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Thermal Treatment of Cottage Cheese
"In Package" By Microwave Heating

presented by

Lisa M. Tochman

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Bruce R. Harte
Major professor

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THERMAL TREATMENT OF COTTAGE CHEESE "IN PACKAGE" BY MICROWAVE HEATING

By

Lisa Marie Tochman

A THESIS

Submitted to
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ABSTRACT

THERMAL TREATMENT OF COTTAGE CHEESE "IN PACKAGE" BY MICROWAVE HEATING

By

Lisa Marie Tochman

Cottage cheese of desirable quality is found to have a relatively short shelf-life compared to most ripened cheeses. The research described herein was an attempt to extend the product's shelf-life. Variables introduced included various "in package" heat treatments using several microwave sources, cooling techniques, and packaging materials. During storage of the cottage cheese, pH, moisture, whey-off, microbial analyses and sensory analysis were performed initially and every two weeks throughout the storage period. This research has shown that:

1. Microwave heating of packaged cottage cheese does influence shelf-life stability.
2. Exact heating times and temperatures are critical to product characteristics.
3. Microwave heating does not affect, by itself, pH of the cottage cheese.

4. Storage as well as microwave heating influences the moisture content of the cheese curd.
5. Packaging materials and techniques will affect the shelf-life of the product.

Sensory analysis demonstrated that microwaving the cottage cheese under different conditions influenced both flavor and texture.

To my parents, William and Irene Tochman,

my brother Mark and sister Lori

ACKNOWLEDGMENTS

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INTRODUCTION

Cottage cheese has become one of the more popular cheeses throughout the world. In the United States alone, the annual consumption is over one billion pounds and is increasing every year. Increased demands have been noted with the rising concerns for nutrition and weight control. One problem facing the cottage cheese industry is that it is a highly perishable product in relationship to many other types of cheeses on the market. For most commercial cottage cheese the shelf life is approximately 12 days. When quality control is stringent, it may last for up to 21 days (Kosikowski, 1977).

The objective of this investigation was to determine the effect of microwave heat treatments on cottage cheese "in package," as a means of shelf life extension. The heat generated from using microwaves must be sufficient to destroy the microorganisms which promote spoilage of the cheese without destroying the characteristic of the cheese.

One intent of this study was to compare microwave processed cheese with non-microwaved cottage cheese for shelf life. The shelf life of control cheese is not meant to be compared with that of commercial cheeses but simply as a means to evaluate and compare heated cheeses.

Microwave energy was used as the heating source for various reasons; the most important being, that, high temperatures can be reached in a very short time. This provides the thermal heat required to destroy spoilage organisms without causing product breakdown or package destruction. If conventional or convectional ovens were used, the time necessary to bring the product to sufficient temperature levels necessary for destruction of spoilage organisms, would cause product breakdown and package-destruction.

A second reason for microwaving "in package" has to do with the package itself. Cottage cheese is inherently loaded with microorganisms, by heating through the package, these numbers can be reduced and shelf life will be increased. Recontamination will be prevented by the package, which acts as a physical barrier; the package must maintain its integrity during and following the heating process. An important part of this study was to evaulate the effect of heating on the physical characteristics of the package.

LITERATURE REVIEW

Cottage Cheese

Cottage cheese is a soft, unripened, white cooked curd from milk to which cream and salt are added. It is a lactic acid coagulated product, in contrast to ripened cheese such as cheddar and swiss which are coagulated using the enzyme preparation, rennet (Kosikowski, 1977). The quality and yield of fresh cheese is largely determined by variables in the manufacturing process, while shelf life is influenced by post-cooking processes, washing, packaging and handling (Marshall, 1975). According to Reidy and Hedrick (1970), a detailed manufacturers report is recommended on each vat of cottage cheese to insure a high quality product.

Perishability and Spoilage

Kosikowski (1977) stated that the shelf life of cottage cheese is the period during which the cheese suffers no marked deterioration in quality including freshness, at a particular storage temperature. Today, cottage cheese may be anywhere from two to three weeks old before it is totally consumed. Because of this consumers demand a top quality product. Cottage cheese is very susceptible to microorganism infestation which can reduce shelf life. Infestation occurs as a result of poor sanitary and handling procedures (Yeager, 1972). Cottage cheese is usually held under refrigeration; because of lower temperatures, most organisms are dormant, but if the cheese is packaged at temperatures which are too high or the temperature of the cheese increases while enroute to the consumer, the organisms will tend to multiply and induce spoilage. The critical spoilage microorganisms for cottage cheese are; yeast, molds and bacteria, specifically: Pseudomonas, Achromobacter, Flavobacterium, Alcaligenes, Escherichia, and Aerobacter. Growth of these organisms produce off odors or flavors, some will result in surface discoloration, others, namely yeasts, will oxidize the lactic acid resulting in a pH increase. It is important to understand that if poor quality control procedures are observed, the above mentioned spoilage organisms will proliferate even at prevailing low holding temperatures. Economic looses and loss of consumer trust will result from the development of these organisms in the cheese (Marth, 1970).

Most spoilage organisms contaminate the product during the cooking stage when, improper temperatures are reached during this period or when the utensils are improperly sanitized, or if contaminated air and/or water enter the processing area or vat (Yeager, 1972). Therefore, it is especially important that the cooking room utilize filtered air, which will eliminate most bacteria, yeasts and molds. The water entering the room must be chlorinated. If the water has any strong off odors or flavors, it may be necessary to install an activated carbon filter, as cottage cheese is very susceptible to absorption of these off odors and flavors. The temperature of the rinse water is the most critical factor to control. The initial rinse water should have a temperature low enough to lower the curd temperature from 51.7°C to 29.0°C, the second, enough to lower the curd to a temperature of 15.5°C and the final rinse water low enough to result in a curd temperature of 4.4°C. Incoming wash water temperatures should be checked at least three times a week, preferably daily. The air and water in the packaging room should meet the same requirements as those in the cooking room (Yeager, 1972).

Defects in cottage cheese play a major role in the quality associated with cheese today. Marshall (1975) suggested that the most frequently occurring defects in flavor, body and texture (high acid flavor, shattered curd, and mealy texture) result due to failure to control, (1) starter activity (2) quality of inoculum (3) incubation time and temperature (4) acidity and method of measuring it (5) cooking procedure and (6) cooling procedure (which is mainly associated with shattered curd).

The average shelf life of cottage cheese is approximately twelve days when held at temperature no higher than 7°C. It has been noted in some cases, where quality control is stringent, to last up to 21 days. In rare circumstances, where sanitary and handling conditions are flawless, the cheese may last for 60 days or longer. The shelf life of the cheese is increased by maintaining the temperature of the curd and creamed product below 7°C at all times (Kosikowski, 1977).

Preservation

Freezing is one technique associated with shelf life extension of cottage cheese. Uncreamed cottage cheese can be held for up to 90 days by either freezing or brine storage. However, quality defects may occur during freezing; graininess and curd shattering are two typical defects observed. In brine salting, extra care in handling is required to insure the curds will remain in good quality for up to six months without evidence of quality change (Kosikowski, 1977).

Successful gasing of cottage cheese was noted by Tsantilis and Kosikowski (1975). Nitrogen or carbon dioxide in an air evacuated, hermetically sealed package extends the shelf life of creamed cottage cheese for several days at refrigerated temperatures.

Dehydrated cottage cheese is a highly soluble powder suitable for reconstitution. This process is expensive but has been useful in the armed services for longer shelf life in the fields. Upon reconstitution with clean water the product has the same qualities as fresh cheese (Kosikowski, 1977).

Sorbates in cottage cheese are used to treat the headspace surface of the cheese package, prior to lid placement. This provides an excellent preservation method for surface mold problems. Yeast, molds and bacteria are inhibited with the use of sorbic acid and its salts, due to the low pH of the cheese, along with sorbates, an excellent control of bacteria is established. Authorization for the use of sorbates is found in the FDA Standards of Identity for cottage cheese (19.530) and lowfat cottage cheese (19.531), CFR, Title 21 (Spiegel, 1973).

Irradiation preservation studies were performed by Yüceer and Gündüz (1980) on cheddar-type aged Kashar Turkish cheese. The results of the study indicated that when more than sufficient numbers of photons hit the sensitive regions of bacteria, only a certain fraction is necessary to destroy them, the rest not being used. Moreover, excess radiation can cause a loss in the nutritional value of cheese. It was found in the study that preservation by irradiation combined with refrigeration increased the shelf life of the cheese approximately, five-fold.

Microwaving

The use of microwave energy for preparation, processing, and preservation of foods today, is attracting a great deal of attention. The idea of microwave application in the food industry originated approximately 35 years ago (Loren, 1976). Successful commercial processing applications employing microwaves remains relatively small, and the majority of the success has been seen only within the last six years (Schiffmann, 1976).

Microwaves are a type of electromagnetic wave or "field" which include waves such as visible light, infrared, radio, and household electricity. Electromagnetic waves are analogous to the mechanical forces which make water move up and down and is described by quantities called "fields."

The field is a quantity expressed in volts per meter (or centimeter) which has the ability to move (+) and (-) charges, which exist in all matter in one form or another. Therefore, we can expect this field to interact with materials, particularly dielectric materials (including food). One can imagine currents, or charges in motion, within the material induced by this field. Because the electromagnetic wave is moving or propagating the charges which are at rest in the material do not see a steady field or force but one which alternates in direction at a rate called "frequency" (Figure 1). All electromagnetic waves

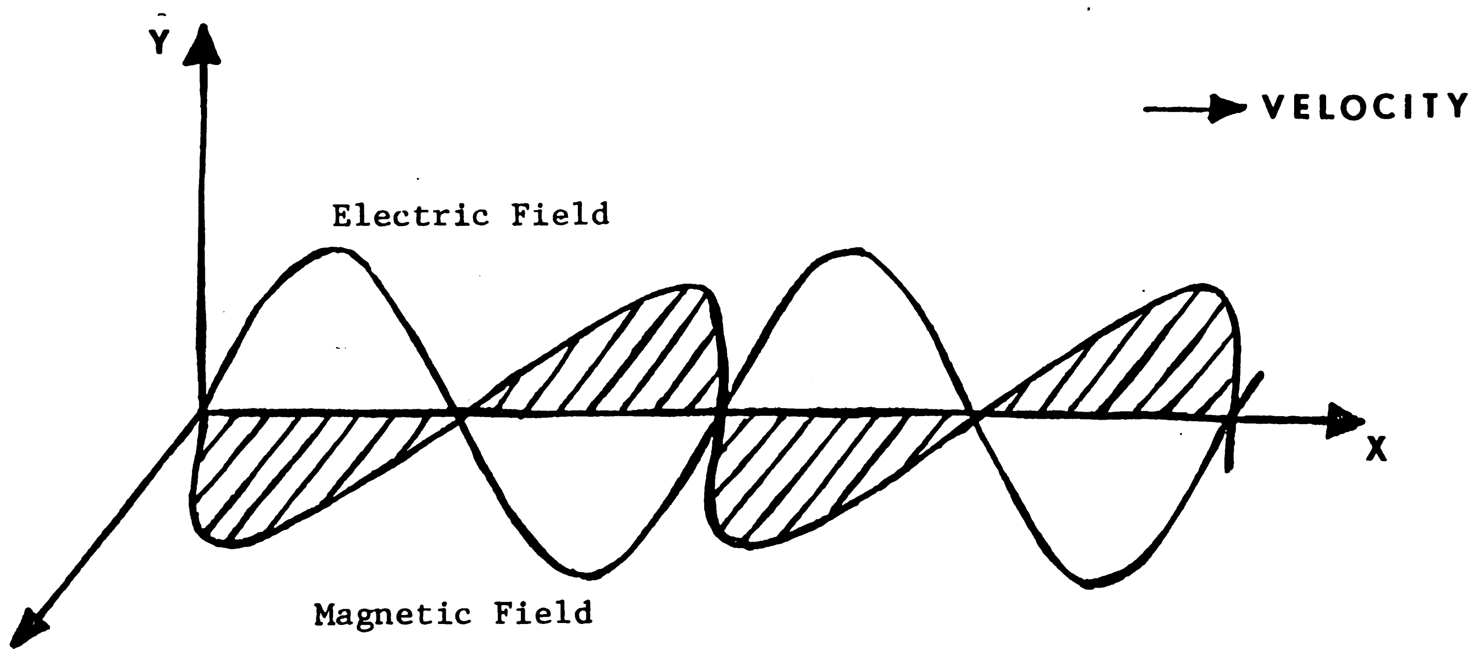


Figure 1. Propagating Electromagnetic Wave.

Source: Osepchuk, J. 1975. Basic Principles of Microwave Ovens Transaction of the International Microwave Power Institute.

move with the same velocity in free space. The frequency f = c/c, where c = the distance the wave moves in one second and c is the distance between field peaks (Osepchuk, 1975).

The microwave portion of the electromagnetic spectrum (Figure 2) is somewhat arbitrary, but can be based on the property of maximum coupling of electromagnetic energy to macroscopic objects (objects with dimensions in the range of 1 millimeter to 1 meter) of common use. The heating, cooking and biological effects of non-ionizing radiation depend on the "penetrating power" of the radiation, and the latter is expected to peak in the microwave region as noted in Figure 3.

At low frequencies food materials reflect the incident energy (directed toward), while at high frequencies the energy is absorbed near the surface of the object. Therefore, the field in the center of the object is comparable to the outside field only in the microwave range. To understand the penetration effect of microwaves in food materials, it is seen that a substantial amount of electromagnetic energy is reflected (Figure 4) while a substantial amount is transmitted into the substance with a change of direction that is called "refraction" (the same principle involved in the apparent shift of an object positioned under water when viewed from above the water). The energy transmitted into the substance is progressively

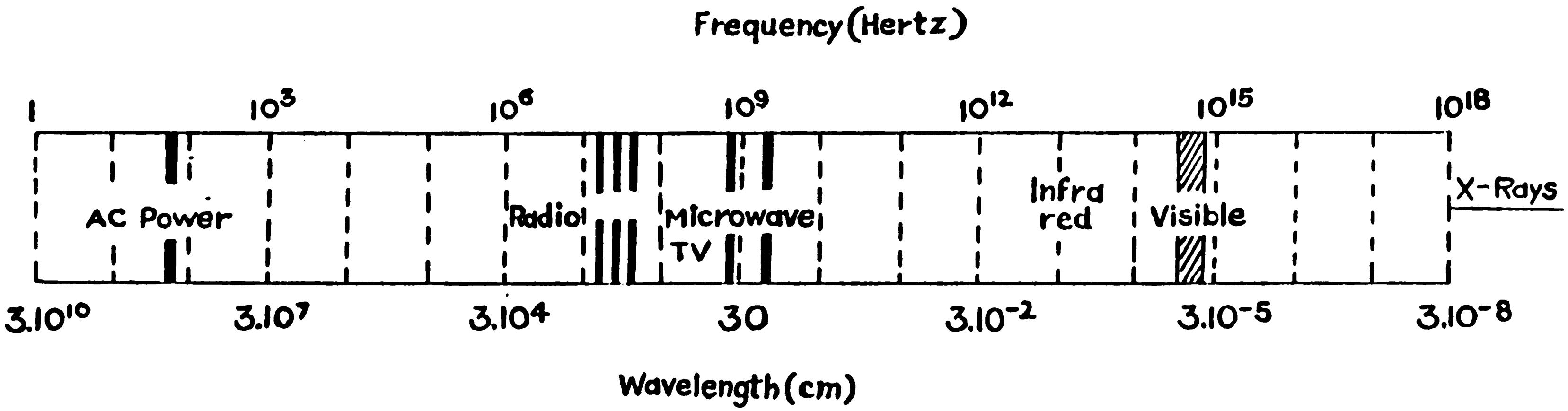


Figure 2. The Electromagnetic Spectrum

Source: Osepchuk, J. 1975. Basic Principles of Microwave Ovens Transaction of the International Microwave Power Institute

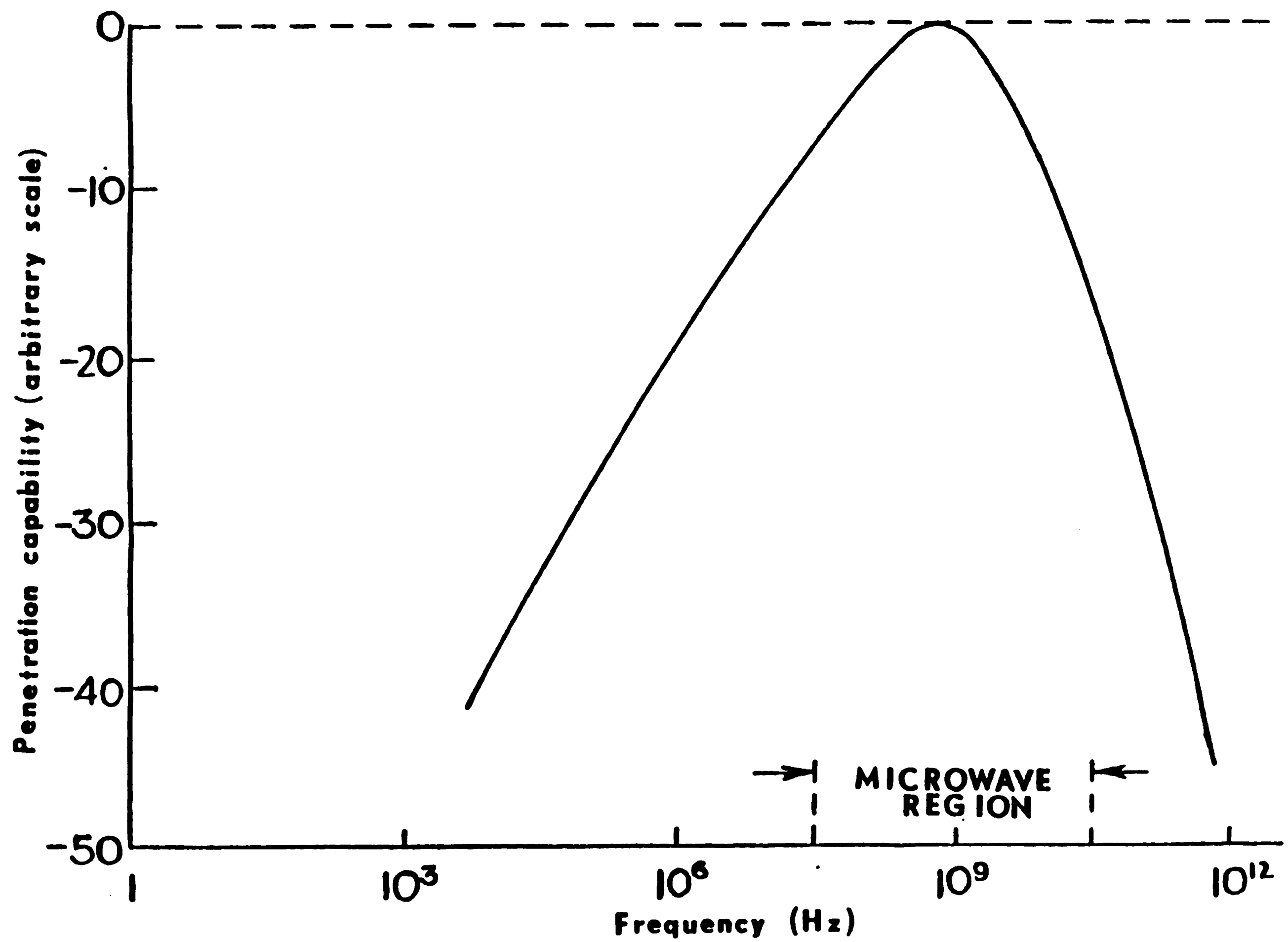


Figure 3. Penetration Capability as a Function of Frequency.

Source: Osepchuk, J. 1975. Basic Principles of Microwave Ovens Transaction of the International Microwave Power Institute.

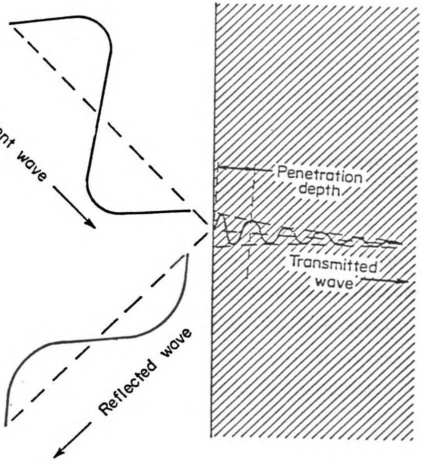


Figure 4. Electromagnetic Energy; Reflection-Transmission Into a Substance

Source: Osepchuk, J. 1975. Basic Principles of Microwave Ovens Transaction of the International Microwave Power Institute absorbed so that the wave decreases in magnitudes as it penetrates into the food.

It is important to note that water and high moisture materials such as food, exhibit a great deal of variation of the dielectric factor with temperature. Material of this nature will heat more rapidly resulting in increased penetration depths of the electromagnetic wave, yet less energy is required, therefore smaller peak absorption rates are observed (Osepchuk, 1975).

Dielectric heating refers to rapid and uniform heating throughout a non-conducting material by a high frequency electromagnetic field (the field is the entire range of wavelengths or frequencies of electromagnetic radiation--a series of electromagnetic waves extending from gamma rays to the longest radio wave including visible light).

When food is placed in a microwave oven, it is important to understand that the microwave rays are randomly reflected off the metal walls, sometimes being directed towards the food but at other times propagating to another wall without encountering the food product. The food load is important in determining whether or not the food is heated to the proper temperature. Large loads have approximately a 90 percent efficiency rate in energy absorbed. As the food load decreases in size, efficiency decreases, indicating loss in the waveguide (which is a metal pipe propagating electromagnetic waves of a given frequency) (Osepchuk, 1975).

Microwave Heating of Foods

Food cooked with microwave energy is heated by the transformation of electrical energy into heat energy upon absorption of the microwaves by the food. Food is a heterogeneous mixture containing water molecules which are not electrically neutral when placed in the electric field. The water molecules behave like magnets, which try to line up with the field. This is a difficult task to accomplish since the charges in the field are constantly switching back and forth. The energy the microwaves produce in trying to overcome this switching effect is converted to heat.

In the preparation of food one consideration to take into account is the cooking endpoint, which is a function of temperature. When speaking in terms of conventional cooking, the rise in temperature within the food product is directly related to its specific heat, which is the number of calories of heat required to raise the temperature of one gram of a substance one degree celsius. In microwave cooking, temperature is a function of specific heat as well as the energy absorbed by the food item. In a study performed by Janicki and Appledorf (1974), it was found that more moisture is lost in a food product when using microwave heat. This loss of moisture is due to a rise in the post oven temperature causing dehydration and shrinkage. In some circumstances, when using microwave power, additional water should be added to the food product or its mixture. It is, therefore, possible that the microwave radiation merely serves to heat the water and in turn the water acts as the heating mechanism to cook the product. Moisture is lost in the product, due to evaporation caused by heating.

Sterilization and Pasteurization

Industrial microwave systems achieve a degree of microbial reduction which is not possible with home or restaurant type ovens. A study performed by Smith (1977) revealed that chickens seeded with microorganisms and placed in small ovens showed no destruction of the organisms. When placed in industrial microwave ovens, microbial destruction was highly efficient. Industrial systems give more uniform heat, thus, infestation reduction is highly efficient. Industrial ovens should always be used for research purposes, since small ovens can yield uncertain results and misleading results.

Bakery products provide a good example of products which may utilize heat for destruction of microorganisms. Sale (1976), reported that cakes are inevitably contaminated by mold spores carried in the atmosphere. This contamination results during wrapping, one way of inactivating mold spores is by heat. Heating a wrapped cake by hot air would take a very long time because heat conducted through a film structure is poor. In contrast, microwaves can heat this type of structure easily.

The concept of microwave heat sterilization is very feasible but it has several problems. First, it presupposes that the heating is even, but this is very difficult to achieve. With uneven heating the temperature reached in the food differs from place to place. It is necessary to ensure that even the slowest heating parts of the food reach proper temperatures, therefore, other parts of the food reach higher temperatures and are overheated. There is no normal temperature limitation when using microwave heating. Heat is continually generated in the food (Sale, 1976).

Microwaves and Packaging

The microwave oven industry has opened up new markets for utensils and packaging to meet compatibility requirements with this type of heating. Since microwave cooking represents convenience, this convenience must be accompanied with appropriate utensils and packaging (Colan, 1979).

Packaging material characteristics that are required for microwave heating are as follows: (1) non-toxic, partially transparent to microwave energy, (2) heat resistant, (3) stain resistant, (4) non-porous,

(5) attractive and (6) inexpensive. Some materials suitable for microwaving are the following.

Polystyrene: The high end of the temperature tolerance range is 82.2°-93.3°C. As the temperature drops the material becomes increasingly brittle. The lower the temperature, the more brittle it becomes. Consequently, it is not suitable for use in the freezer, i.e., frozen T.V. dinners or dessert, as freezing would tend to crack the material.

Polypropylene: The high end of the temperature tolerance range is 104°C. However, the material becomes brittle when used at below freezing temperatures. Another aspect of polypropylene is that it becomes very soft as the temperature of the food inside increases. It has been found to be suitable for use with dry type foods or foods with gravies that contain little fat or sugar.

Low-Density Polyethylene: Low-density polyethylene is similar to polypropylene yet its high end of the temperature tolerance range is much lower, 71°-82.2°C. It does not become brittle at low temperatures but does become soft as the temperature of the food inside increases.

High-Density Polyethylene: Its appearance is similar to that of low density polyethylene but displays a much higher temperature tolerance, 104°C. The material does not become brittle at low temperatures.

Other materials suitable for microwaving are the following. However, they are considerably more expensive than those previously mentioned.

Material	Temperature Tolerance (Colato, 1979)
Polysulfone - extreme impact resistance	176.6°C
Polycarbonate - impact resistant	121.0°C
Nylon - very tough material	65.6°C - 93.3°C
Polyethylene Terephthalate	148.8°C - 204.4°C
Filled Polyester - Rigid Material	232.2°C

When determining which materials are suitable for a specific microwave application, transparency, temperature resistance, thermal strength, impact strength and price must all be considered (Colato, 1979).

In 1973 the paperboard package industry began exploring the growth of microwave oven sales and the potential usage of ovenable paperboard containers. Ovenable paperboard is a term used to describe an acceptable food packaging board which is coated with a heat resistant resin. The board provides grease and moisture barriers as well as imparting no odor or taste to the product being packaged.

Glass is another material which is eminently satisfactory for microwave cooking (when in the form of borosilicate glass, similar to that of Pyrex). Many new designs are being introduced into the market place, specifically designed for microwave cooking applications. Another suitable medium for microwave cooking is the pyroceram type of products as made by Corning. This type of material displays the same features as mentioned for glass (Colato, 1979). However, in terms of food packaging, these types of materials are not suitable due to the weight, shipping protection requirements (due to shattering), and because they would be more expensive than most other materials.

Cottage Cheese Packaging

Proper packaging along with good quality control programs insure quality cheese, leading to increasing uniformity and extension of the products shelf life.

Today's high speed packaging has resulted in providing consumers with monetary savings in regard to cheese prices. According to Kosikowski (1977) high speed packaging of cheese is not without faults. For example, many consumers prefer food in its "natural" state, requesting block cheese cut into sizes they desire and having cottage cheese weighed from a larger holding container into smaller, individual containers of their requested or desired size. This preference may be related to the success of off-size packaging, where each product is unique in size, not resembling other units.

A problem associated with cheese packaging is barrier films entrapping obnoxious gases, specifically hydrogen sulfide, resulting in adverse flavors in natural cheeses. Another problem is that of photo-oxidation, which leads to abnormal flavor qualities when using clear film wrappers (Kosikowski, 1977).

Cottage cheese, quarq, cream cheese, neufchatel and bakers cheese are the major cheese products using rigid packages. Cottage cheese must be carefully handled due to curd fragility. Hoppers and filling pumps must be designed not to shatter the curd. Also, filling requirements and proper seals must be considered when packaging cottage cheese. Filling rates for cottage cheese are dependent upon the machine model involved, whether gas flushing is used, as well as the container size. Kosikowski (1977) states that a single piston machine, designed for air evacuation and gas flushing is capable of packing and sealing 50 small containers per minute, yet a multiple piston filling machine, not designed for air evacuating or gas flushing, can package the same container size at 300 per minute. In the United States the more popular type of cottage cheese package is rigid, circular, nested and pint sized (456 grams), followed by the quart (912 grams). Glass and wax coated paper containers were the traditional type of packages used. Today, mostly rigid polyethylene and polystyrene plastics are used, with some investigation into flexible containers taking place.

Another important application of cottage cheese packaging for shelf life extension is air evacuated containers, flushed with carbon dioxide or nitrogen, as reported by Kosikowski (1977). One problem associated with this technique is that filling rates tend to be slower. At the present researchers are trying to overcome this problem.

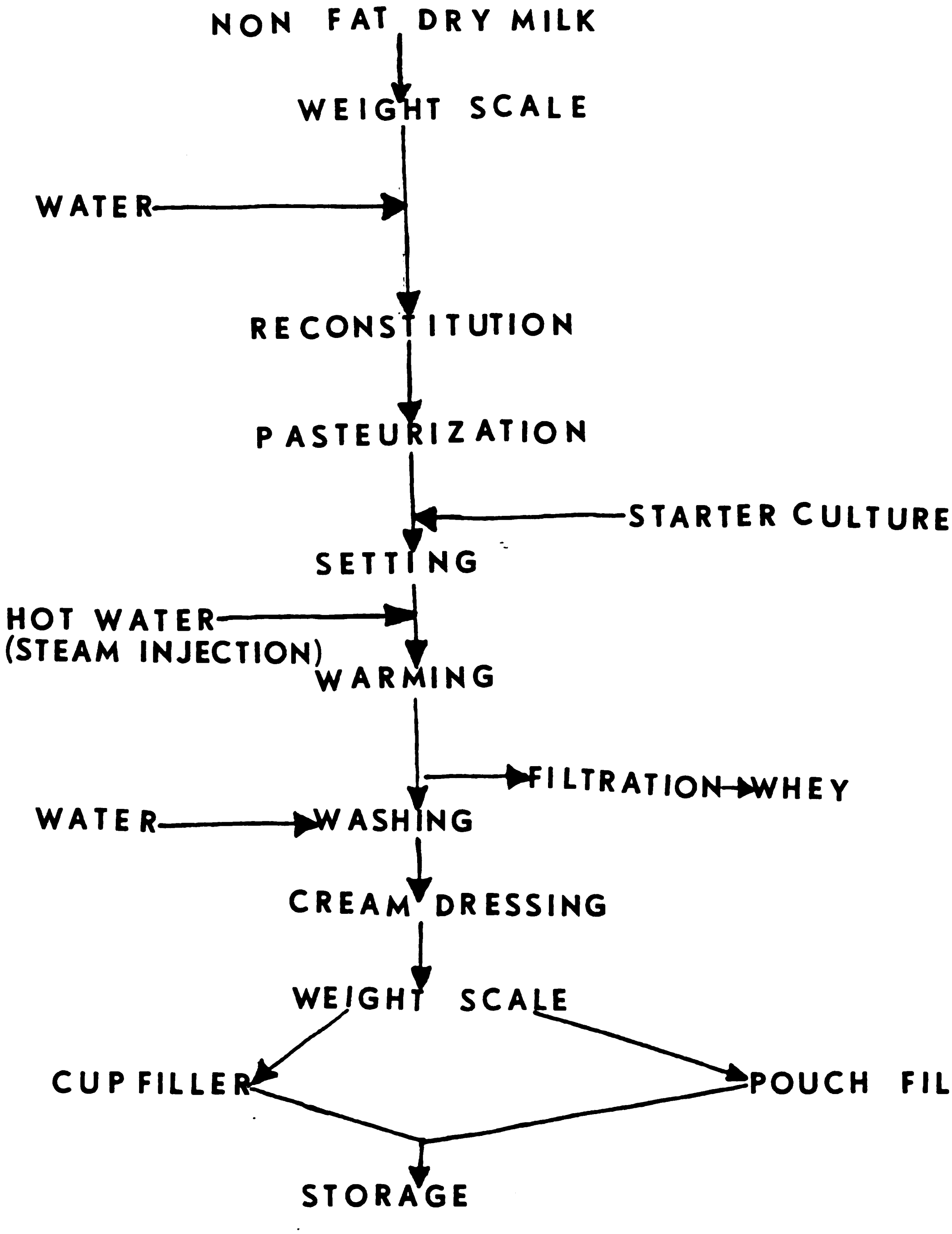
EXPERIMENTAL PROCEDURES

Preparation of Small Curd Cottage Cheese

Small curd cottage cheese was produced by the methods outlined by Snowbrand Milk Products (1981) and Kosikowski (1977). In this procedure nonfat dry milk (low heat) was reconstituted to 10% solids and pasteurized at 62.7°C for 30 minutes and cooled to 25.5°C. An active frozen concentrate lactic culture was then added to the reconstituted milk. When the pH of the cheese milk reached between 4.5-4.7 (approximately 17 hours after inoculated with starter culture) the curd was cut into 0.64 centimeter cubes. After 10 minutes of idling the curd was cooked by slowly stirring and slowly heating to 49°-52°C, increasing at the rate of 3°C/10 minutes. This required approximately 2.0-2.5 hours. The curd was quantitatively examined for firmness. If necessary, cooking continued until the desired degree of firmness was achieved. The whey was then drained to a level in which the surface of the curd particles were visible. Water was added to the vat to reach a temperature of 29.0°C. After stirring the curd for 10 minutes, the whey-water mixture was drained again to the level of the curd particles.

The same procedure was repeated in a second wash to a temperature of 15.0°C. After stirring for 10 minutes, a third and final washing was performed with chilled water to reach a temperature of 7.2°C in the vat. The curd was stirred for 30 minutes. After stirring, the whey-water was completely drained. Salted cottage cheese dressing was added to the curd, one part dressing to two parts curd. After thoroughly mixing the dressing and curd, the mixture was dispensed into 228 gram cups. The cheese was held at refrigerated (4.4°C) conditions for 24 hours prior to any treatment.

Since the objective of this investigation was to examine the possibility of extending the shelf life of cottage cheese without additives or preservatives, heat was the method used. More specifically, microwaves were used as the heat source. Microwave treatments dealt with heating the cheese "in package" to various temperatures, 24 hours after processing. The specific microwave treatments are listed below. After microwaving, the cheese was held under refrigerated (4.4°C) conditions for 24 hours prior to analysis. Most batches of cheese were made in duplicate, some in triplicate to ensure data repetition.



FLOW DIAGRAM: COTTAGE CHEESE MANUFACTURING PROCESS

BATCH I

1.2 kilowatt commercial microwave oven
Package: polystyrene
Blast freezer cool down

Temperature °C	*Time in Seconds
37.0	18
48.8	25
60.0	40
71.1	65
82.2	70
no treatment	-

BATCH II

1.2 kilowatt commercial microwave oven
Package: polystyrene
Deep freezer cool down

Temperature °C	Time in Seconds
37.0	17
48.8	23
60.0	40
71.1	65
82.2	70
no treatment	-

BATCH III

500 watt commercial microwave oven
Package: polystyrene
Blast furnace cool down

Temperature °C	Time in Seconds
37.0	35
48.8	60
60.0	100
71.1	113
82.2	121
no treatment	-

Note: Time in seconds refers to the time in seconds to reach the stated temperature.

BATCH IV

500 watt commercial microwave oven
Package: polystyrene
Deep freezer cool down

Temperature °C	Time in Seconds
37.0	40
48.8	65
60.0	100
71.1	110
82.2	120
no treatment	-

BATCH V

1.2 kilowatt commercial microwave oven
Package: polystyrene
Defrost - heating cycle

Temperature °C	Time in Seconds
37.0	75
48.8	160
60.0	170
71.1	175
82.2	180
no treatment	-

BATCH VI

500 watt commercial microwave oven
Package: polystyrene
Defrost - heating cycle

Temperature °C	Time in Seconds
37.0	100
48.8	180
60.0	240
71.1	330
82.2	385
no treatment	-

BATCH VII

500 watt commercial microwave oven
Package: polystyrene
High-heating cycle

Temperature °C	Time in Seconds
37.0	40
48.8	65
60.0	100
71.1	110
82.2	120
no treatment	-

BATCH VIII

2.8 kilowatt commercial microwave oven
Package: polystyrene
High-heating cycle

Temperature °C	Time in Seconds
37.0	10
48.8	20
60.0	25
71.1	40
82.2	45
no treatment	-

Based upon the results obtained from batches VII and VIII, a final batch was tested. Using the second temperature condition 48.8°C (which extended the shelf life the longest in both cases) different packaging materials were used to determine whether or not materials influence shelf-life stability.

BATCH IX

High heating cycle
Temperature 48.8°C

Material	Microwave Oven	Time in Seconds
cryovac	500 watt	70
cryovac	2.8 kilowatt	35
cryovac	no treatment	-

BATCH X

High heating cycle
Temperature 48.8°C

Material	Microwave Oven	Time in Seconds
polyethylene	500 watt	70
polyethylene	2.8 kilowatt	25
polyethylene	no treatment	-

Cooling Test

The microwaved cottage cheese was subjected to three methods of cooling. First, a blast freezer (-34.4°C) was used to quickly bring the temperature of the cheese to 4.4°C (which represented the storage temperature throughout the study). Secondly, a deep freezer (-17.7°C) was used to determine whether a slower method of cooling would be more adequate. These two methods were performed to determine if rapid cooling of the cottage cheese would result in a lower degree of thermal shock to the product. The final method employed was subjecting the microwaved cottage cheese to an overnight holding period in the storage cooler (4.4°C) (without first using a rapid cooling stage).

ANALYTICAL PROCEDURES

Moisture

The moisture of the cottage cheese was determined by the vacuum oven method described by the Association of Official Analytical Chemists for cheese (AOAC, 1975). Determinations were made in duplicate and performed at the onset of the study and every two weeks throughout the storage period.

pH

pH measurements were made with an Orion digital pH/mV meter equipped with a glass electrode. The measurements were made from a blended cheese sample, making three probes with the electrode to insure that a proper reading was taken. The pH was determined to the nearest one-hundredth of a pH unit. Measurements were taken initially and every two weeks throughout the storage period.

Whey-Off

The whey-off measurements were made qualitatively through visual observations where: (-) no whey-off, (±) very slight, (+) slight, (++) definite, as described by Richmond et al. (1981).

Microbial

Microbial analyses were made to determine coliform, psychrophiles, yeast and molds, and total count as described in the Standard Methods for the Examination of Dairy Products (1978). Analyses were made in duplicate and performed initially and every two weeks throughout the study. Microbial analysis was a key factor in determining end of shelf life.

Pure Culture Analysis

Pure cultures of coliforms, psychrotrophs, and yeast and molds were plated to determine if the procedures described in the Standard Methods for the Examination of Dairy Products (1978) were acceptable for this study. After the incubation period and growth was found to be substantial (confirming the procedure) the same pure cultures were subjected to microwave heating, plated and incubated. The purpose of performing this analysis was to determine whether or not microwave heat would actually destroy the organisms. Analysis was made in duplicate.

Sensory Analysis

A judging panel of four experienced judges scored the cheese. Flavor, body/texture, and appearance/color, were scored on a point system according to the method designed for Intercollegiate Dairy Products Evaluation contests. Initial mouthfeel, curd texture, and residual effect were scored on the basis of 1-10 where 1 represented very dry, soft or mealy and 10 represented very wet, firm or mealy, as described by Watts (1981). Each batch of cheese was judged at the onset of the study and every two weeks thereafter, until samples were considered no longer acceptable. Results were not statistically evaluated but were used to indicate acceptability.

Fat Content

Fat content was determined on the cheese as well as the cream dressings by using of Official and Modified Babcock Methods (AOAC, 1975). Analysis was performed at the onset of the study in duplicates.

RESULTS AND DISCUSSION

Changes in pH During Storage

A random, representative sample for each batch of cottage cheese was analyzed initially and every two weeks during storage. The different batches (microwave treatments) show similar changes in pH during storage. Typical pH profiles are shown in Tables 1 and 2.

Fresh cottage cheese exhibited a pH of approximately 4.7. Immediately following microwaving, the pH varied from 4.74-4.95 for the different microwave heat treatments. During storage the pH in all cases decreased, followed by an increase which coincided with the first visible signs of mold growth. This continued until the end of storage. At the end of shelf life, pH values ranged (for the different treatments) from 4.82-5.10.

The pH of the cheese is important to observe because of its possible effect on the proteolytic enzyme systems. Foster et al. (1961) suggested that the initial decrease in pH is probably due to the production of lactic acid by the starter culture. The rapid increase in pH is caused by the destruction of lactic acid by yeast, liberation of alkaline products of protein decomposition and the formation

Table 1: pH Profiles During Storage of Control Samples

Condition (Control Samples)	Storage Period (Days)	pH
Polystyrene Tub		
500 watt oven - Batch VII	2	4.70
	14	4.86
2860 watt oven - Batch VIII	2	4.70
	14	4.79
Cryovac Pouch - Batch IX	2	4.70
	14	4.77
	21	4.81
	35	4.83
Polyethylene Tub - Batch X	2	4.73

Table 2: Effect of Microwave Heating on pH

Condition	Storage Period (Days)	pH
Polystyrene Tub - 500 watt oven - Batch VII		
37.0°C	2	4.79
	14	4.82
48.8°C	2	4.74
	14	4.56
	21	4.70
	35	4.97
60.0°C	2	4.76
	14	4.58
	21	4.65
	35	4.95
Polystyrene Tub - 2860 Watt Oven - Batch VIII		
37.0°C	2	4.75
	14	4.83
48.8°C	2	4.75
	14	4.68
60.0°C	2	4.75
	14	4.99
Cryovac Pouch - 48.8°C - Batch IX		
500 Watt Oven	2	4.76
	14	4.44
	21	4.50
	35	4.77
	42	4.83
2860 Watt Oven	2	4.76
	14	4.44
	21	4.60
	35	4.79
	42	4.90

Table 2--continued

Condition	Storage Period (Days)	pH
Polyethylene Tub - 48.8° - Batch X		
500 Watt Oven	2	4.95
	14	4.74
	21	4.80
	35	4.99
	42	5.10
2860 Watt Oven	2	4.66
	14	4.44
	21	4.53
	35	4.85

of non-acidic decomposition products (Thakur, 1973). A pH value of 5.0 or lower results in cheese having the longest shelf life.

There was no apparent correlation between microwaving and pH. The pH of all samples were in a range which could be expected for cottage cheese, unaffected by any additional treatment. Therefore pH was not an indicator in variability of microwave treatment. pH values can be used to determine when shelf-life is nearing an end. As was found, the values initially increased and continued to rise throughout storage. The only correlation that pH had on the other variables examined was that of microbial growth, specifically mold growth. The pH values rose more rapidly as mold growth increased.

It is important to note that pH is difficult to measure in cheese samples due to lipid material and proteins adhering to the electrodes.

Effect of Microwaving and Storage on Whey-off

Cottage cheese samples were observed for extent of whey-off. Whey-off is an indicator of curd breakdown. The greater the volume of free whey present, the less desirable the product. Whey-off is a quality defect which is aesthetically undesirable. Observations were performed initially and every two weeks throughout the storage period. During the storage period the control batch ranged from none to only slight whey-off. As noted in Table 3, the samples which were microwaved the longest, and those which reached the highest temperatures, were observed to have the greatest amount of free whey. As storage time progressed and the product began to breakdown a definite increase in free whey was noted. Most batches exhibited the same patterns. At the onset of the study, samples exhibited only slight whey-off, while at termination of storage a considerable amount of syneresis (whey separation) was noted.

It was observed that the effect of microwaving, as well as time in storage caused cheese curd to breakdown, promoting whey separation.

During storage, microorganisms, as well as enzymes can cause deterioration of the cottage cheese curds, causing whey separation (Angevine, 1976). Microwaving also promotes this, in that the heat generated from the microwaves will draw the moisture out of the curd, resulting in curd shrinkage and syneresis, as was found by Smith (1977).

Initially, the control samples had the least amount of free whey, whereas those samples which were microwaved to the highest temperatures had the largest amounts of free whey. Samples microwaved to 71.1°C and 82.2°C were immediately removed from the study because initial whey-off levels and curd disintegration made the product

Table 3: Effect of Microwave Heating and Storage on Whey-Off

Condition	Storage Time (Weeks)	Whey-Off	Storage Time (Weeks)	Whey-Off	Storage Time (Weeks)	Whey-Off	Storage Time (Weeks)	Whey-Off
Polystyrene Tub - Batch VII								
500 Watt Oven								
37.0°C	1	(-)	2	(±)	4	removed	6	removed
48.8°C	1	(±)	2	(+)	4	(++)	6	(++)
60.0°C	1	(++)	2	(++)	4	(++)	6	(++)
Polystyrene Tub - Batch VIII								
2860 Watt Oven								
37.0°C	1	(-)	2	(±)	4	removed	6	removed
48.8°C	1	(+)	2	(±)	4	removed	6	removed
60.0°C	1	(-)	2	(+)	4	removed	6	removed
Cryovac Pouch - Batch IX								
500 watt oven	1	(±)	2	(±)	4	(+)	6	removed
2860 watt oven	1	(±)	2	(±)	4	(+)	6	removed
Polyethylene Tub - Batch X								
500 watt oven	1	(-)	2	(+)	4	removed	6	removed
2860 watt oven	1	(±)	2	(+)	4	(+)	6	removed
Control Samples								
500 watt oven - Batch VII	1	(-)	2	(-)	4	removed	6	removed
2860 watt oven - Batch VIII	1	(-)	2	(±)	4	removed	6	removed
Cryovac pouch - Batch IX	1	(-)	2	(±)	4	(+)	6	removed
Polyeythlene tub - Batch X	1	(-)	2	removed	4	removed	6	removed

Those samples which denote "removed," were removed from the study due to microbial spoilage aesthetically undesirable. Furthermore, these temperatures were not employed in the remainder of the study. Those samples which were subjected to rapid cooling following microwave treatment also exhibited a large amount of free whey. The cooling process utilized in this study actually caused more damage to the product, probably the result of thermal shock. These samples were immediately removed from the study because of the extensive curd breakdown that was noted.

Free whey as a quality defect was also initially observed in those samples which were microwaved on the defrost cycle. As mentioned earlier, heat will draw moisture out of the curd therefore, by heating the cheese on the defrost cycle, the time required to reach the desired temperature was much longer. This implies that time of heating also influences the amount of moisture drawn from the product during heating. This phenomen was noted in samples from the 2860 watt oven and 500 watt oven. Cheese samples showed less free whey initially, from the 2860 watt oven when compared to samples taken from the 500 watt oven, where the heating time was longer.

Package variation did not influence whey-off. The only correlation of free whey to package variation was the difference in shelf life stability. Samples with the longest shelf life (cryovac pouches) initially, had less free whey present, but exhibited the same trends as the other samples throughout the products shelf life.

Effect of Microwaving and Storage on Moisture Content

The data in Tables 4, 5, and 6 show the relationship between microwaving and storage on moisture content of the cottage cheese curd. Each batch of cheese (curd only) was analyzed for moisture content initially and every two weeks throughout the study. The percent moisture (for all batches) ranged from 86.4% to 50.5% from the onset of the study to its termination, respectively. Cottage cheese is a soft cheese where moisture levels should not exceed 80% and should not be less than 50%. In this study, some samples of cheese did contain more than 80% moisture. A possible reason for high moisture levels could have been that cooking times were not long enough, causing excess moisture to be entrapped within the curd.

Cottage cheese is classified as a colloidal food with capillary pores. The cheese consists of capillaries with flexible walls and upon absorption or loss of moisture, changes form. Eventually, during storage of the cheese, the curd releases moisture and dries to a crumbly consistency, which is undesirable. On the other hand, if the curd contains too much moisture it is very soft, almost mushy, which again is undesirable. Therefore, either extreme will result in a product unacceptable to the consumer.

Table 4: Moisture Content During Storage of Control Samples (samples without a microwave heat treatment)

Condition (Control Samples)	Storage Period (Days)	Moisture Content %
Polystyrene Tub		
500 watt oven - Batch VII	2	85.40%
	14	72.55%
2860 watt oven - Batch VIII	2	80.85%
	14	78.00%
Cryovac Pouch - Batch IX	2	76.50%
	14	74.00%
	21	72.60%
	35	69.00%
Polyethylene Tub - Batch X	2	72.50%

Table 5: Effect of Microwave Heating and Storage on Moisture Content. Batch VII and Batch VIII (Polystyrene Tub--500 watt oven and 2860 watt oven)

Condition	Storage Period (Days)	Moisture Content %
Batch VII		
Polystyrene Tub - 500 watt oven		
37.0°C	2	83.74%
	14	73.50%
48.8°C	2	84.26%
	14	74.57%
	21	61.45%
	35	50.52%
60.0°C	2	84.96%
	14	80.95%
	21	69.00%
	35	62.70%
Batch VIII		
Polystyrene Tub - 2860 watt oven		
37.0°C	2	80.50%
	14	79.25%
48.8°C	2	83.25%
	14	78.05%
60.0°C	2	82.00%
	14	78.50%

Table 6: Effect of Microwave Heating and Storage on Moisture Content. Batch IX and Batch X (Cryovac Pouches and Polyethylene Tubs)

Condition	Storage Period (Days)	Moisture Content %
Cryovac Pouch - Batch IX		
500 watt oven	2	77.5%
	14	76.5%
	21	69.5%
	35	58.7%
	42	52.3%
2860 watt oven	2	76.5%
	14	72.6%
	21	70.8%
	35	69.7%
	42	60.3%
Polyethylene Tub - Batch X		
500 watt oven	2	69.0%
	14	65.0%
	21	59.4%
	35	55.6%
	42	50.5%
2860 watt oven	2	66.5%
	14	63.4%
	21	60.7%
	35	53.5%

Most foods are regulated in water content and/or define a product during processing. Cottage cheese is classified as a soft cheese due to its moisture content. A semisoft cheese would be a cheese with a moisture content not exceeding 45-46%, such as brick or muenster. Hard cheeses, cheddar, edam or provolone have moisture contents ranging up to 40%. Very hard cheeses range in moisture levels up to 32-36%, such as parmesan and romano.

The moisture content of cheese is critical because it is a major factor in influencing the development of storage defects. Moisture contents which are too high will not meet the requirements stated in the Federal Standards of Identity and will be quite susceptible to microbial, enzymatic and textural alterations. If the moisture content of the cheese is too low, it will be aesthetically undesirable.

It was found that samples which contained high initial moisture contents exhibited the greatest amount of undesirable levels of whey separation. Since the curd initially contained high moisture levels more moisture was available to be released during product breakdown, from both the microwave heating and storage effect.

Cheese packed in cryovac bags and polyethylene tubs showed the least amount of change in moisture content throughout the study. This was probably associated with the barrier properties of the materials (which will be discussed in further detail). These materials offer more protection to the product than the polystyrene tubs, therefore less product breakdown was observed, resulting in a longer shelf life and not as much fluctuation in moisture levels.

In this study moisture content and whey-off levels were dependent upon one another. As the whey-off levels increased, the moisture content of the curd decreased. Microwaving and storage drew moisture from the curd, resulting in lower moisture contents as the storage period progressed and the degree of heating rose. The samples which were microwaved to the highest temperatures had the lowest moisture levels.

Microbial Analysis of Microwaved Cottage Cheese

Microbial analyses were performed on all batches of cheese. Coliforms, psychrophiles, yeast/molds and standard plate counts were run in order to determine the efficiency of the microwave treatments as preservation techniques.

Pure cultures of organisms were microwaved and plated to determine whether the amount of heat generated from the microwave was sufficient to destroy the organisms in question. Data in Table 7 show the counts obtained from the pure cultures prior to and after microwaving. The number of microbial organisms was substantially reduced.

Table 7: Effect of Microwave Heating on Pure Cultures

Organism	Treatment	Count
Mold/Yeast	unmicrowaved	$1.5x10^{3}$ molds/ml
(Aspergillus niger)	microwaved	$<3.0x10^{2}$ molds/ml
Coliform	unmicrowaved	$4.5x10^{2}$ coliforms/ml
(Escherichia coli)	microwaved	$<3.0x10^{2}$ coliforms/ml
Standard Plate Count	unmicrowaved	$2.5x10^{4}$ cells/ml
	microwaved	$<3.0x10^{2}$ cells/ml
Psychrophiles	unmicrowaved	$3.0x10^{4}$ cells/ml
(Alcaligenes)	microwaved	$<3.0x10^{2}$ cells/ml

Note: Microbial counts were based upon averages from duplicated plates.

In all batches of cheese, coliforms and psychrophilic growth remained relatively low throughout the entire study, therefore tests for these organisms were discontinued on a weekly basis and only checked at the end of the study.

As seen in Tables 8, 9, 10, 11, and 12, initial microbial counts were low for all samples under investigation and for all analyses performed. At termination, counts exceeded ranges for microbial numbers. The cheese packaged in cryovac air evacuated pouches had the lowest microbial counts throughout the study, followed by the samples in the polyethylene tubs and lastly, samples in the polystyrene tubs, 500 watt oven at 48.8°C. Consequently, the samples in the cryovac pouches had the longest shelf life, from both the microbial and sensory analysis data. It was found that cheese packaged in polystyrene tubs (the 500 watt and 2860 watt ovens) which were subjected to a temperature of 48.8°C, resulted in lower microbial counts and longer shelf life than the other temperatures under investigation.

The organisms which were associated with the spoilage of cottage cheese were identified tentatively as _Aspergillus niger_, which produce spore bearing black heads, _Rhodotorula mucilagenosa_, which produced vivid pink spots on the surface of the cheese, _Escherichia coli_, which produced dark centers with an almost fluorescent green

Table 8: Microbial Counts During Storage of Control Samples (samples without a microwave heat-treatment) for Batch Numbers: VII, VIII, IX, X.

Condition Control Samples	Organism	Storage Period (Days)	Number of Survivors
Polystyrene 500 Watt Oven Batch VII	Total Count	2	3.0×10^{6} cells/ml
		14	3.0×10^{6} cells/ml
2860 Watt Oven Batch VIII	Total Count	2	2.5×10^{6} cells/ml
			3.0×10^{7} cells/ml
Cryovac Pouch Batch IX	Total Count	2	2.7×10^{5} cells/ml
		14	2.5×10^{6} cells/ml
		21	2.5×10^{6} cells/ml
		35	2.0×10^{7} cells/ml
Polyethylene Tub Batch X	Total Count	2	3.0×10^{6} cells/ml
Polystyrene 500 Watt Oven Batch VII	Coliforms	2	$<3.0\times10^{2}$ coliforms/ml
		14	$<3.0\times10^{2}$ coliforms/ml
2860 Watt Oven Batch VIII	Coliforms	2	$<2.0\times10^{2}$ coliforms/ml
		14	$<3.0\times10^{2}$ coliforms/ml
Cryovac Pouch Batch IX	Coliforms	2	$<3.0\times10^{2}$ coliforms/ml
		14	$<3.0\times10^{2}$ coliforms/ml
		21	$<3.0\times10^{2}$ coliforms/ml
		35	$<3.0\times10^{2}$ coliforms/ml
Polyethylene Tub Batch X	Coliforms	2	$<3.0\times10^{2}$ coliforms/ml
Polystyrene 500 Watt Oven Batch VII	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
2860 Watt Oven Batch VIII	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
Cryovac Pouch Batch IX	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
		21	$<3.0\times10^{2}$ cells/ml
		35	$<3.0\times10^{2}$ cells/ml
Polyethylene Tub Batch X	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml

Table 8--continued

Condition Control Samples	Organism	Storage Period (Days)	Number of Survivors
Polystyrene			
500 Watt Oven			
Batch VII	Yeast/mold	2	$2.5x10^3$ yeast/mold/ml
		14	$2.0x10^5$ yeast/mold/ml
2860 Watt Oven			
Batch VIII	Yeast/Mold	2	$2.3x10^3$ yeast/mold/ml
		14	$3.0x10^7$ yeast/mold/ml
Cryovac Pouch			
Batch IX	Yeast/Mold	2	$<3.0x10^2$ yeast/mold/ml
		14	$1.1x10^6$ yeast/mold/ml
		21	$2.0x10^6$ yeast/mold/ml
		35	$2.5x10^6$ yeast/mold/ml
Polyethylene Tub			
Batch X	Yeast/Mold	2	$<3.0x10^2$ yeast/mold/ml

NOTE: All microbial counts were based upon averages from duplicated plates.

Table 9: Effects of Microwave Heating and Storage on Plate Counts, Batch VII (Polystyrene - 500 Watt Oven Samples)

Condition	Organism	Storage Period (Days)	Number of Survivors
Polystyrene-500 Watt Oven			
37.0°C	Total Count	2	2.0×10^{4} cells/ml
		14	2.5×10^{4} cells/ml
48.8°C	Total Count	2	2.5×10^{3} cells/ml
		14	2.0×10^{2} cells/ml
		21	3.0×10^{6} cells/ml
		35	2.9×10^{7} cells/ml
60.0°C	Total Count	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
		21	2.8×10^{6} cells/ml
		35	3.0×10^{7} cells/ml
37.0°C	Coliforms	2	$<3.0\times10^{2}$ coliform/ml
		14	$<3.0\times10^{2}$ coliform/ml
48.8°C	Coliforms	2	$<3.0\times10^{2}$ coliform/ml
		14	$<3.0\times10^{2}$ coliform/ml
		21	$<3.0\times10^{2}$ coliform/ml
		35	$<3.0\times10^{2}$ coliform/ml
60.0°C	Coliforms	2	$<3.0\times10^{2}$ coliform/ml
		14	$<3.0\times10^{2}$ coliform/ml
		21	$<3.0\times10^{2}$ coliform/ml
		35	$<3.0\times10^{2}$ coliform/ml
37.0°C	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
48.8°C	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
		21	$<3.0\times10^{2}$ cells/ml
		35	$<3.0\times10^{2}$ cells/ml
60.0°C	Psychrophiles	2	$<3.0\times10^{2}$ cells/ml
		14	$<3.0\times10^{2}$ cells/ml
		21	$<3.0\times10^{2}$ cells/ml
		35	$<3.0\times10^{2}$ cells/ml

Table 9--continued

Condition	Organism	Storage Period (Days)	Number of Survivors
37.0°C	Yeast/Mold	2	<3.0×10^2 yeast/mold/ml
		14	1.5×10^4 yeast/mold/ml
48.8°C	Yeast/Mold	2	1.7×10^3 yeast/mold/ml
		14	2.0×10^3 yeast/mold/ml
		21	1.4×10^3 yeast/mold/ml
		35	3.0×10^4 yeast/mold/ml
60.0°C	Yeast/Mold	2	<3.0×10^2 yeast/mold/ml
		14	1.0×10^3 yeast/mold/ml
		21	2.0×10^4 yeast/mold/ml
		35	3.0×10^4 yeast/mold/ml

NOTE: All microbial counts were based upon averages from duplicated plates.

Table 10: Effect of Microwave Heating and Storage on Plate Counts, Batch VIII (Polystyrene 2860 Watt Oven Samples)

Condition	Organism	Storage Period (Days)	Number of Survivors
Polystyrene - 2860 Watt Oven			
37.0°C	Total Count	2	$2.5x10^{6}$ cells/ml
		14	$3.0x10^{6}$ cells/ml
48.8°C	Total Count	2	$2.5x10^{4}$ cells/ml
		14	$3.0x10^{6}$ cells/ml
60.0°C	Total Count	2	$2.5x10^{5}$ cells/ml
		14	$2.3x10^{5}$ cells/ml
37.0°C	Coliforms	2	$<3.0x10^{2}$ coliform/ml
		14	$<3.0x10^{2}$ coliform/ml
48.8°C	Coliforms	2	$<3.0x10^{2}$ coliform/ml
		14	$<3.0x10^{2}$ coliform/ml
60.0°C	Coliforms	2	$<3.0x10^{2}$ coliform/ml
		14	$<3.0x10^{2}$ coliform/ml
37.0°C	Psychrophiles	2	$<3.0x10^{2}$ cells/ml
		14	$<3.0x10^{2}$ cells/ml
48.8°C	Psychrophiles	2	$<3.0x10^{2}$ cells/ml
		14	$<3.0x10^{2}$ cells/ml
60.0°C	Psychrophiles	2	$<3.0x10^{2}$ cells/ml
		14	$<3.0x10^{2}$ cells/ml
37.0°C	Yeast/Mold	2	$2.5x10^{3}$ yeast/mold/ml
		14	$3.0x10^{5}$ yeast/mold/ml
48.8°C	Yeast/Mold	2	$2.6x10^{3}$ yeast/mold/ml
		14	$3.0x10^{6}$ yeast/mold/ml
60.0°C	Yeast/Mold	2	$<3.0x10^{5}$ yeast/mold/ml
		14	$3.0x10^{5}$ yeast/mold/ml

NOTE: All microbial counts were based upon averages from duplicated plates.

Table 11: Effect of Microwave Heating and Storage on Plate Counts, Batch IX (Cryovac Pouches)

Condition	Organism	Storage Period (Days)	Number of Survivors
Cryovac Pouches 48.8°C			
500 Watt Oven	Total Count	2	2.3x10^5 cells/ml
		14	2.0x10^6 cells/ml
		21	2.2x10^6 cells/ml
		35	2.0x10^7 cells/ml
		42	3.0x10^7 cells/ml
2860 Watt Oven	Total Count	2	2.0x10^5 cells/ml
		14	2.5x10^6 cells/ml
		21	3.0x10^6 cells/ml
		35	2.0x10^7 cells/ml
		42	2.5x10^7 cells/ml
500 Watt Oven	Coliforms	2	<3.0x10^2 coliforms/ml
		14	<3.0x10^2 coliforms/ml
		21	<3.0x10^2 coliforms/ml
		35	<3.0x10^2 coliforms/ml
		42	<3.0x10^2 coliforms/ml
2860 Watt Oven	Coliforms	2	<3.0x10^2 coliforms/ml
		14	<3.0x10^2 coliforms/ml
		21	<3.0x10^2 coliforms/ml
		35	<3.0x10^2 coliforms/ml
		42	<3.0x10^2 coliforms/ml
500 Watt Oven	Psychrophiles	2	<3.0x10^2 cells/ml
		14	<3.0x10^2 cells/ml
		21	<3.0x10^2 cells/ml
		35	<3.0x10^2 cells/ml
		42	<3.0x10^2 cells/ml
2860 Watt Oven	Psychrophiles	2	<3.0x10^2 cells/ml
		14	<3.0x10^2 cells/ml
		21	<3.0x10^2 cells/ml
		35	<3.0x10^2 cells/ml
		42	<3.0x10^2 cells/ml
500 Watt Oven	Yeast/Mold	2	<3.0x10^2 yeast/mold/ml
		14	1.5x10^4 yeast/mold/ml
		21	1.7x10^5 yeast/mold/ml
		35	2.0x10^5 yeast/mold/ml
		42	2.1x10^6 yeast/mold/ml
2860 Watt Oven	Yeast/Mold	2	<3.0x10 yeast/mold/ml
		14	1.5x10^4 yeast/mold/ml
		21	2.1x10^5 yeast/mold/ml
		35	2.5x10^5 yeast/mold/ml
		42	3.0x10^5 yeast/mold/ml

NOTE: All microbial counts were based upon averages from duplicated plates.

Table 12: Effect of Microwave Heating and Storage on Plate Counts, Batch X (Polyethylene Tubs)

Condition	Organism	Storage Period (Days)	Number of Survivors
Polyethylene Tubs 48.8°C			
500 Watt Oven	Total Count	2	$3.0x10^6$ cells/ml
		14	$2.0x10^7$ cells/ml
		21	$2.5x10^7$ cells/ml
		35	$3.0x10^7$ cells/ml
		42	$2.0x10^8$ cells/ml
2860 Watt Oven	Total Count	2	$3.0x10^6$ cells/ml
		14	$2.5x10^7$ cells/ml
		21	$2.7x10^7$ cells/ml
		35	$3.0x10^7$ cells/ml
500 Watt Oven	Coliforms	2	$<3.0x10^2$ coliforms/ml
		14	$<3.0x10^2$ coliforms/ml
		21	$<3.0x10^2$ coliforms/ml
		35	$<3.0x10^2$ coliforms/ml
		42	$<3.0x10^2$ coliforms/ml
2860 Watt Oven	Coliforms	2	$<3.0x10^2$ coliforms/ml
		14	$<3.0xlo^2$ coliforms/ml
		21	$<3.0x10^2$ coliforms/ml
		35	$<3.0x10^2$ coliforms/ml
500 Watt Oven	Psychrophiles	2	$<3.0x10^2$ cells/ml
		14	$<3.0x10^2$ cells/ml
		21	$<3.0x10^2$ cells/ml
		35	$<3.0x10^2$ cells/ml
		42	$<3.0x10^2$ cells/ml
2860 Watt Oven	Psychrophiles	2	$<3.0x10^2$ cells/ml
		14	$<3.0x10^2$ cells/ml
		21	$<3.0x10^2$ cells/ml
		35	$<3.0x10^2$ cells/ml
500 Watt Oven	Yeast/mold	2	$<3.0x10^2$ yeast/mold/ml
		14	$1.2x10^3$ yeast/mold/ml
		21	$2.2x10^6$ yeast/mold/ml
		35	$2.5x10^6$ yeast/mold/ml
		42	$2.8x10^7$ yeast/mold/ml
2860 Watt Oven	Yeast/Mold	2	$<3.0x10^2$ yeast/mold/ml
		14	$2.1x10^3$ yeast/mold/ml
		21	$2.5x10^6$ yeast/mold/ml
		35	$3.0x10^6$ yeast/mold/ml

NOTE: All microbial counts were based upon averages from duplicated plates.

outer edge, Penicillium, which produced a blue-green to almost gray surface discoloration, and Flavobacterium, which was gram-negative, rod shaped and produced a yellow-orange surface discoloration. The species of the genus Penicillium and Flavobacterium were not possible to detect (since each genus has many species, all of which resemble one another) without further investigation.

Coliforms and psychrophilic bacteria are more likely to grow and cause spoilage in the cottage cheese when poor sanitary and handling procedures are found. Since good manufacturing procedures were followed, along with low holding temperatures, these organisms were kept to a minimum throughout the shelf life period.

Microbial counts obtained from using the 500 watt oven were substantially lower than those obtained when using the 2860 watt oven. One possible explanation for this may be due to the fact that when using the 500 watt oven, the organisms were subjected to heat for a longer period of time, resulting in greater destruction of microbial spores. Kosikowski (1977) stated that it is important that air be evacuated from the cottage cheese containers before success in longer shelf life is achieved. This technique was employed when using the cryovac pouches. A vacuum was pulled on the pouches to remove as much air as possible, which would inhibit the growth of aerobic organisms. Consequently, these samples were found to exhibit the lowest microbial counts, resulting in the longest shelf life.

In using the 1200 watt microwave oven, data repetition in terms of time/temperature relationships were inconsistent, therefore data from these batches are not reported.

Microbial growth was definitely influenced by changes in pH. It was difficult for microorganisms to grow in a low pH (less than pH 5.0) environment. It was apparent in this study when low pH values were noted, microbial growth was kept to a minimum. As pH rose, mold growth was definitely a problem. It is important to remember that molds and yeasts can grow at low pH (*Aspergillus oryzae* is found to grow at pH 1.6) but are more likely to grow (in general), as pH values increase.

Moisture levels were also found to have an affect on microbial counts. Initially, when moisture was high, bacteria was the major problem. As the curd began to dry out, yeast and mold counts rose. When moisture content was at the lowest level, mold counts were found to be the highest. Overall, mold growth, specifically *Penicillium*, was the major cause of product spoilage.

Sensory Evaluation of Microwaved Cottage Cheese

Sensory evaluation is one of the most critical tests that can be performed on a food product. It should always be done when working with a product if any commercial implication is suggested.

Each batch of cottage cheese was evaluated for flavor, body and texture, appearance and color, as well as initial mouthfeel, curd texture and residual effect. Flavor was assigned a maximum total of 10 points, body/texture 5 points and appearance/color 5 points. It was felt that flavor should be given maximum importance. Not only is cottage cheese eaten alone, but it is suitable for incorporation into other products, thereby requiring flavor to be of the highest quality. A sample which contained 12 out of a possible 20 points (60 percent) was considered acceptable. A sample with a total of less than 12 points showed definite microbial growth and textural alterations which resulted in an unacceptable product.

Initial mouthfeel, curd texture and residual effect was also analyzed. Points between 1 and 10 were assigned where either extreme represented a poor quality cheese. A score of 1.0 was very dry, soft or not mealy and a sample with a score of 10.0 was either very wet, firm or mealy. A score between 4 and 6 points was considered an average score representing an acceptable product.

Tables 13, 14, and 15 represented the findings associated with flavor, body/texture and appearance/color. The results show trends similar to those associated with the other variables under investigation. Cheese packaged in polystyrene tubs had the best scores throughout the storage period, for the samples which were microwaved at 48.8°C. These scores were found to be significantly better than the samples microwaved at 37.0°C and 60.0°C (this was true for both the 500 watt oven samples and 2860 watt oven samples). Samples microwaved at higher temperatures (71.0°C and 82.2°C) were not evaluated due to the excessive product breakdown that was observed. It was found that samples from the 2860 watt oven generated lower sensory scores towards the end of shelf life than those samples which were microwaved in the 500 watt oven. This finding was similar to data found for the other variables analyzed. It was established in the other analyses that toward the end of shelf life, samples from the 2860 watt oven showed distinct signs of spoilage, more so than samples which were microwaved in the 500 watt oven. Microbial counts were higher as were pH values. For both batches analyzed, sensory data paralleled the results from the microbial analyses, pH values and whey-off. As samples began to spoil, sensory data dropped, microbial counts rose, pH values increased and free whey became excessive.

Table 13: Sensory Evaluation During Storage of Control Samples

Condition (All Control)	Flavor	Body and Texture	Appearance and Color	Total
Polystyrene Tub - Batch VII				
2 day storage	9.0	3.0	4.0	16.0
14 day storage	8.0	2.0	2.0	12.0
Polystyrene Tub - Batch VIII				
2 day storage	8.0	3.0	3.0	14.0
14 day storage	1.0	3.0	3.0	7.0
Cryovac Pouch - Batch IX				
2 day storage	8.0	3.0	3.0	14.0
14 day storage	7.0	3.0	3.0	13.0
21 day storage	7.0	3.0	3.0	14.0
35 day storage	6.0	2.0	3.0	11.0
*Polyethylene Tubs - Batch X				
2 day storage	8.0	4.0	3.0	15.0

NOTE: All samples were stored at 4.4°C.

*At 14 days samples from Batch X had spoiled.

Table 14: Sensory Evaluation During Storage of Microwaved Cottage Cheese. Batch VII and Batch VIII (Polystyrene Tubs 500 Watt Oven and 2860 Watt Oven)

Condition	Flavor	Body and Texture	Appearance and Color	Total
Polystyrene Tub 500 Watt Oven				
37.0°C				
2 day storage	8.0	3.0	3.0	14.0
14 day storage	8.0	2.0	3.0	13.0
48.8°C				
2 day storage	8.0	4.0	4.0	16.0
14 day storage	8.0	3.0	3.0	14.0
21 day storage	8.0	3.0	3.0	14.0
35 day storage	7.0	2.0	2.0	11.0
60.0°C				
2 day storage	8.0	3.0	3.0	14.0
14 day storage	8.0	2.0	3.0	13.0
21 day storage	7.0	2.0	2.0	11.0
35 day storage	7.0	2.0	2.0	11.0
Polystyrene Tub 2860 Watt Oven				
37.0°C				
2 day storage	8.0	3.0	4.0	15.0
14 day storage	5.0	1.0	2.0	8.0
48.8°C				
2 day storage	8.0	3.0	3.0	14.0
14 day storage	5.0	1.0	2.0	8.0
60.0°C				
2 day storage	8.0	2.0	3.0	13.0
14 day storage	5.0	1.0	1.0	7.0

NOTE: All samples were stored at 4.4°C.

Table 15: Sensory Evaluation During Storage of Microwaved Cottage Cheese. Batch IX and Batch X (Cryovac Pouches and Polyethylene Tubs)

Condition	Flavor	Body and Texture	Appearance and Color	Total
Cryovac Pouches - 48.8°C				
500 Watt Microwave Oven				
2 day storage	8.0	3.0	3.0	14.0
14 day storage	8.0	3.0	3.0	14.0
21 day storage	8.0	3.0	3.0	14.0
35 day storage	7.0	3.0	3.0	13.0
42 day storage	7.0	2.0	3.0	12.0
2860 Watt Microwave Oven				
2 day storage	8.0	2.0	4.0	14.0
14 day storage	8.0	3.0	3.0	14.0
21 day Storage	7.0	3.0	3.0	13.0
35 day storage	7.0	3.0	3.0	13.0
42 day storage	7.0	3.0	3.0	13.0
Polyethylene Tubs - 48.8°C				
500 Watt Microwave Oven				
2 day storage	8.0	3.0	4.0	15.0
14 day storage	8.0	3.0	4.0	15.0
21 day storage	8.0	2.0	3.0	13.0
35 day storage	7.0	2.0	3.0	12.0
42 day storage	7.0	2.0	3.0	12.0
2860 Watt Microwave Oven				
2 day storage	9.0	3.0	4.0	16.0
14 day storage	9.0	3.0	4.0	16.0
21 day storage	8.0	2.0	3.0	13.0
35 day storage	8.0	2.0	3.0	13.0

NOTE: All samples were stored at 4.4°C.

Evaluation of the cheese packaged in cryovac pouches and polyethylene tubs resulted in similar correlations. These materials showed excellent results in sensory data throughout the storage period. The sensory data was similar for the two containers. This relationship was similar to what was noted from the data generated for pH, whey-off, moisture and microbial.

Sensory evaluation and microbial analysis were the two main tests used to determine the end of shelf life. The relationship between these variables was critical throughout the study and the results obtained showed similar patterns. As shelf life increased, microbial counts rose and the data from sensory evaluation showed declining scores. Microbial analysis was the determinant factor in deciding when samples should be discarded from the study. Though, when sensory scores declined significantly, the samples were removed from further evaluation. For example, samples judged after 14 days of storage from Batch VIII (2860 watt oven) were found to have scores below 12, resulting in removal from the study. For the other samples, specifically the polyethylene tubs and cryovac pouches, samples were removed from further evaluation due to high microbial counts, even though sensory data did not show signs of product spoilage.

Tables 16, 17 and 18 represent sensory data based upon initial mouthfeel, curd texture and residual effect.

Table 16: Sensory Evaluation During Storage of Microwaved Cottage Cheese Based Upon Initial Mouthfeel, Curd Texture, and Residual Effect (control samples).

Condition	Initial Mouthfeel	Curd Texture	Residual Effect
<u>Control Samples</u>			
Polystyrene Tub - Batch VII			
2 day storage	7.0	4.0	2.0
14 day storage	6.0	3.0	3.0
Polystyrene Tub - Batch VIII			
2 day storage	6.0	5.0	4.0
14 day storage	6.0	4.0	4.0
Cryovac Pouch - Batch IX			
2 day storage	4.0	6.0	7.0
14 day storage	4.0	6.0	7.0
21 day storage	4.0	6.0	7.0
35 day storage	4.0	5.0	6.0
Polyethylene Tub - Batch X			
2 day storage	6.0	5.0	4.0

NOTE: All samples were stored at 4.4°C.

Table 17: Sensory Evaluation During Storage of Microwaved Cottage Cheese Based Upon Initial Mouthfeel, Curd Texture, and Residual Effect. Batch VII and Batch VIII (Polystyrene Tubs 500 Watt Oven and 2860 Watt Oven).

Condition	Initial Mouthfeel	Curd Texture	Residual Effect
Polystyrene Tub - Batch VII			
37.0°C			
2 day storage	5.0	4.0	4.0
14 day storage	6.0	5.0	5.0
48.8°C			
2 day storage	6.0	5.0	4.0
14 day storage	6.0	6.0	4.0
21 day storage	6.0	4.0	4.0
35 day storage	7.0	4.0	4.0
60.0°C			
2 day storage	5.0	7.0	8.0
14 day storage	5.0	6.0	5.0
21 day storage	7.0	5.0	8.0
35 day storage	8.0	4.0	8.0
Polystyrene Tub - Batch VIII			
37.0°C			
2 day storage	6.0	5.0	4.0
14 day storage	6.0	4.0	4.0
48.8°C			
2 day storage	6.0	4.0	2.0
14 day storage	6.0	3.0	1.0
60.0°C			
2 day storage	6.0	4.0	4.0
14 day storage	6.0	4.0	4.0

NOTE: All samples were stored at 4.4°C.

Table 18: Sensory Evaluation During Storage of Microwaved Cottage Cheese Based Upon Initial Mouthfeel, Curd Texture, and Residual Effect. Batch IX and Batch X (Cryovac Pouches and Polyethylene Tubs).

Condition	Initial Mouthfeel	Curd Texture	Residual Effect
Cryovac Pouches - Batch IX			
500 Watt Microwave Oven			
2 day storage	5.0	6.0	6.0
14 day storage	5.0	7.0	6.0
21 day storage	5.0	7.0	6.0
35 day storage	5.0	7.0	6.0
42 day storage	6.0	7.0	6.0
2860 Watt Microwave Oven			
2 day storage	4.0	7.0	6.0
14 day storage	4.0	6.0	6.0
21 day storage	4.0	6.0	6.0
35 day storage	4.0	6.0	6.0
42 day storage	4.0	7.0	6.0
Polyethylene Tub - Batch X			
500 Watt Microwave Oven			
2 day storage	4.0	7.0	4.0
14 day storage	4.0	7.0	4.0
21 day storage	4.0	6.0	4.0
35 day storage	4.0	6.0	4.0
42 day storage	4.0	5.0	5.0
2860 Watt Microwave Oven			
2 day storage	4.0	6.0	5.0
14 day storage	4.0	6.0	5.0
21 day storage	4.0	6.0	6.0
35 day storage	5.0	6.0	7.0

NOTE: All samples were stored at 4.4°C.

It was found for these tests that results were similar to those associated with the data for flavor. It was noted that as the product began to deteriorate (in terms of microbial spoilage, lower moisture contents, increasing pH and excessive free whey), initial mouthfeel, curd texture and residual effect were all influenced by the spoilage process; in terms of lower scores.

Textural alterations were observed at the onset of the study in all samples. Alterations occurred due to the effect of heating the product. Extensive alterations were noted in samples which were microwaved to high temperature levels (71.0° and 82.2°C) and samples which were heated for long periods of time (samples microwaved on the defrost cycle). Samples subjected to these conditions resulted in a mass of product (curd characteristics were not visible), which resulted in removal from the study immediately following the heat treatment.

Effect of Microwave Heating Upon Package Stability

Another important aspect of the research was to examine the effect of microwave heating upon packaging materials and container form. Material stability is of utmost importance to the products keeping quality. It is very important that the material protects the product from possible recontamination with microorganisms. Maintenance of the containers integrity is critical; the material should also have capacity to allow transmission of energy, specifically that generated from the microwaves for thermal heating of the contents.

In this study, the packaging components were affected by the heat generated from the microwave ovens with respect to the product. The heat from the product therefore affected the packages. All of the materials under investigation were influenced (by means of strutural change) upon heating to high temperatures.

The first container used was made of 15 mil poly-styrene, it is rigid and has excellent tensile strength, yet it has poor shock and flex strength. The material generally has good chemical resistance, but poor resistance to petroleum derivatives. It is odorless and tasteless, therefore making it an excellent material for food. The material retained its original structure and integrity when subjected to all heating temperatures with the exception of 82.2°C. At this temperature, regardless of the oven used, the lid of the container was forced off and the bottom began to show signs of buckling. During storage, at a temperature of 4.4°C, the material showed no change from its original structure.

High density polyethylene containers (25 mil) were also investigated. The material is opaque, flexible, tough and chemically inert. During heating, the container structure was only influenced when subjected to a temperature of 82.2°C. Even at that temperature, the only change noticeable was a slight softening, which immediately reversed after removal from the microwave. There was no evidence of structural change during refrigerated (4.4°C) storage.

Cryovac pouches (1.5 mil) comprised of nylon-saran and polyethylene have excellent properties with regard to cottage cheese shelf life. Cheese packaged in cryovac pouches retained a high degree of quality for the longest time. This was evident for both the microwaved samples and nonmicrowaved control samples. One reason for this was that the pouches were air evacuated, reducing the potential that aerobic organisms could survive. Each of the layers offers certain characteristics. At refrigerated temperatures, nylon offers excellent abrasion resistance, puncture resistance and tensile strength. It is a good gas barrier and has good elongation. Nylon lacks as a barrier against moisture, though the saran is an excellent barrier to moisture. Saran is also an excellent gas barrier, has good optical properties and resists chemicals, oils and greases. Finally, the polyethylene has an attractive mix of properties and characteristics. Among them are flexibility, toughness, strength, chemical inertness, heat sealable and clarity. Combining these materials into a single structure and converting it into a pouch results in a design which is difficult to tear, has low water transmission, very low oxygen permeability and is resistant to chemical interaction. There was one problem which was observed when using this package form; there was a definite change in shape when subjected to a temperature of only 48.8°C. At that temperature the material began to swell (resembling that of a balloon affect) stretching and thinning of the material was also observed. Upon reaching higher temperatures, specifically 60.0°C and above, the pouches split open, making it impossible to subject them to temperatures above 48.8°C. The pouches were not affected by the storage temperatures of 4.4°C.

SUMMARY AND CONCLUSIONS

A good quality, long shelf life cottage cheese can be manufactured by subjecting the finished product to an "in package" thermal heat treatment. The product is acceptable and free from the legal implications associated with using additives or preservatives as means to extend the shelf life of the product.

The heat generated from the microwave ovens used, proved to be satisfactory in reducing the number of viable organisms in the finished product. There were two problems associated with using microwave energy to heat the product. First, excessive heating (71.0°C-82.2°C) caused extreme product breakdown and textural changes and secondly, low thermal heat treatments (37.0°C) resulted in inadequate destruction of the microorganisms in question. An optimum temperature was determined (48.8°C) which sufficiently reduced the number of spoilage organisms as well as maintaining an aesthetically appealing product.

When the proper thermal heat treatments were employed, along with proper packaging and sanitation, the cottage cheese had an extended shelf life (from one week to one month longer than the normal 12-21 days). The air evacuated cryovac pouches had shelf lives which were double to that of the present shelf life of cottage cheese.

The cottage cheese was produced in a research lab where sanitation conditions were different than dairy plant standards. This may have influenced the shelf life, resulting in a storage life different than what may have otherwise been observed. Various other types of cheeses were being produced in the lab during the same time, some of which were inoculated with ripening organisms. These organisms may have influenced the initial microbial count in the cottage cheese. Also, the lab was not equipped with proper filling equipment. Due to the filling procedures that were employed, spoilage organisms may have been able to contaminate the finished product at that time. If all variables were controlled to the same degree as those found in a dairy plant, the cottage cheese would definitely have a much longer shelf life. Another possible cause for short shelf lives may have been the result of using commercial research microwave ovens. Difficulties encountered included improper timing, interruption of the heating cycle, improper temperature readings, as well as equipment wear (due to the number of persons using the equipment for various research applications).

The variables that were investigated during the study (pH, moisture, free whey, microbial and sensory analysis) all followed similar patterns. As shelf life increased, the pH rose, moisture loss was noted, free whey increased, microbial counts increased and the sensory scores declined. Definite trends were noticed, for example, when mold growth was apparent, pH values climbed and continued to climb until growth became excessive. As the free whey became extensive, the moisture content of the curd dropped. Sensory data corresponded with microbial results for deciding when samples were no longer acceptable.

The cottage cheese should be subjected to an optimum temperature and a satisfactory length of come up time, sufficient for destruction of spoilage organisms as well as retaining product quality.

Future Research

This area of research is new, thus there are many changes, additions and/or modifications possible. An important area to be further researched would be time/temperature relationships. Holding periods at specific temperatures should be looked at as well as higher temperatures at shorter time intervals.

Industrial microwave oven application, for greater accuracy in timing and temperature controls.

The proper filling equipment should be utilized to insure better sanitary conditions.

Packaging materials should be varied to a greater extent. Pouch utilization for air evacuation, back flushing, material thickness variation as well as coextruded films should definitely be further investigated.

Techniques to reduce textural alterations should also be investigated.

APPENDIX

Microbial Analysis

Reagents

Sodium Citrate: Dissolved 20 grams sodium citrate in 1000 ml distilled water. Solution was heated to 40°C.

Tartaric Acid: Dissolved 10 grams tartaric acid in 1000 ml distilled water.

Agar

Plate Count Agar: Dissolved 23.5 grams in 1000 ml distilled water. Autoclaved for 15 minutes then cooled to 44°-46°C. (Tryptone 5.0 gms; yeast extract 2.5 gms; glucose 1.0 gm; agar 15 gms).

Potato Dextrose Agar: Dissolved 39.0 grams in 1000 ml distilled water. Autoclaved for 15 minutes then cooled to 46.0°C. pH was adjusted to 3.5 using a 10% tartartic acid solution. (Potato infusion 200 ml; dextrose 20 gms, agar 15 gms).

Violent Red Bile: Dissolved 41.5 grams in 1000 ml distilled water. Solution was cooled to 44°-46°C (yeast extract 3.0 gms; Peptone 7.0 grms; bile salts #31.5 gms; lactose 100 gms; chloride 5.0 gms; agar 15.0 gms; neutral red 0.03 gms).

Microwave Information

	OVEN I	OVEN II	OVEN III
Trade Name:	Sears Kenmore	Litton	Hobart
Model Number:	747.9947510	425	m312T
Frequency:	2450 MH_z	2450 MH_z	2450 MH_z
Power:	1200 watts	500 watts	2860 watts
Electricity:	120 volts at 60 H_z	120 volts at 60 H_z	120 volts at 60 H_z
Cooking Positions:	Cook and defrost	Warm Defrost Simmer, Roast Reheat, High	Cook
Timer Capacity:	0 to 20 minutes	0 to 35 minuts	0 to 8 minutes

Fat Content

Fat content of cheese samples and the cream dressing were determined by performing the Official and Modified Babcock methods and are presented below.

Fat Content of Cottage Cheese Curds and Creamed Dressing

Sample	Fat Content
Cream Dressing	17.55%
Cottage Cheese Curd (Modified Babcock)	4.1%

NOTE: Fat content was based on the average of duplicated samples.

Cottage Cheese Dressing

Based upon 6.8 kilograms of cheese curd

whole cream	1.02 kilograms
whole milk	1.25 kilograms
salt	.055 kilograms
stabilizer	.006 kilogram

The ingredients are blended cold, heated to 73.88°C for 30 minutes, held overnight in refrigerated 4.4°C conditions.

Frozen Lactic Culture: Obtained from Chrs. Hansen Laboratories, Inc.

SCORE CARD

SENSORY EVALUATION

Date:____________________ Panelist:______________

Product - treatment: ______________

N: No Defect
S: Denotes Slight Defect
P: Denotes Pronounced Defect

	SCALE				
	N	S	D	P	
Flavor					
Coarse	10	9	8	7	
Flat	10	9	8	7	Score:_________
High Salt	10	9	8	7	
Lacks Freshness	10	8	5	1	
Body Texture					
Firm/Rubbery	5	4	2	1	
Mealy/Grainy	5	4	2	1	Score:_________
Weak/Soft	5	4	3	1	
Appearance Color					
Matted	5	4	2	1	Score:_________
Shattered Curd	5	4	3	2	

Initial Mouthfeel: Wetness-Dryness: (very dry-----very wet) [1-10]
Score:_________

Curd Texture: Cohesiveness: (very soft-----very firm [1-10]
Score:_________

Residual Effect: Mealiness: (not mealy-----very mealy)
Score:_________

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