerfiridis and Kristoffersen (59) reported that the total bacterial count was $2.5 \times 10^6$ and $2.0 \times 10^6$/g, for 7 days and 2 month Feta cheese made without added lipase. The corresponding values for yeast and mold were $< 10$ and $260 \times 10^3$/g, respectively.

Potentialities in New and Improved Type Cheeses

Statistical data reported by the U.S.D.A. Crop Reporting Service in 1970 indicated that milk used for cheese production set a new record high for the sixth consecutive year of 1969 (56). Cheese
manufacture utilized 30% of all milk used in manufactured dairy products. Soft cheeses such as cream, cottage and creamed cottage increased by higher percentages than hard type cheeses. This reflects a highly improved acceptance of cheese by the consumer which in all probability is due to improved quality.

In addition, as previously mentioned, the American market is striving continuously for new dairy product developments in the way of new or modified items to meet the potential of new markets for dairy products.

Price (39) stated that in considering the potentialities in new and improved types of cheese, the manufacturer, processor or distributor must determine what the consumer wants, what varieties or types of products best meet these wants and how the product can be introduced to the consumer. New and different cheese products are difficult to develop but modified or unusual varieties, well packaged, offer potential for either specialty or volume trade.

The consumer demand for fat-free or low-fat ripened cheese has increased in the past few years according to Hargrove et al. (16). They predicted that this trend will continue. Numerous attempts have been made by the cheese industry and others to develop a palatable, ripened skim milk or low-fat cheese. As a result, several types such as Canadian and South Africa's low fat cheeses have been described in the literature (19, 31). However, such cheeses in general have failed to receive consumer acceptance and therefore, their manufacture has been limited or even discontinued (16). Hargrove et al. (16) described their product as having a mild pleasing flavor somewhat like very mild cheddar. The body was close in texture, resilient
and smooth, making it well suited for slicing. They believed that the
development of this low fat cheese will appeal to diet-conscious
consumers and open new markets for surplus nonfat milk.

Webb (58) reviewed new cheese products, as well as possible
new whey products. "EUDA" represents one of these semi-soft skim
milk cheeses, as having possibilities for new product development.
Other products listed were spreads, dips, fluid concentrates, whipped
cottage cheese with sour cream body, long-life cottage cheese, fresh
and high flavor cheese and others. The new whey products listed were
whey protein concentrates, sweetened condensed whey products, whey-
based beverages with CO2, alcohol, fruit and fermentation products
for food and pharamaceuticals. In addition, others have reported
different products from different raw materials. Manufacture of
cheese spreads from concentrated dairy products has been given by
Quraishi (41). A low fat soft ripened cheese had been described by
Reisfield and Harper (42). Kosikowski (29) outlined some possibilities
in which whey can be utilized by humans, as in Ricotta cheese as well
as blending whey powder with basic food materials of developing
countries including cereals, to produce a new, inexpensive food,
rich in proteins, calories, calcium and flavor.

From the previous comments on cheese developments, namely
the improved acceptability, new styles and new flavors, it appears that
modifications of some of the existing old world varieties offer
excellent opportunities for new cheese product development acceptable
to the American palate.
EXPERIMENTAL METHODS

Statement of the Problem

A well established native white cheese manufacturing method was selected, and modified to obtain general information on the effect of several processing techniques on the body and texture characteristics of the cheese, as well as its acceptability to the American market. This method of reference, adopted in principle in this study, has been described by Fahmi and Sharara (14). It has been used to produce Domiati cheese, very similar to Feta, from raw, uncultured cows' or buffalos' milk or mixture of both, with addition of a high concentration of sodium chloride to the milk prior to renneting.

The following experimental procedures were carried out to examine the possibility of modifying the above mentioned procedure to produce a uniform cheese from cows' milk, with a milder flavor and slightly lower acidity together with a lower salt content acceptable to the American consumer.

Experimental Procedures

Cows' milk containing 3.8% milk fat was obtained from the Louisiana State University milk processing plant for all experiments.

Experiment I

Two trials were carried out, each consisted of 20 lb pasteurized homogenized milk. This milk was processed in small water jacketed vats. Figure 1 represents a diagram of the experiment.
Figure 1. Diagram of Experiment I.

**Trial (1):** In this trial, 6% salt was dissolved into the milk preheated to 35°C followed by the addition of 20 ml liquid rennet per 100 lb milk; the rennet had previously been diluted 1:6.

**Trial (2):** In this trial, 1% of a commercial lactic starter culture was added to the milk, and set for 1 hour. The same amount of salt and rennet were added as in trial (1).

In both trials coagulation to the proper degree of firmness required 2.5-3 hours. The curd was ladled with a cheese scoop into creole cream cheese plastic cups with permanent bottoms. These cups are made with perforation 1/8" in diameter and approximately 1/2" apart on sides and bottoms for whey drainage. Extreme care was exercised
During the ladling operation, since excessive curd breakage resulted in slow drainage when the forms were filled. The cups were covered by cheese cloth. The cheese forms were gently tipped and inverted every 10-12 hr for 2 days at room temperature (21-23°C), to assist in the expulsion of whey. The curd was then packaged as follows: One portion was wrapped in aluminum foil (fresh), another portion was placed in a jar then covered with 3% brine and sealed, a third portion was placed in a jar then covered with 3% whey brine and sealed.

Duplicate samples were prepared with one stored at room temperature (21-23°C), and the other stored at 4.4°C.

**Experiment II**

To stimulate the typical mild rancid flavor of high quality Feta cheese absent in the first experiment, new variables were introduced. These were: lower salt content (5%) and milk comprised of equal portions of raw and pasteurized homogenized milk. (Fig. 2)

**Experiment III**

To examine the effects of different cultures on the process, combinations of pure strains of *S. lactis* and *L. casei* were used in various proportions. In addition, a different salting technique was used as a new variable. Finally lipase paste was introduced as a substitute for the mixed raw and pasteurized homogenized milk trial. (Fig. 3)

**Experiment IV**

To further evaluate the use of lipase paste, two different types were used in a similar manner as in Experiment III, trial (4). In addition a dry salting technique was attempted. (Fig. 4)
Figure 2. Diagram of Experiment II.
III

Trial (1)  Trial (2)  Trial (3)  Trial (4)

equal amounts of raw + pasteurized milk, mixed, set for 1 hr, repasteurized

1% starter  1% starter  1% starter  1% starter

lactis:casei L:C L:C same as same as same as
1:1 1:2 2:1 trial (1) trial (1) trial (1)

5% salt no salt 5% salt 5% salt

rennet  rennet  rennet  rennet

packaging  packaging  packaging  packaging

same as same as
trial (1) trial (1)

fresh  5% brine  5% salted whey

°C  °C  °C

4.4 10 21-23 4.4 10 21-23 4.4 10 21-23

fresh  3% brine  3% salted whey  3% brine + milk

°C  °C  °C  °C

4.4 10 21-23 4.4 10 21-23 4.4 10 21-23 4.4 10 21-23

Figure 3. Diagram of Experiment III.
Figure 4. Diagram of Experiment IV.
Experiment V

To further evaluate cultures, two levels of inoculations of commercial mixed strain starter cultures were used. In addition a different level of salt (4%) was introduced, as well as a new storage temperature of 12.8°C.

\[
\begin{align*}
\text{Trial (1)} & \quad \text{Trial (2)} & \quad \text{Trial (3)} \\
pasteurized\ milk & \quad \text{mixed raw and pasteurized} & \quad \text{pasteurized milk + lipase paste (-L)} \\
\text{commercial lactic culture} & \quad \text{same as trial (1)} & \quad \text{same as trial (1)} \\
1\% & \quad 1.5\% & \\
4\%\ salt & \quad 5\%\ salt & \quad 4\%\ salt & \quad 5\%\ salt \\
\begin{array}{c}
4.4, 10, 12.8 \\
4.4, 10, 12.8 \\
4.4, 10, 12.8 \\
4.4, 10, 12.8
\end{array}
\end{align*}
\]

Figure 5. Diagram of Experiment V.

Experiment VI

Since earlier experiments had shown that the level of lipase paste used was apparently too high, a reduced level was tried. (Fig. 6)

Experiment VII

To determine possible effects of whey drainage method, two new techniques were examined, packing with and without pressure in young American cheese hoops. (Fig. 7)
VI

Trial (1)
mixed raw and pasteurized milk
commercial lactic culture
1% 1.5%
4% salt 5% salt 4% salt 5% salt
4.4 10 4.4 10 4.4 10 4.4 10

Trial (2)
pasteurized milk + lipase paste (-L), 0.5g/100 lb
commercial lactic culture
same as trial (1)

Figure 6. Diagram of Experiment VI.

VII

Raw and Pasteurized Milk with 1.5% Starter
5% salt
rennet

Trial (1) Trial (2) Trial (3)
packed in cups packed in young packed as in trial (2)
American hoop
hand pressure no pressure
for 12 hours

Figure 7. Diagram of Experiment VII.
Weekly evaluation of the cheese by six trained judges was carried out for 8 weeks, to obtain information on the flavor, general appearance and body, and texture characteristics associated with the acceptance of the product. Two of the panel members were familiar with the accepted characteristics of the traditional Feta cheese.

A copy of the 5 point score card used for product evaluation is shown in Appendix II.

Collection and Preparation of Samples

Samples were collected according to the official methods of analysis of the Association of Official Agricultural Chemists A.O.A.C. (2). Material in containers were thoroughly stirred for at least 5 min with sterilized spatula, so that all portions were blended.

About 400 g samples were placed in a sterilized Waring blender and blended at high speed for 2 min to obtain a homogenous mixture. Final temperatures during blending were 25°C or less.

The samples were placed in sterilized sealable sample jars and were immediately analyzed bacteriologically, then 3 drops of toluene were added to the remaining sample as preservative. Samples thus prepared were kept in a deep freeze at -22°C for future chemical analysis.

Chemical Analysis of Cheese

Moisture Content

The A.O.A.C. method (2) was followed with slight modification. An aluminum moisture dish was dried along with a glass rod (with a widened flat end) and 20 g of analytical grade silver sand, for one
hour in an oven at 100°C then cooled in a desiccator and reweighed. Two grams of cheese samples were weighed in the dish, and well mixed with the sand by means of the glass rod. The plate was then transferred to an electric oven at 100°C and held for six hours. It was then cooled to room temperature in a desiccator and reweighed.

**Fat Percentage**

Fat percentages were determined by the Mojonnier method as described by the A.O.A.C. (2).

**Salt Content**

The modified Volhard test for salt with nitrobenzene was used according to Kosikowski (28). Two grams of cheese samples were accurately weighed in a 300 ml Erlenmeyer flask, followed by addition of 25 ml of 0.1 N Ag NO₃. Ten ml of halogen-free HNO₃ and 50 ml of distilled water were introduced into the flask. The contents were gently heated to boiling under a hood.

During boiling, 15 ml of fresh 5% (KMnO₄) solution were added in three 5 ml portions. Each successive 5 ml portion was added after the purple color changed to yellow.

The digested yellowish solution, was then cooled to room temperature followed by addition of 2 ml of nitrobenzene and then 2 ml of saturated FeNH₄(SO₄)₂ with immersion pipettes.

The contents were titrated directly with N/10 KSCN to a brick-red endpoint, while stirring.

**Titratable Acidity**

Estimation of titratable acidity was carried out according to Ling (32). Two grams of cheese were ground with 30 ml of distilled
water in a mortar and titrated while grinding with N/10 NaOH using 1 ml phenolphthalein.

**pH**

Two grams of cheese were ground with 30 ml of distilled water. The pH of supernatant was obtained with a Beckman pH meter utilizing a glass electrode.

**Total Nitrogen Content**

The A.O.A.C. Kjeldahl method (2) was used for total nitrogen and to determine the protein percentage, a factor of 6.38 x total nitrogen was used.

**Soluble Nitrogen Content**

Five grams of cheese were ground with 20 ml hot distilled water in a small mortar and the supernatant was transferred to a 100 ml volumetric flask. The decantation procedure was repeated until 80 ml extract were collected. The cooled mixture was made up to 100 ml with water, mixed, and then filtered through whatman's No. 40 filter paper into a 250 ml volumetric flask. Twenty ml of the filtrate were used for determination of nitrogen by the Kjeldahl method.

**Free Fatty Acids**

**Short Chain Fatty Acids (C2-C5):**

The Cottyn and Boucque (6) method with a slight modification was used for preparation of samples for detection of acetic, propionic, butyric and valeric acids by gas liquid chromatography (GLC).

Five grams of sample were mixed with 5 ml solution consisting of 3 ml 25% metaphosphoric acid + 1 ml 5% formic acid. The mixture
was allowed to stand for 30 min, then centrifuged at 4000 rpm for 20 minutes. After centrifugation, the supernatant was removed and filtered through whitman paper No. 40. The aqueous solution was then injected into a Microtek model 1600 G.C. The output of the hydrogen flame detector circuit was recorded on a Sargent recorder. The gas chromatograph was equipped with stainless steel column, packed with chromosorb 101, 50-60 mesh, 4' x 1/8" which was the same type column used by Cottyn and Boucque (6). The nitrogen, air and hydrogen flow rates were adjusted to 40, 35 and 15 ml/min, respectively. The column was conditioned by flowing nitrogen over night at 165°C. This was the desired operating temperature. Both detector inlet and injection inlet temperatures were 250°C.

**Long Chain Fatty Acids (C₆-C₁₈):**

The extraction-titration method of Thomas et al. (55) was used to extract the fat from cheese. Fat was recovered from 5 g cheese samples, using BDI reagent (a mixture of a nonionic surface-active agent and sodium tetra phosphate, "Calgon", in water) for separation.

The method of Smith (53) was used for methyl ester preparation, by dissolving 0.2 g fat in 2 ml of ethyl chloride and heating in a 50°C water bath for 1 hr in presence of methanolic KOH. The esters were extracted after one hour with ethyl chloride and the solvent was allowed to evaporate at room temperature for two hours.

Analysis of the fatty acid methyl ester mixtures was carried out by means of GLC. Biomedical Gas Chromatograph model 400 (F & M) was used, using a 6' x 1/4" stainless steel column containing 10% apiezon L on 80/100 chromport XXX. Temperature programing was used from 150 to 210°C at a rate 5°C/min. Detector temperature and flash
heater temperaturer were 275°C and 280°C, respectively. The carrier gas flow rate was 90 ml/min.

Free Amino Acids

The method of Moore, Spackman and Stein (35) was adopted for the analysis of free amino acids in cheese samples, using Beckman Amino Acid Analyzer model 120. Five gram samples were ground in 50 ml of 1% picric acid. Then, the picric acid precipitates were removed promptly by centrifugation followed by passing the supernatant liquid through a prepared bed of Dowex 2-X8 resin. The chromatographic tube and the resin bed were washed with five 2-ml portion of 0.02 N HCl. Both the effluent and washings were concentrated on a rotary evaporator to a volume of about 2.5 ml. The solution was adjusted to pH 7.2-7.5 with 1 N NaOH, followed by addition of 0.4 ml of a freshly prepared 0.5 M solution of sodium sulfite. The pH was re-examined to check if it was still in the above range after which the solution was allowed to stand open to the air for 4 hours. The pH was readjusted to 2.0-2.2 with 1N HCl. The solution was diluted to 25 ml in a volumetric flask after which a 1.0 ml aliquot was pipetted for analysis. The operation for analysis was performed as described in Beckman Manual*.

Bacteriological Analysis of Cheese

The bacteriological analysis were made initially and weekly during ripening according to the 12th edition of standard method for the examination of Dairy Products (1).

Standard Plate Count

Standard plate counts (SPC) were made using TGE agar with plates incubated at 32°C for 48 hr.

Coliforms

Coliform counts were made using violet red bile agar with plates incubated at 32°C for 18-24 hr.

Yeast and Mold

Yeast and mold counts were made using acidified potato dextrose agar with sterile 10% lactic acid with plates incubated at 21-25°C for 5 days.

Proteolytic Activity

Proteolytic count was made using an equal amount of nutrient agar medium and sterilized skim milk. Plates were incubated at 21°C for 48 hr. Colonies surrounded by a clear zone were counted and reported as proteolytics.

Psychrophilic Count

Psychrophilic counts were made using TGE agar with plates incubated at 5°C for 10 days.
RESULTS AND DISCUSSION

Organolyptic Qualities and Appearance

The method of Fahmi and Sharara (14) for manufacturing Domiati cheese (very similar to Feta) was adopted as having potential for modification into a new type. The following variables were introduced: raw and pasteurized cows' milk, various lactic cultures, lipolytic enzyme preparations, various salt concentrations, modified methods of cutting the curd, whey drainage, and finally cheese packaging, and ripening temperatures.

The previously outlined experimental procedures were carried out in an attempt to produce a mild flavored cheese with moderate acid, salt, and a slight bitterness blended with a slight rancidity acceptable to the American market. The product finally developed, was also analyzed chemically and bacteriologically, initially and at various stages during ripening.

Experiment I

Organolyptic examination of the product produced in Trial 1, (Fig. 1), indicated that none of the cheeses made from uncultured pasteurized homogenized milk using 6% salt, developed the characteristic flavor of commercial Domiati cheese even after 4 weeks of ripening. After 1 week, panel members described the product as, lacking flavor, having an excessive salt, with weak body and coarse texture. This was probably due to the lack of acid and flavor development since no starter organisms were used. This would naturally result in a weak
body devoid of flavor. In addition, the high salt content reported by panel members could be the possible reason for that coarse texture. After 1 month, the product was criticized as lacking flavor, excessive saltiness but with improved body and slicing characteristics.

Improvement in cheese flavor was noticed in the samples packed in aluminum foil (fresh) and stored at room temperature (21-23°C), over other methods of holding. Meanwhile, the samples held at 4.4°C exhibited no improvement in flavor or body characteristics. This emphasized the importance of ripening temperatures on the development of cheese flavor. Furthermore, the product stored in 3% brine or 3% salted whey at 21°C, developed a harder curd, excessive gassiness, very salty taste, together with fruity and putrid flavors. This could be the result of contamination plus the fact that no culture was used.

The pasteurized milk containing a lactic culture in Trial 2, generally produced a product with less objectionable salt, and with some flavor improvement. After 1 month, the flavor was superior over the uncultured cheese; i.e. and addition of starter culture as well as moderate ripening temperature, were the important factors in developing some cheese flavor. The use of brine or salted whey packaging, at 21°C gave some improvement in cheese flavor over samples stored at 4.4°C which lacked in flavor and body firmness. In total, the products produced by these methods were considered unacceptable, lacking in both flavor and firmness of body.

**Experiment II**

To stimulate the typical mild rancid flavor of high quality Feta cheese, absent in the first experiment, new variables were
introduced. These variables were: lower salt content (5%) and milk comprised of equal amounts of raw and pasteurized milk (R & P). These milks in equal quantities were mixed and allowed to set for 1 hr, to permit the natural lipase enzyme in raw milk to react with the homogenized milk fat. This mixture was then repasteurized to inactivate the lipase, and destroy undesirable organisms present in the raw portion of the milk.

Procedures in Trial 1 (Fig. 2) resulted in a cheese having the highest score, as compared to others, for cheese flavor and acceptability of salt, when stored at 21-23°C after 1 and 2 weeks, respectively. After 1 month of ripening, the cheese packed in aluminum foil at 4.4°C was graded superior to samples stored at 21°C in relation to all other samples in Trial 1. All trials using brine, comprised of brine and milk, or salted whey, gave varied results. These samples stored at 4.4°C, were described as having unnatural bitter flavors and weak body. A gassy condition was also evident at 21°C. Lack of proper acid development would be related to a weak body at the lower storage temperature. High storage temperatures together with bacterial contaminants would explain the samples exhibiting gas and bitter flavor.

From this experiment the following conclusions can be made:

1. The use of mixed raw and pasteurized milk repasteurized, produced a limited fat hydrolysis and mild rancid flavor. This represented a major accomplishment for the product being developed.

2. At least 1% starter was needed to produce the desired acidity and flavor characteristics in the final product.
(3) Using 5% salt produced an acceptable product, in relation to
taste, body and texture.

(4) Packaging in aluminum foil was superior to brine packaging in
respect to the flavor development during storage.

Experiment III

In Experiment III (Fig. 3), the effect of different cultures on
the process was examined. Pure strains of *S. lactis* and *L. casei* were
combined in various proportions. These organisms were selected because
the former is primarily an acid producer with limited proteolytic
activity, while the later also produces acid but is more proteolytic
than *S. lactis*. In addition, a new salting technique was tried
(Trial 2), in which no salt was added to the milk. The product was
then packed in foil, 5% brine and 5% salted whey, respectively.
Finally, two other variables were introduced, one using a lipase
enzyme preparation, to substitute for the mixed raw and pasteurized
milk trial. For the other variable a new storage temperature (10°C)
was used. Results of the third experiment are summarized as follows:

(1) In Trial 1, the product in which (1:1) mixed starter was used,
appeared promising, particularly when packed in aluminum foil and
stored at 4.4°C or 10°C. The products developed from (1:2)
starter mixture resulted in a weak body, perhaps related to the
lack of total acid production. The samples made with (2:1)
starter developed a bitter flavor. Again, this could be due to
the imbalance of growth between the two strains of organisms.

(2) Trial 4 resulted in a cheese with a pasty texture, perhaps
related to a weak body firmness and lack of whey drainage.
(3) All samples included in Trial 2 had body and texture defects due to the slowness of whey drainage.

Experiment IV

To further evaluate the use of lipase, two types of lipase enzyme preparations KL- and L- were used. In addition, a new dry salting technique was tried. Results of Experiment IV (Fig. 4), indicate that the fresh product stored at 4.4°C and 10°C, with 5% salt added to the milk in Trial 2, gave an acceptable product. Some pastiness and an excessive rancid flavor developed in the cheese in Trail 3, in which both Kir and L-lipase preparations were used. All samples stored in 3% salted whey at 21°C developed a hard curd, excessive saltiness and some gassiness. The samples in which a 5% salted whey was used as the salting process did not develop a satisfactory cheese flavor or body. By using the new salting technique of adding 3% dry salt to the curd, a hard and coarse curd was produced with an excessive salt content. This may have been due to an improper salt distribution and its effect on whey drainage. Finally, an excessive bitterness probably from protein degradation was noted in all samples in the experiment. This could be due to the more than expected activity of L. casei.

Results of this experiment indicated that the highest score was given to cheese made from R & P milk, using 1% starter, packed dry in aluminum foil and stored at 10°C for 3 weeks.

Experiment V

From Experiments III and IV, it was noted that L. casei resulted in excessive bitterness, i.e. protein degradation. To offset this
problem, a high level inoculum of (1.5%) commercial lactic culture was tried, and a lower salt concentration (4%) was introduced as new variables.

Results of Experiment V (Fig. 5) confirmed that cheese made by the R & P treatment in Trial 2, scored the highest in all respects during ripening when compared to Trial 1 which lacked proper flavor, and Trial 3 which developed a pasty curd. All panel members agreed that the most acceptable product was from samples in which 5% salt was dissolved in the milk together with 1.5% commercially mixed strain of lactic culture followed by storage at 10°C. This improved product was probably due to the activity of the lactic culture organisms (Streptococcus sp. and Leuconstoc sp.), and proper ripening temperatures.

Experiment VI

Experiment VI (Fig. 6) was carried out to study the possible effect of reducing the amount of L-lipase to achieve a milder flavored cheese. Results indicated that even after reducing the recommended amount of lipase from 1.5 g to 0.5 g/100 lb of milk, the product has a very rancid flavor from excessive lipolytic enzyme activity.

Preliminary trials with a small hand pressing device for more rapid whey drainage were successful on the cheese produced in each of the trials in this experiment. These samples developed a satisfactory firm body during 4 weeks of ripening. All cheese curds in this experiment were cut by the vertical American knives, in place of the traditional method of ladling. This method resulted in the cheese having a satisfactory body and texture, as well as good slicing characteristics.
Results of the sixth experiment are summarized as follows:

1. The mixed R & P milk cheese produced the desired milk rancid flavor in contrast to the L-lipase treated pasteurized milk cheese.
2. Use of 1.5% commercial lactic culture produced a cheese with a more desirable acid, flavor and aroma than use of 1.0% inoculum.
3. The use of 5% salt gave a more satisfactory degree of saltiness than samples containing 4%.
4. Although the use of mechanical pressing reduced the time of whey drainage and resulted in a very satisfactory body and texture, the use of plastic cups resulted in a product with a more desirable flavor.

Experiment VII

This experiment (Fig. 7) was designed to further evaluate the effect of whey drainage methods on cheese flavor, as well as the effect of storage temperatures on the shelf life.

Results of scoring by the pannel indicated that the curd drained in plastic cups (Trial 1), was superior in flavor and body and texture, in contrast to the curd drained in cheese hoops with (Trial 2) or without pressure (Trial 3). During storage, samples from Trials 2 and 3 lacked in development of flavor and aroma profile. The high moisture level retained in samples from Trail 1 was probably conducive to bacterial flora for proper flavor development during storage.

In summary, results of Experiment VII, revealed that samples packed in cups (Trial 1) and stored at 10°C for 3 weeks then transferred to 4.4°C for 4 weeks, developed a more desirable flavor profile, body and texture and longer shelf life over samples from Trials 2 and 3.
From all of the previous experiments, the following procedure is recommended for manufacture of a modified white cheese. Equal amounts of raw and homogenized pasteurized milk are mixed thoroughly, allowed to set for 1 hr at 15.5°C and then repasteurized. After cooling to 35°C following pasteurization, 1.5% inoculum of mixed strain commercial lactic culture (FLAV-O-LAC cultures, The Dairy Laboratories), is added. After the titratable acidity increases to 0.02%, 5% salt is added. Twenty ml of concentrated rennet per 100 lb of milk is added and the curd is then ready to cut after 2.5 hr. The curd is cut by vertical knives used in both directions, transferred to creole cheese molds, inverted every 10-12 hr for 2 days. The finished product surface is treated with 0.2% sorbic acid to control mold and surface growth. Samples may be packaged in sterilized plastic bags and stored for 3 weeks in cheese room at 10°C, followed by storage at 4.4°C for the remaining ripening period of 4 weeks.

Further work is needed to determine the best method for commercial packaging.

Chemical Changes During Ripening

Information on chemical composition of the cheese manufactured by the recommended procedures is summarized in Tables 1 to 5 and in detail in Appendix Table 1.

Moisture

Generally, during the ripening of cheese a loss in weight occurs and is mainly due to evaporation of moisture, however in the present study the loss in weight was due to high moisture content and
Table 1

Average Composition of White Cheese During Ripening Period*

<table>
<thead>
<tr>
<th>Sample Age (Weeks)</th>
<th>Moisture %</th>
<th>Fat %</th>
<th>Acid %</th>
<th>pH</th>
<th>Salt %</th>
<th>Total Protein %</th>
<th>W. Soluble Protein %</th>
<th>Soluble Protein Coefficient</th>
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<td>0.20</td>
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<td>0.45</td>
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<td>19.82</td>
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<td>3.43</td>
<td>11.28</td>
<td>3.23</td>
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</table>

*Three replicates
Table 2  
Average Composition of White Cheese During Ripening Period*  

<table>
<thead>
<tr>
<th>Sample Age (Weeks)</th>
<th>Total Solids</th>
<th>Fat</th>
<th>Acid</th>
<th>Salt</th>
<th>Total Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26.42</td>
<td>45.57</td>
<td>0.76</td>
<td>13.85</td>
<td>26.88</td>
</tr>
<tr>
<td>1</td>
<td>35.21</td>
<td>53.30</td>
<td>0.68</td>
<td>9.57</td>
<td>31.20</td>
</tr>
<tr>
<td>2</td>
<td>37.48</td>
<td>57.33</td>
<td>1.20</td>
<td>8.21</td>
<td>33.07</td>
</tr>
<tr>
<td>3</td>
<td>37.87</td>
<td>57.06</td>
<td>1.69</td>
<td>8.58</td>
<td>30.53</td>
</tr>
<tr>
<td>4</td>
<td>38.20</td>
<td>52.87</td>
<td>1.78</td>
<td>8.32</td>
<td>31.57</td>
</tr>
<tr>
<td>5</td>
<td>38.74</td>
<td>49.81</td>
<td>1.76</td>
<td>8.57</td>
<td>31.07</td>
</tr>
<tr>
<td>6</td>
<td>38.64</td>
<td>51.65</td>
<td>1.81</td>
<td>8.33</td>
<td>30.33</td>
</tr>
<tr>
<td>7</td>
<td>38.54</td>
<td>51.42</td>
<td>2.02</td>
<td>8.90</td>
<td>30.08</td>
</tr>
</tbody>
</table>

*Dry Basis
subsequent whey drainage. As shown in Table 1, the cheese lost 12.12% of its moisture during the 7 weeks of ripening. The major loss took place in the first week, being about 8.79% followed by a slight decrease, and remained fairly stable thereafter. This loss may be due to the higher moisture content of the fresh product. The average moisture content was 73.58% initially, 62.13% after 3 weeks, and 61.46% at the end of 7 weeks.

Van Slyke and Price (57) summarized the factors affecting the rapidity and extent of loss of moisture as follows: (1) temperature of the curing room or storage; (2) the proportion of water vapor presented in the air of the curing room; (3) size and shape of the cheese; (4) moisture content of the cheese; (5) the quality of the cheese; and (6) the use of paraffin or type of wrapping. These factors, particularly 1, 3, 4 and 5, are related to the variations observed in moisture content of the white soft cheese in this study.

The above results were higher than those found by Zerfiridis and Kristoffersen (59) who reported an average moisture of 57% for Feta cheese after 8 weeks. Kaloyereas (20) reported a lower figure of 50.02% moisture for Greek Feta cheese found in the American market. His results may have been due to the aged cheese, as well as the different methods of salting and packaging.

Fat

The average fat percentages in the original cheese and also on a dry weight basis, are shown in Tables 1 and 2.

Results in Table 1 indicate that there was an increase in fat percentage during the first 3 weeks of ripening, followed by a slight
decrease. The average on the first day was 12.02% and 21.61% after 3 weeks, which was expected due to the loss of moisture during ripening.

When the fat percentage was calculated on dry weight basis in Table 2, figures obtained showed the same pattern of increase during the first 3 weeks, and remained fairly stable thereafter. The averages were 45.57% initially, 57.06%, 51.42% after 3 and 7 weeks of storage, respectively.

Hofi et al. (17) reported lower results for fat on dry basis (FDM) for Domiati cheese made from cows' milk, namely 40.7%, 48.6%, and 48.8% after 1 day, 1 and 2 months of ripening, respectively. Meanwhile, Zerfiridis and Kristoffersen (59) reported an average of 57% FDM for Feta cheese 2 month old which was considerably higher than found in the present study.

**Titratable Acidity**

It has been established that the rate and extent of acid development influences the texture and subsequent ripening of the cheese. Results in Table 1 indicated that the acidity of white cheese increased steadily during the ripening process. The titratable acidity was 0.2% initially, 0.64% and 0.78% after 3 and 7 weeks of storage, respectively. The same pattern was noted when acidity was calculated on a dry basis (Table 2). The corresponding values were 0.76%, 1.69%, and 2.02%, respectively.

Hofi et al. (17) reported higher values than these above, for titratable acidity of raw milk Domiati cheese. Their values were 0.59%, 1.0%, 1.61%, and 2.29% after the first day and 1, 2 and 3 months
of ripening. The use of uncultured raw milk and its unknown bacterial flora could be the reason for their higher values.

**Hydrogen-ion Concentration**

There was a general decline in the pH values of all cheese samples during ripening (Table 1). These decreases in the pH similar to the increases in titratable acidity, were mainly due to the production of lactic acid by lactose fermentation. The average pH values were 6.72, 6.27, and 5.7 for 1 day, 3 and 7 weeks, respectively.

The above results were higher than Sirry and Kosikowski (52) who reported pH values of 6.4, 6.2, and 5.9 for Domiati cheese made from pasteurized milk using a lactic starter after 1, 7 and 30 days, respectively. They also noted the same gradual decrease in pH values with raw milk treated with H$_2$O$_2$ using an entroccoci starter.

Zerfiridis and Kristoffersen (59) reported pH values for Feta cheese made without added lipase paste, as 4.6 and 4.5 for storage period of 7 days and 2 months, respectively. They reported the same results for samples made with added lipase.

**Salt Content**

As previously mentioned, the traditional method of using high salt concentrations was practiced to inhibit the undesirable bacterial growth caused by the use of raw milk. In the present study, 5% salt was added to the milk first, to insure its proper distribution, as well as improve flavor and shelf-life by partial retardation of undesirable bacterial growth.

The results for the analysis of salt (expressed as sodium chloride) are shown in Table 1, in which a slight decrease was noted
during the first 2 weeks of storage. No significant change occurred thereafter. It was 3.66% initially, 3.11% and 3.43% after 2 and 7 weeks, respectively. When salt was calculated on dry basis (Table 2), there was a drop from 13.85% after the first day to 9.57% after 1 week, after which there was no significant change.

All other workers reported higher results than above, since the amount of salt added exceeded the quantity and percentages used in the present study. Hofi et al. (17) reported the salt content of Domiatı cheese as 4.4%, 5.0%, 5.2%, and 5.3% after 1 day, 1, 2 and 3 months, respectively. Meanwhile, Sadek and Hamed (45) gave an average value of 6.27% for market Domiatı cheese. Zerfiridis and Kristoffersen (59) listed the salt content of Feta cheese as 4.5% and 4.7% for 7 days and 2 months, respectively.

**Total and Soluble Protein**

In the previous literature review, it was noted that proteins are one of the principle constituents of milk which undergo chemical and physical changes during ripening of cheese. The insoluble nitrogenous constituents are to some extent changed to soluble forms. During this progressive proteolysis, the paracasein and other proteins are gradually converted to simpler nitrogenous compounds.

Results for the total and soluble protein content of cheese calculated from Kjeldahl N are presented in Tables 1 and 2. Although the figures for total protein indicated a steady increase during the first 2 weeks, it remained fairly constant thereafter, as would be expected due to change in moisture content. The average total protein content was 7.17% initially, 12.40% and 11.28% after 2 and 7 weeks,
respectively. When total protein was calculated on dry basis (Table 2), the same pattern was noted, namely 26.88%, 33.07%, and 30.08% initially, after 2 and 7 weeks, respectively. These results confirm those of Kelly (21) in his study on cheddar cheese. He noted that there is no significant change in total nitrogen content during ripening.

Hofi et al. (17) reported a total protein content of 11.65% for 1 month Domiati cheese made from raw cows' milk. Cheese of a similar age in this study contained 12.08%. Meanwhile, Kaloyereas (20) also listed a very high total protein content of 17.29% for commercial Feta cheese found in American market.

The higher total protein percentages observed in pasteurized milk cheese in contrast to raw milk cheese is due to the denaturation and retention of soluble proteins in the pasteurized milk curd. Van Slyke and Price (57) demonstrated the effect of heat on whey soluble proteins by electrophoretic techniques. They concluded that the high degree of heat treatment of milk was associated with an increase in the denatured albumin and globulin. In addition, Kosikowski (28) noted that when the heated milk was allowed to clot by rennet, the denatured soluble proteins will be retained in the resulting paracasein curd causing an increase in the total protein content of the finished cheese.

As previously mentioned, during the ripening process, casein undergoes several changes with the production of simpler nitrogenous compounds such as polypeptides, peptones, amino acids and ammonia, which are soluble in water and trichloroacetic acid. The degradation of protein in cheese ripening is caused by the enzymes and bacterial activity. The extent of activity by these agents are influenced by
factors such as time, moisture, acidity, salt, cultures and type of original milk used.

Results presented in Table 1 indicate a steady increase in soluble protein content. It was 2.14% on the first day, 2.58% after two weeks followed by slight decrease, then increased at the end of ripening to 3.23%. This could have been due to the change in ripening temperature from 10°C for 3 weeks to 4.4°C for the remaining 4 weeks.

The decline of soluble protein coefficient (soluble protein/total protein) from 25.02% in the first day to 20.14% after 1 week, may have been due to the higher moisture loss at the beginning of ripening which was 12.12%. The coefficient increased gradually towards the end of ripening to 28.46% after 7 weeks, which is an indication of some protein breakdown.

Kaloyereas (20) reported a soluble protein content of 5.57% for Feta cheese sold in the United States, which was a greater breakdown of casein than found in the cheese in this study. Hofi et al. (17) listed 3.29%, 3.10% and 3.69% soluble protein for 1, 2 and 3 months, respectively, which was higher than the corresponding data in this work. Sirry and Kosikowski (52) reported a lower soluble nitrogen percentage of 0.18% for 1 month Domiati cheese using lactic culture. This lower value could be due to the inhibitory action of salt used; i.e. 7.5%.

Free Fatty Acids

The action of lipolytic enzymes has long been recognized in the liberation of fatty acids by hydrolysis of the fat and its flavor importance in the ripening of many cheese varieties. The free fatty
acids content of the cheese in this study are listed in Tables 3 and 4, and are expressed as μMoles/100 g cheese on dry basis. It can be noted from these data that there was an increase in the C₂ short chain fatty acid during the first 3 weeks followed by a gradual decrease. No established pattern was noted for C₃, C₄, and C₅, but generally, a gradual decrease was observed during the same period. Apparently the change in ripening temperature (10°C for 3 weeks and 4.4°C for the remaining period) resulted in a decrease of the lipolytic activity.

Concerning the longer chain fatty acids (C₆ and higher), it was noted that the concentration reached a peak in 5-6 weeks, followed by a slight decrease. It was also noted (Table 4), that myristic, palmitic, oleic, linoleic, and linolenic acids represented the largest proportion and concentration, particularly palmitic acid.

Zerfiridis and Kristoffersen (59) conclude that Feta cheese, which contained approximately 15 mg/g of ≥C₄ fatty acids at 2 months, possessed the most desired flavor.

Efthymiou and Mattick (8) indicated that the rancid flavor in Feta cheese was associated with the free fatty acids from C₂ through C₁₀, while objectionable rancid flavor developed with high levels of C₁₂ - C₁₈ fatty acids. This was in agreement with the present study, it was noted at the end of ripening, objectionable rancidity had developed.

In another study by Efthymiou (9), a low concentration of total FFA, were characteristic of mild Feta cheese, however with acetic acid dominant. The sharp flavored samples were characterized by maximum amounts of FFA as compared to milder flavored samples. The acetic acid content did not change but its ratio to the total showed
Table 3

Free, Water Soluble Fatty Acid Content During Ripening*

<table>
<thead>
<tr>
<th>Sample Age (Weeks)</th>
<th>C₂</th>
<th>C₃</th>
<th>C₄</th>
<th>C₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>13.40</td>
<td>34.44</td>
<td>29.90</td>
<td>54.88</td>
</tr>
<tr>
<td>1</td>
<td>81.23</td>
<td>16.19</td>
<td>22.44</td>
<td>35.50</td>
</tr>
<tr>
<td>2</td>
<td>74.71</td>
<td>17.88</td>
<td>21.08</td>
<td>36.02</td>
</tr>
<tr>
<td>3</td>
<td>88.72</td>
<td>18.75</td>
<td>20.86</td>
<td>51.49</td>
</tr>
<tr>
<td>4</td>
<td>60.99</td>
<td>15.97</td>
<td>18.32</td>
<td>29.58</td>
</tr>
<tr>
<td>5</td>
<td>68.66</td>
<td>15.75</td>
<td>20.39</td>
<td>20.39</td>
</tr>
<tr>
<td>6</td>
<td>68.32</td>
<td>17.34</td>
<td>18.12</td>
<td>32.35</td>
</tr>
<tr>
<td>7</td>
<td>77.06</td>
<td>18.47</td>
<td>24.65</td>
<td>29.84</td>
</tr>
</tbody>
</table>

*UMoles/100 gm. cheese on dry basis
<table>
<thead>
<tr>
<th>Sample Age (Weeks)</th>
<th>C₆</th>
<th>C₈</th>
<th>C₁₀</th>
<th>C₁₂</th>
<th>C₁₄</th>
<th>C₁₆</th>
<th>C₁₈:2 &amp; C₁₈:3</th>
<th>C₁₈:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>239.0</td>
<td>106.0</td>
<td>337.0</td>
<td>333.0</td>
<td>1,438</td>
<td>29,150</td>
<td>2,082</td>
<td>1,851</td>
</tr>
<tr>
<td>1</td>
<td>190.3</td>
<td>85.2</td>
<td>328.3</td>
<td>372.9</td>
<td>1,449</td>
<td>59,642</td>
<td>1,968</td>
<td>2,272</td>
</tr>
<tr>
<td>2</td>
<td>355.7</td>
<td>80.0</td>
<td>284.7</td>
<td>300.2</td>
<td>1,281</td>
<td>53,360</td>
<td>1,849</td>
<td>1,600</td>
</tr>
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<td>176.9</td>
<td>106.0</td>
<td>328.5</td>
<td>314.0</td>
<td>1,347</td>
<td>47,530</td>
<td>2,041</td>
<td>1,700</td>
</tr>
<tr>
<td>4</td>
<td>117.8</td>
<td>86.0</td>
<td>290.8</td>
<td>196.0</td>
<td>864</td>
<td>20,420</td>
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<td>1,152</td>
</tr>
<tr>
<td>5</td>
<td>343.3</td>
<td>149.7</td>
<td>505.0</td>
<td>290.0</td>
<td>1,317</td>
<td>51,630</td>
<td>2,170</td>
<td>2,010</td>
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<tr>
<td>6</td>
<td>517.6</td>
<td>132.0</td>
<td>495.0</td>
<td>228.0</td>
<td>1,087</td>
<td>46,580</td>
<td>1,930</td>
<td>1,780</td>
</tr>
<tr>
<td>7</td>
<td>134.9</td>
<td>75.0</td>
<td>265.0</td>
<td>292.0</td>
<td>1,142</td>
<td>20,413</td>
<td>1,760</td>
<td>1,557</td>
</tr>
</tbody>
</table>

*μMoles/100 gm. cheese on dry basis
a sharp decrease. In his study the acetic acid did not comprise a high portion of the total acids, but in the sharp-flavored samples, either moderate or excessive amounts (4,225 - 10,876 mg/kg) of FFA were detected.

The above findings concerning the White cheese flavor were in agreement with Patton (37) who concluded that volatile acids were of prime importance in the aroma of cheddar cheese. This conclusion is also supported by earlier workers (30).

**Free Amino Acids**

The concentrations of free amino acids (FAA) found during ripening of white cheese are shown in Table 5. In general, a gradual increase of the FAA content was noted during 4 weeks followed by substantial decline. This increase coincides with the increase in the proteolytic bacterial counts as well as Standard plate count (SPC) and Psychrophilic counts, through the fourth week of storage. Analysis of samples from the fifth week indicated a marked decrease in the amount of FAA present after which a slight increase was observed. The bacterial counts including SPC, proteolytic and psychrophilic counts also significantly decreased on the fifth week, after which a slight increase was evident up to the seventh week. It would therefore appear that the two phenomena were related. The storage temperature reduction could account for the reduced bacterial counts and its activities. Consequently these organisms under stress probably utilized the FAA as an immediate source of nitrogen. Yet upon its gradual recovery, utilized other components of protein degradation.
Table 5
Free Amino Acid Content During Ripening \(^{(1, 3)}\)

<table>
<thead>
<tr>
<th>Sample Age (Weeks)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.20</td>
<td>0.31</td>
<td>0.46</td>
<td>0.74</td>
<td>1.87</td>
<td>0.25</td>
<td>0.06</td>
<td>0.14</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0.52</td>
<td>0.32</td>
<td>1.21</td>
<td>1.26</td>
<td>2.13</td>
<td>0.25</td>
<td>0.08</td>
<td>0.24</td>
</tr>
<tr>
<td>Aspartic</td>
<td>0.03</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
<td>0.04</td>
<td>0.05</td>
<td>0.003</td>
<td>0.02</td>
</tr>
<tr>
<td>Serine</td>
<td>—</td>
<td>(2)</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
<td>0.05</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Glutamic</td>
<td>0.06</td>
<td>0.09</td>
<td>0.08</td>
<td>0.11</td>
<td>0.15</td>
<td>0.02</td>
<td>0.004</td>
<td>0.02</td>
</tr>
<tr>
<td>Proline</td>
<td>—</td>
<td>0.03</td>
<td>0.07</td>
<td>0.08</td>
<td>0.16</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Glycine</td>
<td>0.01</td>
<td>0.01</td>
<td>0.002</td>
<td>0.006</td>
<td>0.006</td>
<td>—</td>
<td>—</td>
<td>0.002</td>
</tr>
<tr>
<td>Alanine</td>
<td>0.01</td>
<td>0.09</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>—</td>
<td>0.002</td>
</tr>
<tr>
<td>Valine</td>
<td>—</td>
<td>0.04</td>
<td>0.04</td>
<td>0.06</td>
<td>0.07</td>
<td>0.02</td>
<td>—</td>
<td>0.02</td>
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<tr>
<td>Methionine</td>
<td>—</td>
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<td>—</td>
<td>—</td>
<td>0.02</td>
<td>—</td>
<td>0.01</td>
<td>—</td>
</tr>
<tr>
<td>Isocitrulline</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.003</td>
</tr>
<tr>
<td>Leucine</td>
<td>0.01</td>
<td>0.03</td>
<td>0.02</td>
<td>0.10</td>
<td>0.15</td>
<td>0.04</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>0.004</td>
<td>0.01</td>
<td>0.02</td>
<td>0.002</td>
<td>0.03</td>
<td>0.01</td>
<td>—</td>
<td>0.01</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.10</td>
<td>0.12</td>
<td>0.05</td>
<td>0.004</td>
<td>0.02</td>
</tr>
</tbody>
</table>

\(^{(1)}\) On wet basis
\(^{(2)}\) Unmeasurable quantity of amino acid
\(^{(3)}\) Histidine, Arginine, Threonine, Cystine were not present or found in unmeasurable quantity
It appeared that the basic amino acid lysine and ammonia were present in larger percentages than the other FAA. From the same data in Table 5, it can be seen that the major amino acids present after 4 weeks were phenylalanine, leucine, proline, glutamic acids, as well as lysine and ammonia.

Many statements have been made in regard to the importance of cheese flavor development and formation of amino acids and peptides. Kosikowski (25), in a study of cheddar cheese, reported the appearance of many free amino acids very rapidly in both raw and pasteurized milk cheese. Glutamic acid, leucine, methionine, basic amino acids, valine and phenylalanine reached high concentrations in raw milk cheese after 180 days of ripening, while for the pasteurized milk cheese, glutamic acid, basic amino acids, phenylalanine and asparagine increased in high proportions. Other amino acids were detected in raw milk cheese but not in the pasteurized milk cheeses.

Kosikowski and Dahlberg (27), estimated the FAA and related compounds of 30 commercial foreign type cheeses. Their study revealed that glutamic acid, leucines, valine and basic amino acids were predominating. Although some differences were observed, they concluded that no foreign cheese could be solely identified by its chromatographic amino acid pattern.

Koning (24) stated that every type cheese has its proper peptide pattern and assumed that a particular type may be identified by its peptide pattern.

From the preliminary results in the present study, the amino acid pattern could be identified by the presence of larger percentages of glutamic acid, proline, leucine, phenylalanine, as well as lysine
and ammonia. Further studies would be needed on this type white cheese to determine whether or not the above pattern is characteristic.

Bacteriological Changes During Ripening

Bacteriological analysis are shown in Table 6. The standard plate count increased from $16 \times 10^4$/g on the first day to $46 \times 10^6$/g after the third week of ripening, followed by a slight decline then stayed fairly constant thereafter. The decrease after the fourth week was probably due to the change of temperature during ripening.

Zerfiridis and Kristoffersen (59) reported counts of $2.5$ and $2.0 \times 10^6$/g for Feta cheese, made without added lipase paste, stored for 7 days and 2 months, respectively. This lower count could be due to their use of 1% lactic culture instead of 1.5% in this study, as well as the inhibitory effect of 4.7% salt concentration in their cheese.

The coliform count increased from 2/g initially to 7/g after 3 weeks, then decreased to 3/g and <1/g after 4 and 6 weeks, respectively. This decrease of coliform could be due to the inhibitory effect of acidity and salt concentration as well as the change in temperature after 4 weeks. Sadek and Eissa (47) reported that a salt concentration of 9.5% or higher and an acidity of not less than 1.2%, had an inhibitory effect on the growth of coliforms in Domiati cheese. Sadek and Hassan (44) concluded that the high salt content of Domiati cheese also had an inhibitory effect on gas formation. Other workers (5, 22) reported similar findings as Sadek and Eissa (47).
Table 6
Average Bacterial Content of White Cheese During Ripening(1)

<table>
<thead>
<tr>
<th>Sample Age (Weeks)</th>
<th>Standard Plate Count</th>
<th>Coliform Count</th>
<th>Proteolytic Count</th>
<th>Yeast and Mold</th>
<th>Psychrophilic Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$16 \times 10^4$</td>
<td>2</td>
<td>$2 \times 10^4$</td>
<td>$22 \times 10^5$</td>
<td>$3 \times 10^4$</td>
</tr>
<tr>
<td>1</td>
<td>$32 \times 10^5$</td>
<td>19</td>
<td>$35 \times 10^4$</td>
<td>$22 \times 10^5$</td>
<td>$2 \times 10^6$</td>
</tr>
<tr>
<td>2</td>
<td>$40 \times 10^6$</td>
<td>15</td>
<td>$13 \times 10^5$</td>
<td>$39 \times 10^5$</td>
<td>$7 \times 10^6$</td>
</tr>
<tr>
<td>3</td>
<td>$46 \times 10^6$</td>
<td>7</td>
<td>$20 \times 10^5$</td>
<td>$21 \times 10^5$</td>
<td>$58 \times 10^4$</td>
</tr>
<tr>
<td>4</td>
<td>$22 \times 10^6$</td>
<td>3</td>
<td>$30 \times 10^5$</td>
<td>$5 \times 10^5$</td>
<td>$39 \times 10^5$</td>
</tr>
<tr>
<td>5</td>
<td>$14 \times 10^6$</td>
<td>3</td>
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<td>6</td>
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<td>7</td>
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<td>&lt;1</td>
<td>$51 \times 10^5$</td>
<td>$164 \times 10^5$</td>
<td>$198 \times 10^5$</td>
</tr>
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</table>

(1) Per gram, on wet basis
The proteolytic bacterial counts during ripening have been presented in Table 6. A steady increase was noted in the proteolytic count from $2 \times 10^4$ initially to $30 \times 10^5/g$ in 4 weeks, followed by a slight decrease and a final increase at the end of ripening to $51 \times 10^5/g$. This corresponds with the analysis of the FAA, which revealed that the highest percentage of the FAA appeared within 4 weeks followed by a marked decrease on the 5th week.

The yeast and mold count reported in Table 6, indicated an increase from $22 \times 10^5$ initially, to $39 \times 10^5$ after 2 weeks, followed by slight decrease, then an increase to $164 \times 10^5$ at the end of ripening. This could have been related to the temperature changes of ripening, which was $10^\circ C$ for the first 3 weeks and $4.4^\circ C$ for the remaining period. Zerfiridis and Kristoffersen (59) reported a yeast and mold count of 10 and $26 \times 10^3/g$ for 7 days and 2 months, respectively for Feta cheese made without lipase paste.

Psychrophilic count exhibited the same phenomenon as that found in the SPC and proteolytics. It was $3 \times 10^4/g$ initially, increased to $7 \times 10^6/g$ in 2 weeks, and then dropped slightly. On the 7th week the count significantly increased to $198 \times 10^5/g$. The higher counts of psychrophiles, as well as higher yeast and mold counts were associated with the samples having excessive rancidity and other objectionable flavors.
SUMMARY AND CONCLUSIONS

This investigation was initiated to study the possibility of developing a new type of a mild cheese acceptable to the American consumer, based on the traditional method of making white cheese by the name "Feta". This is very similar to Domiati cheese. In this project pilot scale experiments were carried out using: mixed raw and pasteurized milk, lactic starter culture, lipolytic enzyme preparations, controlled cooling, pasteurized milk, various techniques for cheese cutting and whey drainage. Other variables introduced were lower salt content, mechanical pressing, various types of packaging, control of surface growth by sorbic acid and various ripening temperatures.

A score card was designed and six trained judges participated for weekly evaluation of the cheese up to 8 weeks of storage.

A procedure for manufacturing a mild type "Feta" cheese has been developed. The two unique factors involved were the blending of raw and pasteurized homogenized milk followed by repasteurization and the sequential ripening temperature of 10°C and 4.4°C. Cheese made by this procedure possesses a mild blend of fat hydrolysis, proteolysis and associated cheese flavors. Results of two trials for consumer evaluation revealed that 78% would buy this new cheese product at reasonable price.

Samples from the fresh product and during ripening were analyzed chemically and bacteriologically. The average composition after 3 weeks of ripening was: 62.13% moisture, 21.61% fat, 11.57%
total protein, 2.45% soluble protein, 0.64% titratable acidity, pH 6.27 and 3.25% salt with standard plate count of $46 \times 10^6$/g, coliform count 7/g, yeast and mold $21 \times 10^5$/g, psychrophilic count of $58 \times 10^4$/g and proteolytic count $20 \times 10^5$/g.

It has been recognized that there is a relation between the development of cheese flavor and formation of free fatty acids and amino acids. The short chain fatty acids, particularly acetic, and the longer chain fatty acids ($C_{14}$, $C_{16}$ and $C_{18}$ group) as well as the amino acids glutamic, proline, leucine, phenylalanine, lysine and ammonia, play a major role in developing the characteristic white cheese flavor.
SELECTED BIBLIOGRAPHY


Appendix I. Average composition of white cheese during the ripening period.

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<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Fat</th>
<th>% Dry Basis</th>
<th>Acidity % Dry Basis</th>
<th>pH</th>
<th>% Salt Dry Basis</th>
<th>% Total Protein Dry Basis</th>
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<td>3.42</td>
<td>12.67</td>
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## Appendix II. White cheese score card.

<table>
<thead>
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<th>Panel member name</th>
<th>Date</th>
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### Sample number

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<th>7</th>
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</table>

1. **General Appearance:**
   - A. Creaminess
   - B. Free whey
   - C. Sliminess
   - D. Other comments

2. **Body and Texture:**
   - A. Smoothness
   - B. Firmness (slicing quality)
   - C. Other comments

3. **Flavor level:**
   - A. Acid
   - B. Bitter
   - C. Salt
   - D. Cheese flavor
   - E. Fat hydrolysis (rancidity)
   - F. Other comments

4. **Other criticisms not covered above:**

5. **Please explain above criticisms:**

Please give a grade from the five point scale as follows:

1. Rejectionable  
2. Dislike  
3. Acceptable  
4. Like very much  
5. Like extremely

---

*Note: The table is a template for scoring white cheese based on various attributes.*
VITA

The author was born in Cairo, Egypt on August 28, 1939. He attended grammar, junior high, and high schools in Cairo, where he was graduated in 1955. In September 1955 he entered Ain Shames University, and completed the requirements for the B.S. degree in the field of Dairy and Food Science in June 1959. During the years 1959 to January 1967, he taught high school chemistry and biology for one year, then worked for the Department of Agriculture.

He entered the Graduate School of Ain Shames University in 1963 to pursue work toward the M.S. degree in Dairy Chemistry and Manufactured Products. He received the degree in June 1966.

In February 1967, he came to the United States as a permanent resident, and worked in New Orleans, Louisiana as Senior Chemist, Standard Brands, Inc. and as Quality Control Supervisor, Sealtest Foods. The author entered the Graduate School of Louisiana State University and Agricultural and Mechanical College in February 1969 to pursue work toward the Ph.D. degree under the guidance of Dr. J. H. Gholson in the field of Dairy Manufacturing with a minor in Food Science. He completed the requirements for the degree in August, 1971.
Candidate: Edward Halim Youssef

Major Field: Dairy Science (Manufacturing)

Title of Thesis: Studies on a Newly Developed White Cheese

Approved:

James A. Thorson
Major Professor and Chairman

Max Ferdinand
Dean of the Graduate School

EXAMINING COMMITTEE:

J. B. Frye, Jr.
Robert M. Grohner

A. D. Lawson

Date of Examination:

July 19, 1971