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from

THE SEVENTEENTH

MARSCHALL INVITATIONAL ITALIAN CHEESE SEMINAR

held in the FORUM of the

Dane County Exposition Center

Madison, Wisconsin

U.S.A.

September 10 & 11, 1980

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September 12, 1980

The paper entitled "CORNING'S SOLUTION FOR THE WHEY DISPOSAL PROBLEM," delivered by Mr. Bhav Sharma, Senior Project Engineer, Corning Glass Works, Corning, New York 14830, was not made available to us to be included in the "Proceedings From the 17th Marschall Invitational Italian Cheese Seminar."

We are sorry this paper was not made available for this purpose but this apparently was a management decision on the part of the Corning Glass Works, over which we have no control.
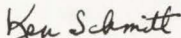
The entire paper was delivered verbally by Mr. Sharma, on schedule, at the 17th Marschall Italian Cheese Seminar, on Wednesday, September 10, 1980.

We are sorry we cannot make a copy of this paper available in this proceedings book, but we feel sure you will understand our position.

It may be possible at some future date to get a copy of this paper by writing to the following:

> Mr. Bhav Sharma
> Senior Project Engineer
> Corning Glass Works
> Corning, New York 14830

Sincerely yours,

Ken Schmitt

Ken Schmitt, Co-Chairman
Marschall Italian Cheese Seminar
Madison, Wisconsin 53701

The following paper was presented by Mr. Harold L. Rasmussen, Supervisor, Micro-
biological Controls, Marschall Division, Miles Laboratories, Inc., P.O. Box 592,
Madison, Wisconsin, 53701, U.S.A., especially for the 17th Marschall Invitational
Italian Cheese Seminar, held in the Forum of the Dane County Exposition Center,
Madison, Wisconsin, on September 10 and 11, 1980.

IN-PLANT EXPERIENCES RELATED TO PREVENTION
AND CONTROL OF BACTERIOPHAGE

By Harold L. Rasmussen

The primary cause of starter failures in cheesemaking operations is the wide-
spread presence of bacteriophages in cheese factories. It is not the purpose
of this paper to describe these bacterial viruses. For this type of information
please refer to a paper entitled "Bacteriophages in Italian Cheesemaking Today"
which was presented at the 9th Annual Marschall Invitational Italian Cheese
Seminar, 1972.

As cheese factories have become larger the problems caused by phages have become
greater. And as more cultures have been introduced more phages have developed.
Regardless how many precautions are taken to eliminate phages from the factories
these pests still persist. It may be simple enough to destroy phage particles
on the surfaces of equipment but it is a different matter to prevent them from
getting into the air and being transported by air currents. As whey is moved
around the plants and passes through equipment such as curd fine savers and separ-
ators, and finally in some instances condensed or condensed and dried on the
same premises cheese is manufactured, it becomes almost impossible to keep phage
out of the plant atmosphere. Consequently the situation existing in cheesemaking
is that we have to live and deal with the problems caused by bacteriophages.

There are a number of plant practices that result in recycling of phage from the
whey back into the milk handling system.

One of these is the Use of the Same Separator
for Standardization of Milk and Separation of Whey:

This was found to be the practice in some cheese factories. The consequences
are very evident. Standardization of milk in the same separator used to remove
fat from whey will directly contaminate the milk with phage particles from the
whey. Needless to say, this practice had to be stopped. Prior to discovering
this slow vats were occurring daily subsequent to start-up of whey separation.

Another Practice has been the Use of Whey Cream for Milk Standardization:

This also directly contaminates the milk with phage particles from the whey.
As the whey is separated many phage particles go out with the cream. Starter
performance and cheesemaking were greatly improved when this practice was
discontinued.

Whey Handling in Area of Raw Milk Storage and Pasteurization

Whey processing equipment such as curd fine savers, whey collection or surge
tanks and separators should not be located in the same room with raw milk
holding tanks or pasteurization equipment and vacreators. Phage particles will
be transferred into raw milk holding tanks through the air vents. As milk is
drawn from the tanks air is drawn in to replace the space vacated by the milk.

If there are phage particles in the air they are drawn into the tank and contamination of the milk with phage will occur. If whey surge tanks, curd fine savers and whey separators are located in the raw milk holding tank area the surrounding air will become contaminated with phage particles.

Likewise, if the air surrounding the pasteurizer is contaminated with phage particles the milk can become contaminated with phage in the balance tank since this tank is not air tight. We have demonstrated this in a number of factories.

Also, milk will be contaminated with phage in the vacreator if the ambient air contains phage particles as a vacreator draws in a small volume of ambient air continuously.

A number of years ago we made phage surveys in plants where the raw milk holding tanks, curd fine-savers, whey separators and pasteurization equipment was located in the same room. Under these conditions phage was found in the raw milk and of course the pasteurized milk. The cheesemaking operations in these factories were greatly improved when all whey handling operations were moved to a separate room isolated from the milk storage and milk processing areas.

Pasteurizer in the Cheese Vat Room:

It is not uncommon in cheese factories to find the pasteurizing equipment located in the cheese vat room. During cheesemaking the phage titer in the air surrounding the vats increases. Thus during the cheesemaking operation phage can cycle from one cheese vat into the milk at the pasteurizer balance tank and into the next vat being filled. The effect will depend on the amount of phage being generated in the cheesemaking process. We have demonstrated the possibility of this happening by bubbling air through sterile milk in an enclosed container adjacent to the pasteurizer balance tank with an Anderson Air Sampler pump. At each sampling we calculated approximately ten cubic feet of air was bubbled through 100 ml. of sterile milk. In all instances phage particles could be detected in this milk sample by activity test acid depression technique.

Whey Holding Tanks in Cheese Vat Room:

There are factories that have an open tank in the cheese vat room for collecting whey ahead of the separator. This is a poor practice as it increases the phage titer in the air surrounding the cheese vats and leads to phage contamination of the milk in the vats. All equipment for processing of the whey should be in a separate room isolated from the cheesemaking area.

Flushing Curd from Vats with Whey:

This practice is followed in some cheese factories. A pipeline carrying whey runs along one side or end of the cheese vats. Connections are provided for a plastic hose. Whey from this line is used to rinse each vat and flush out all of the curd particles. This is considered a poor thing to do as the spray or mist (or fog) coming out of the vat as the rinsing is done will contaminate the surrounding air with phage. The phage will find its way into other vats by air transport of the mist or fog. Connecting and disconnecting the plastic hose also could result in whey drippings which would be undesirable.

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Starter Tanks in Vat Room:

If starter tanks are located in the cheese vat room there is a good chance of contaminating the starter with phage during preparation of the media and by air replacement during removal of the starter from the starter tank. Starter tanks should be located in a room isolated from the cheesemaking area, and traffic of people from the cheese vat room into the starter room should be held to a minimum. The ideal situation is to have someone other than the cheesemaker responsible for the starter operation. The starter room should be under positive air pressure to prevent passage of air from the cheesemaking area into the starter making area. The starter room should be free of floor drains. The floor should slope toward the door with space under the door for drainage to a drain outside the room. Good lighting should be provided and the walls, ceiling and floors should be easily cleanable. Powder mixing equipment should be located outside the starter room to prevent dust collection in the starter making area.

Importance of Air Currents:

Since phage particles are transferred to the air by splashing or atomizing of whey during whey handling, or even by passing air over open cheese vats, the direction of movement of the air becomes very important. Air should never move from whey handling areas back into the raw milk storage, pasteurization or cheese vat areas. The ideal situation is for air to pass through the factory in the direction of milk and product flow. The consequences of phage laden air circulating around milk storage tanks, pasteurizing equipment and over cheese vats have already been pointed out.

Importance of Proper Piping System for Pumping Starter to the Cheese Vats:

The piping system must be constructed in such a manner that no milk containing starter will lay in the milk pipeline between filling of vats. Very reliable check valves must be provided to prevent leakage of milk or starter from backing up into the milk line system. There should be a minimum of pipeline holding culture between filling of vats. Only positive pumps should be used for pumping starter.

Importance of Keeping Floor Drains Clean:

Floor drains can be a source of phage contamination if they are not kept in a clean and sanitary condition. Nutrients and starter bacteria from milk and whey collect in the drains. Phage in the whey can actually multiply in the drains if they are not flushed regularly and washed and sanitized at the end of the day or at intervals during the day when cheesemaking continues for most hours of the day. Drainage trenches or troughs built into the floor at one end of the vats with one common drain at one end or in the middle is a good way to eliminate or reduce phage build-up from floor drains.

Importance of Washing and Chlorinating Vats:

In the modern cheesemaking operations it is necessary to wash the vats and then sanitize them with chlorine sanitizer between fillings. If this is not done phage titers become so high in the succeeding vats that the starter will not function properly. In a test made by one research worker it was reported that 0.3 ml. of a high titer phage preparation added to a cheese vat was sufficient to cause complete failure of a homologous single strain culture. Thus it may

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require only a few milliliters of whey remaining in a vat to inhibit the starter. All whey residues and curd particles must be removed by thorough washing with detergents. Following this the vats, paddles and curd cutting knives must be thoroughly rinsed and finally flushed or rinsed with a chlorine solution of 400 ppm. available chlorine for open vats. For the closed vats, which are washed by in-place cleaning systems, there should also be a final rinse with a chlorine solution containing 100 to 200 ppm. available chlorine. It has been reported that using chlorine solutions of high available chlorine content of 300 to 400 ppm in enclosed vats will cause sticking of solids on the vat surfaces. The higher temperature and more thorough flushing through spray balls of the in-place cleaning system should make it possible to inactivate the phage at lower chlorine concentrations of 100 to 200 ppm.

The importance of chlorination of vats was dramatically demonstrated in a factory which had a bad condition of recycling phage. Whey and curd was difficult to keep off the floor which was in poor condition. Whey also remained standing in drain pans under the vat drain valves. The whey separator was located next to the pasteurizer and close to an open receiving tank in the milk intake room. As soon as whey was pumped away from the first vat the recycling began and continued for the remainder of the cheesemaking operations. The factory had 5 vats and made 10 vats of cheese each day. The first 5 vats would be satisfactory but beginning with the sixth vat (the second round) and continuing for the remainder of the day the acid development became slower and slower from one vat to the next and finally there was hardly any acid . development in the last couple of vats. The vats were not being properly chlorinated.

Two things were done for the last two vats one day. The ripening time of the starter in the cheese vat was reduced from 1 hour and 20 minutes to a time of just 30 minutes, and the vats were swabbed by sponge with a strong chlorine solution containing at least 400 ppm. available chlorine. That day the last two vats came through very well even though the two or three preceding vats were slow. This method of chlorinating continued for all vats and made it possible to go the two rounds with the vats with the same culture and made ten vats of good cheese. It was possible to do this in spite of the poor factory conditions cited above.

This company was in the process of building a new factory in which the conditions existing in the old factory were to be corrected.

Hazards of Washing Equipment with Condenser Water or with Reverse Osmosis Permeate:

We are aware of instances where recommendations have been made to cheese factories that condense their own whey to use evaporator condenser water for washup purposes. This is being done in other types of dairy operations but should be strongly discouraged in cheese factories. Another suggestion has been to use permeate from reverse osmosis treatment of whey for the same purpose. Both recommendations would be hazardous in a cheese factory, as the water from both operations would contain bacteriophages. In one test we made, the R.O. permeate contained high levels of bacteriophage. The condenser water, called COW water, will contain phage at a lower level due to dilution. This has been confirmed by tests in our laboratory.

All equipment coming in contact with these waters would become contaminated with phage particles and compound the problem of keeping phage populations down.

Importance of Starter Ripening Time in Cheese Vat:

Starter ripening time is the time span from the time the starter is added to the cheese vat until the coagulant is added. Phage contamination from the air and phage proliferation is most rapid during this period. The longer the ripening time the greater the number of phage particles produced. When acid development in the cheese vat becomes slow it is helpful to add slightly more starter and shorten the ripening time.

In certain parts of the world no ripening time is used. A high level of starter, perhaps as much as 3%, is added to the vat and the milk is set with coagulant immediately after the starter is mixed in. The theory here is to coagulate the milk before the phage has time to multiply. Once the curd is formed the starter organisms are protected from phage invasion. The curd shuts out the phage particles.

Importance of Starter Rotations:

Normally phage is produced during the cheesemaking process. Phage will usually be present in a factory for any starter culture after it has been used for a period of time. When a new culture is introduced, which is immune to the phages present in a factory, it is just a matter of time before a phage active against it will show up. Where it comes from is anybody's guess. Since phages can change through mutation the same as bacteria do, it could be a mutant of a phage already in the factory. Or, it could be activation of a dormant phage introduced on dust particles in the air. Another possibility is the induction of prophage which is carried by many starter organisms. This is the process of lysogeny which is a subject by itself and one that I will not attempt to deal with in this paper.

Since all starter cultures are subject to phage attack there is no culture that can be used indefinitely for cheesemaking in any factory. In large factories, making cheese almost around the clock, starter slow-down may be noticed after six to eight vats of cheese have been made. As phages are culture specific it is possible to set up starter rotations to follow each culture with one or two cultures which are completely immune to the phage that may be produced by the first culture. Most cheese factories in the United States would not be able to operate successfully without following a good starter rotation program. This, coupled with good sanitation makes it possible to make cheese continously for 20 to 22 hours per day seven days a week without experiencing dead vats.

Importance of Phage Inhibitory Media:

Not too many years ago all bulk starters were grown in milk. Phage infection of the milk in starter tanks frequently resulted in slow or dead starter cultures, depending on how severe the phage infection was. As cheesemaking operations became larger, slow or dead bulk starters became more frequent. This became such a serious problem that certain segments of the cheese industry in this country came to our company for help. The first help came through marketing of phosphate buffer salt solutions for treating milk at the cheese factories. Later a dry powdered milk based phosphated phage inhibitory medium was developed which simply

required reconstitution in water and heat treatment in the cheese factory. Today most bulk starters are prepared in buffered media. The cheesemaker can always rely on having an active bulk-starter when he uses one of these media.

The function of these media is to protect the starter culture against phage attack in the starter tank. Bacteriophage particles cannot propagate in these media as they cannot attach themselves to the bacterial cells. If the medium becomes contaminated with phage the culture continues to grow and produce acid normally. However, the starter vessel should be protected as much as possible from phage contamination. Though the phage particles cannot propagate in the medium, the medium does not destroy them and they will rapidly propagate in the cheese vat if they are homologous with the starter culture. Thus it must be emphasized that the phage protection does not extend beyond the bulk-starter tank. The precautions discussed throughout this paper must still be taken.

The following paper was presented by Mr. Verle W. Christensen, Director, Madison Operations, Marschall Division, Miles Laboratories, Inc., P.O. Box 592, Madison, Wisconsin 53701, especially for the 17th Marschall Invitational Italian Cheese Seminar, held in the Dane County Exposition Center, Madison, Wisconsin, on September 10 and 11, 1980.

NEW DEVELOPMENTS AND THEIR EFFECT ON FLAVOR DEVELOPMENT AND IMPROVEMENT IN ITALIAN CHEESE

By Verle W. Christensen

Flavor and body characteristics which make up a good Italian cheese, such as Provolone, Romano, Asiago, and Mozzarella are well known to those skilled in the art of cheese making. The specific processes for the development of the desirable flavor characteristics of these cheeses have been partially identified and understood.

As stated in other presentations given at previous seminars, cheesemaking is a microbiological and enzymatic process. However the basic criteria for obtaining a good product having the desirable body and flavor characteristics still requires the use of:

1) Good milk with the proper chemical and physical properties.
2) The use of proper bacterial cultures and enzymatic coagulants.
3) Maintenance of a manufacturing procedure free of undesirable bacterial contamination.
4) Close control of the various operating conditions during all processing steps.
5) Expertise of the cheesemaker.

There has been, and continues to be, a great need to explore newer methods of cheese manufacture, to reduce costs, and increase marketing potential without destroying the inherent, traditional, and desired characteristics of the well-known Italian cheeses that have been traditional in both the USA and Italian markets.

New technology has been, and continues to be, developed to progressively refine the current curd forming method of the manufacture of cheese. However, the ultimate goal will be to introduce new and radically different techniques that would significantly reduce present costs of manufacture, packaging, and storage of cheese; improve product quality and uniformity; reduce the ripening period; and eliminate the uncertainty in the outcome of ripening.

When we look at some of the newer technology that has been introduced to the present conventional cheese manufacturing process, most of them have involved new cultures, culture media, and enzyme improvements. Some developments have taken place in equipment modifications especially in the development of large enclosed vats, use of draining tables, salting methods, and stretching and packaging equipment. However these equipment changes have had a greater influence on body and yield characteristics than on flavor development.

Marschall's research in the development of culture media has usually been keyed to development of the optimum medium rather than the lowest priced medium for it is easier to prevent culture problems than to cure them. A key point in this is the use of high quality ingredients and especially the use of some non-fat-dry milk solids to provide the casein necessary for good starter balance. This has recently been substantiated by some very good work reported in an article by Kothan and Nambudripad of the India National Dairy Research Institute entitled "Casein is a Necessary Factor in the Production of Stimulatory Material for Associative Growth of Lactic Streptococci."[1]

I especially want to call your attention to the use of media comprised mostly of whey solids. Although these products are cheap and cultures will grow in them, they have resulted in a greater variation in starter activity. This is primarily due to the lack of casein in their make-up, the great variation in whey solids from whey powder suppliers, and the possible presence of inhibitory substances in the powders. We have found many whey powders to be carriers of bacteriophage and although these bacteriophage particles can be destroyed in heating the culture media, the dust particles during reconstitution can remain in the starter room area to contaminate the ripened culture. This is one of the reasons why whey media work well for a short period but then give rise to serious starter acidity fluctuation in cheese manufacture, after continual use.

The selection of the cultures to be used in the production of Italian-type cheeses is equally as significant as the medium in which it is to be grown. It is in this area, since the First Marschall Italian Cheese Seminar in 1964, that great emphasis has been placed on this subject. Unlike those early days of using seed cultures when one general purpose culture was used, today the Italian cheese manufacturers can select specially developed cultures to fit their specific needs.

A key to the development of these starter programs was the excellent pioneering work of leading dairy scientists such as Dr. W.C. Frazier, Dr. Marvin Speck, Dr. George Reinbold, Dr. Frank Kosikowski, Dr. Z.D. Roundy, and Dr. W.J. Harper. Professor Harper, for example, in his paper[2] given at the 2nd annual Marschall Seminar in 1965 pointed out that combinations of organisms were beneficial in increasing the rate of flavor development in Provolone and Romano Cheese. The type of culture markedly influenced the flavor development in cheese through the selected use of individual cultures. L. Bulgaricus produced the best flavored cheese, followed by L. Lactis and then S. Thermophilus. The best cheese was made with a combination of L. Bulgaricus and S. Thermophilus. This cheese generally possessed the highest amount of butyric acid, a flavor compound necessary to provide the unique "Piccante" flavor found in Provolone and Romano Cheese.

We believe most Italian cheese manufacturers who cooked the curd over 104°F, will agree that the key to a successful starter program is the maintenance of the proper ratio of coccus to rod organisms during the cheese manufacturing process. This can now be accomplished by using proven starter media and proven starter cultures designed for the purpose of acid control during manufacture and flavor development when the cheese ages.

For future Italian cheesemaking, we believe minor improvements will be made in starter media whereas some very important developments will take place with starters. These starter developments will be in two areas, the selection of more strains for culture rotation purposes and for improved cheese flavor developmen

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The development and acceptance of new chemical and analytical techniques such as those of chromalographic separation, refined new microscopic examination of cheese structure, and the use of aseptic cheese manufacture have identified that lactic cultures cause proteolysis in cheese and are important factors in cheese flavor development in additional to acid production. It has been observed that some cultures were more proteolytic than others and that the lactobacilli were more proteolytic than the streptococci. Variations in proteolysis were observed to vary greatly between individual strains of a given species of culture.[3]

The protease found in cultures can be of three types, and are either extracellular (outside the cell wall), bound to the cell wall membrane, or intracellular (within the cell wall). The intracellular enzymes would be released only when the cell wall is autolyzed or ruptured. In the cheese manufacturing process the numbers of culture microorganisms in cheese decline rapidly[4] in the initial stages of ripening. Flavor development follows. This suggests that flavor development is therefore related to the enzymes of starter bacteria that are released after the death of the cell rather than from the activity of live or viable cells. This theory has now been fairly well documented by the work of Schormuller[5] when he used aseptic vat techniques and reported that proteases and many other enzymes from culture organisms were involved in the flavor and development of both soft and hard type cheeses rather than ezymes from the milk, coagulant, or the bacteria in the milk.

It is with this confirmed knowledge that we are today selecting cultures not only for reliable acid production or desirable cheese body characteristics but also for flavor enhancement. This will help contribute to the lowering of costs of aging and improvement in flavor uniformity that will be of increased value to the cheesemaker.

Also important in the selection of culture microorganisms will be new methods of culture composition. Cultures will still be isolated and selected from our natural environments such as milk, cheese, soil, and grasses; however a new and perhaps more valuable tool in the future will be manipulation of the genetic material of existing strains. These isolates can then be made to perform or inhibit certain functions in the cheese process, as needed.

The area of coagulants will also be of great importance in the future to the Italian cheese manufacturer. Calf rennet is declining in availability and at the present high price will be used in only selected, expensive, aged cheeses. I believe everyone will agree that it is extremely difficult to find a replacement enzyme system that exactly duplicates that of calf rennet. Not only is coagulation important but the intricate balance of fine cheese flavor and yield are found to be of equal importance. The introduction of lower cost microbial coagulants has been of great value in replacing calf rennet although some difficulties have been found in duplicating the exact flavor characteristics in aged cheeses. Also some whey processing problems have occurred, especially in those products where less than pasteurization temperatures and holding times are used.

Recently improved methods of production and purification have been developed to help these microbial preparations overcome some of the difficulties I have discussed. This is demonstrated in the development of Marzyme II which performs much more like calf rennet in aged cheese and flavor development and also is more heat labile so that it reacts like calf rennet to some of the lower heat treatments presently being used to prepared whey products for use with milk ingredients. Previously some of the enzyme would carry-over into the whey

powder preparation and then could cause separation of the casein in the milk ingredient to form an undesirable casein gel structure.

Coagulant manufacturers are working to improve their microbial products and I am sure other developments will be made to more closely duplicate calf rennet performance. Microbial coagulants also have an advantage for use in that they can easily be koshered to meet this important marketing function.

An area where tremendous growth has been made is in the use of lipase products to produce the "piccante" flavor in cheeses like Provolone and Romano and enzyme modifications of those products for use in process cheese and other food ingredients. The use of calf, lamb, and kid lipase products such as our Lipase 300, 400 and 600 have been discussed with you previously and I am sure you are all familiar with them.

This is true also of our regular rennet pastes such as rennet paste #12 and #32. Marschall rennet pastes not only contain lipase enzymes and other flavor producing properties but also are standardized to provide uniform coagulation properties. Some custom-tailored rennet pastes are made to exact specifications of the buyer, upon request. Because of the success of the program and also because of the need by the Italian cheese manufacturers, Marschall will intensify its efforts in these areas to give the Italian cheese makers specific products to fit your needs. We therefore will be offering to those manufacturers that need increased flavor in less curing time, a broader flavor profile range, and increased coagulation benefits, special custom blended products for your needs.

I would also like to point out that lipase powders can be formulated for different needs in the trade. Therefore some custom blending of lipase systems will be made available to meet customer specifications and special package sizes. You may contact our Italian Cheese Product Manager, Norm Wood, for further information if you are interested.

I have discussed some of the areas of new development in flavor improvement using conventional cheese manufacturing methods. Other new developments will take place rapidly with progressive refinement of conventional cheese methods and with entirely new cheese production schemes, such as ultra-filtration.

The use of special cultures for flavor production using new techniques will follow the order of the present concentrated lactic starter cultures. For those who want other types of flavors, concentrations of leuconostoc, S. Diacetylactis, L. Casei, S. Lactis and other special types common to certain special cheeses will be available. These cultures can then be added as starter to the milk or can be grown externally and then injected into the cheese milk as concentrates. Other alternatives will be to extract the culture enzyme systems and add them along with the coagulant to the milk. Still another method would be the production of flavor compounds externally and adding them to the cheese to reduce extensive ripening time.

Some of these methods will include the use of food approved special additives for cheese manufacture such as enzymes, enzyme products, and microbial cell concentrates and their extracts. These will be added to accelerate ripening with very specific flavor characteristics. These flavors should reach their optimum flavor level at desired periods required based on the levels and temperatures used and should have the stability needed to move through distribution channels to reach the customer without deterioration of quality.

With increased knowledge in the area of identification of flavor compounds
present in a good cheese flavor, a major effort has been directed to the
identification of free amino acids, free fatty acids, citric acid fermentation
products and the aldehydes and ketones resulting from the degradation of various
amino and free fatty acids. These products are derived from the three major
constituents of milk including the protein, carbohydrate and milk fat. We
believe modification of these materials in varying degrees can be accomplished
to shorten the cheese maturing process.

The use of enzynes, especially those of a proteolytic and lipolytic nature, can
also be used alone or in combination with culture concentrate flavor systems.
Recently much additional knowledge has been gained through experimental work
at the University of Wisconsin and Cornell University. Some very good research
by Professor Norman Olson and his staff[6] has shown that lipase enzymes, when
added to cheese curd, does not migrate or diffuse through the curd structure,
probably because of its high molecular weight.

Although this research showed that the lipase enzymes would not migrate, they
did hydrolyze the milk fat. The fatty acids released were of smaller molecular
size allowing them to diffuse through the cheese and contribute to a uniform
flavor development. This research is important from the standpoint of allowing
for reduction in enzyme costs as very little of the enzyme would be lost in the
whey as compared to adding it to the milk.

Professor Olson has further modified the enzyme system by using the method
of"Microencapsulation" in which the enzymes are enrobed within milk fat capsules.
These capsules can then be added to pasteurized milk at the start of the cheese-
making process. The use of this process will allow the cheesemakers to control
his cheese flavor by selecting particular enzymes, the amount of milk fat or
protein substrate, and other desirable flavor ingredients to be encapsulated.

Another very important development will be the use of cheesemaking by ultra-
filtration. This method is already used to some degree in France for the
manufacture of Camembert and Brie. One of the problems encountered here is the
slow growth of lactic cultures in a milk concentrate and the problems with body
and texture of the curd. Therefore ultra-filtration will find a significant use
in the soft cheeses such as Ricotta, Impastata, and Latin-American type cheeses
but the application to the hard type Italian cheeses and molded cheese such as
Mozzarella will need more study. One of the main problems will be to find how
to reduce the buffering effect of the concentrated proteins and the high calcium
salt levels which prevent the lowering of the pH of the material to proper levels.
Also involved are the concentration levels of lactic microorganisms and their
enzyme system which are necessary for flavor development.

The development of concentrated cultures offers a means of adding cultures of
various types in large concentrations in small amounts and it is by this means
that some of the problems of ultra-filtration of conventional cheeses may be
resolved.

Accelerated cheese ripening and other modified flavor developments will provide
the cheesemaker with the methods to lower storage costs and increase or develop
broader cheese flavor profiles. However, these modifications and new techniques
will not be accomplished easily and without some problems. Problems that will

need to be resolved will be maintenance of traditional cheese flavor, controllable flavor development to prevent over-ripening and bitterness, retainment of traditional body and texture characteristic, practical methods of ingredient use, decreased production costs that can generate additional real savings to the cheesemaker, and perhaps some legal difficulties with regulatory agencies with ingredients not presently approved for use in Italian cheeses.

However, these flavor "catalysts" promise to play a very important role in the future of the continual development and expansion of the Italian natural cheese industry.

Thank you for your kind attention.

The following paper was presented by Ms. Roberta McNaught, Applications Chemist, Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA 02139, especially for the 17th Marschall Invitational Italian Cheese Seminar held in the FORUM of the Dane County Exposition Center, Madison, Wisconsin, on September 10 and 11, 1980.

SALT ANALYSIS IN CHEESE PRODUCTS BY ION SELECTIVE ELECTRODE METHOD

By Roberta McNaught

John C. Synnott

Anne Goulston

Introduction

The measurement of salt content of cheeses is important for a variety of reasons. Process control, quality control, and increasing labelling requirements come to mind immediately, and the effect of salt level on the flavor development of aging cheese must, of course, be monitored. Italian cheeses, whose salt content tends to be relatively higher than other cheeses, are particularly affected, so the measurement becomes even more important.

Analytical methods in current use are generally based on the work of Mohr[1] in 1856, and of Volhard[2], in 1874. In the former, chloride is directly titrated with silver nitrate using a color indicator such as potassium chromate as the endpoint indicator. Volhard's method involves a back titration of excess silver added to a chloride sample, again using a color indicator for the endpoint. For these, as with all color-imetric procedures, there exists a problem when the samples contain suspended solids or colored material of any kind, and the result is usually decreased accuracy in the measurement. These techniques also suffer from the cost of silver nitrate.

Obviously, the inaccuracies of the color endpoints can be solved by using a silver electrode paired with a reference electrode for the titration, and, indeed, one can get reproducible, accurate results.

This, unfortunately, does nothing to reduce the cost per sample analyzed, and can be time-consuming. As these costs escalate, the need for a new method has become more pressing. Such a method would have to be as accurate as the potentiometric silver titration, but easier to use, and, thus, less time-consuming. It should also eliminate the use of silver so cost might be reduced. Orion's applications group has set out to develop such a method in recognition of both the problem, and the growing market that the cheese industry represents. We feel that an ion-selective electrode[3] method might solve the problem.

The Problem

As we have suggested, we need an analytical technique for analysis of chloride in Italian cheese. It must be simple to use, as accurate as titration, and inexpensive. The procedure would also have to address sample preparation insofar as it affects measurement. Potential interferences must be considered, and real world samples run by both standard and proposed methods. In theory, at least, all of the above can be addressed by use of a chloride ion-selective electrode in conjunction with a double junction reference and an appropriate electrometer. This "system" relates a measured potential to the activity of a species in solution. Under proper measurement conditions, the activity relates concentration to the interaction of the measured species to all others in the solution. Though this sounds complex, and can be further complicated by a discussion of theory, it can also be simplified in practice. For measurement of salt, the potential measured can be simply expressed by the following equation:

$$E = E_o + K \operatorname{Log} (C)$$

where   E is the measured potential

E_o is a constant for a specific temperature

C is the concentration of salt

and   K is a constant which incorporates temperature, ionic charge, the gas constant, and the Faraday constant

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The potential, then, is a straight line function of concentration, and that straight line has a slope equal to K. This means that a calibration curve can be developed by measuring the potentials of a small number of known salt solutions and that samples can be compared to it. Such a curve is shown in Figure 1. The only requirements are a stable reference electrode and a reasonably constant ionic strength background in both standards and samples.

In order to establish feasability, we first calibrated the electrodes using reagent grade sodium chloride in a background of .1M sodium nitrate, as shown in Figure 1. We then titrated a known (10^{-2}M) chloride solution using 10^{-1}M $AgNO_3$ as titrant, and the electrode pair as endpoint indicator. That titration is shown in Figure 2. Comparison of the initial potential, as read from the calibration curve, with the value calculated from titration data, shows that the electrode technique provides the same correct result as the titration. This, of course, means that one needn't have wasted the silver. It also means that we have shown feasability for a method that is simpler, more rapid, as accurate, and less expensive than currently used techniques. Applicability to real samples remained to be tested.

Experimental

From earlier work on butter and margarine, we had recognized the necessity of denaturing protein material by acid extraction, and of taking precautions to remove fats from the electrode surface. The latter is easily accomplished by wiping the electrode, between measurements, using an acetone-wet tissue. The former condition presents additional problems. Electrode calibration should be carried out in the same background as that used for sample extraction, if direct measurement is to be attempted. At the extremes (<1, >12) of pH, changes in the potential observed at the reference junction are quite considerable, and can adversely affect the overall reading. However, if the pH of the standards and samples is the same, the problem is avoided. We started by using a cold, .1M nitric acid extraction, in hopes of avoiding the boiling extractions commonly used, but were unable to get good correlation between the titration and electrode techniques using butter samples.

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Fig. 1
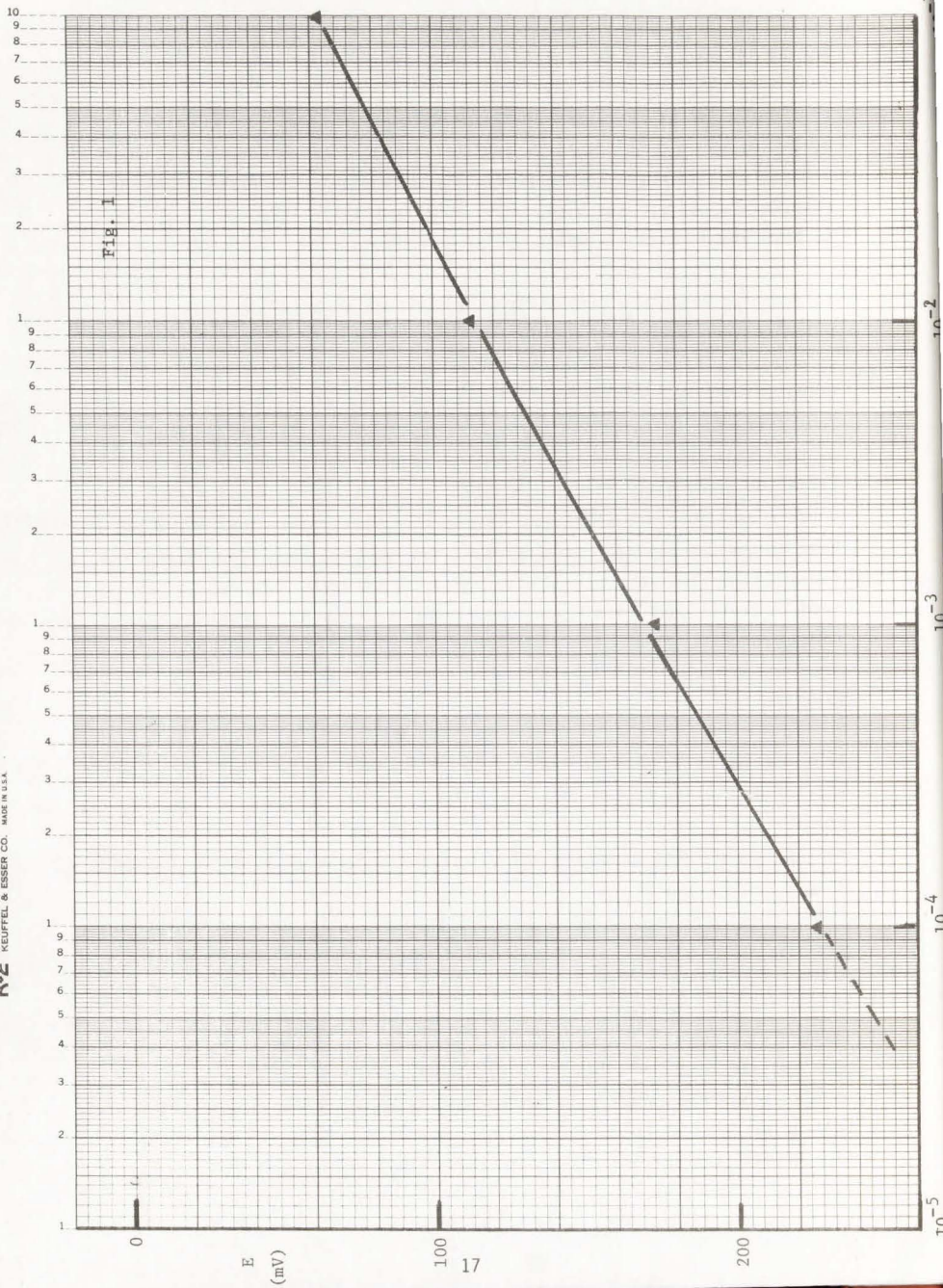
Fig. 2
Titration Of 10^{-2}M NaCl

E_1 = 111.8 mV
$\equiv 10^{-2}$M NaCl

E.P. = 10.0 ml
$\equiv 10^{-2}$M NaCl

ml 10^{-2}M $AgNO_3$

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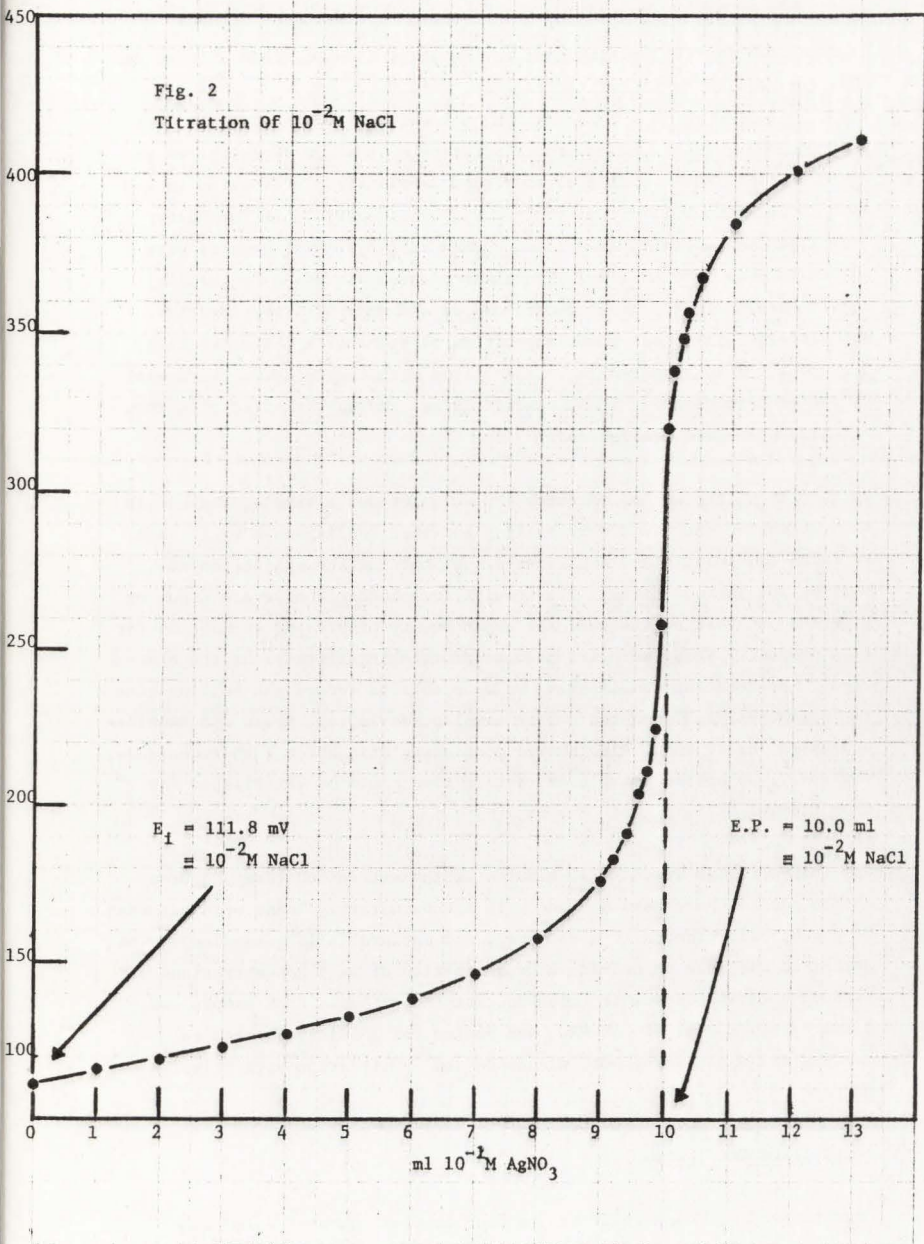
By reintroducing the boiling step to the extraction, we were able to get the same results by either technique.

The procedure, then, amounts to calibration of the electrode system in .1M HNO_3 and direct reading of a weighed sample after extraction in .1M HNO_3, brought to boiling and cooled. It was shown to work for butter and margarine, so we applied it to cheese analysis. The results were not immediately encouraging. The electrode technique showed results consistently slightly lower than those developed by silver titration, but reproducibility was good, suggesting problems with the extraction. The problem also appeared to be associated with the relative "hardness" of the product tested. Thus, cheddar cheese showed poorer results than American processed cheese food.

Up to that point, we had extracted by weighing out a sample, adding .1M HNO_3, bringing the mixture to boiling and then cooling in a water bath. We reran the comparative experiments, but holding the extraction at boiling for various times. The results for cheddar cheese are shown on Figure 3, indicating the need for about twenty minutes of extraction for this product. This, we attributed to protein interference at the electrode. By reducing sample size, we were able to reduce the boiling time to 15 minutes, and show that other samples (Jarlsberg cheese and American processed cheese food) also showed good correlations for both techniques. Obviously, an optimum sample extraction time could be established for each sample.

For this work, we selected 15 minutes as the extraction time and used cheese samples purchased at random in a supermarket. These were parmesan (1 g samples), ricotta (5 g samples), and mozzarella (5 g samples). The selection was made to provide a cross-section of salt concentrations and product consistencies with which to test the method. Each sample was extracted in 100 ml of .1M HNO_3 and boiled for 15 minutes prior to cooling and analysis by both electrode and by titration with silver nitrate.

Results and Conclusions

Comparative data were collected on four samples, each of which was

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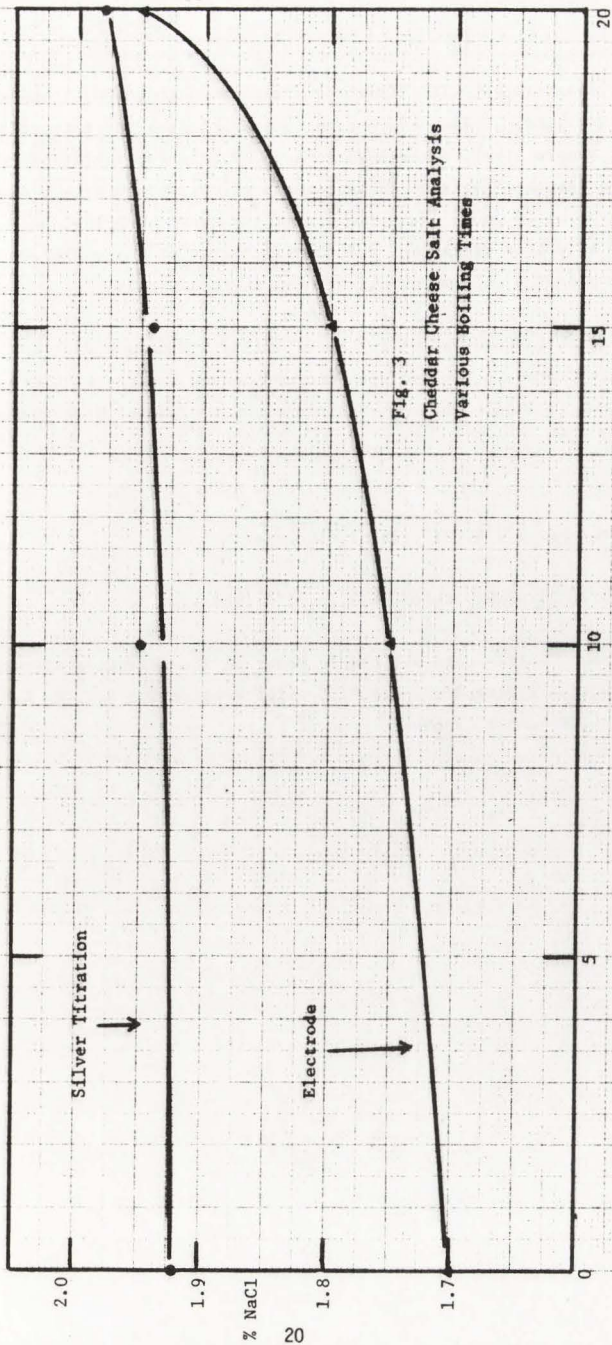
Fig. 3

Cheddar Cheese Salt Analysis

Various Boiling Times

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analyzed at least twice. The results are tabulated in Table 1, and show excellent agreement. These have not yet been optimized for extraction time or for sample size. A reasonable range of salt concentrations was covered, and agreement at each level between titration and direct electrode measurement is good. We believe that the increasing cost of measurement by silver titration, and the simplicity of the electrode technique may be the only major differences in the methods.

At present, work is underway to further simplify the measurement by adapting this procedure for use with microprocessor analyzers, where direct readout in % salt will be possible without calibration curves.

References

1. Fr. Mohr, Ann. 97, p. 355 (1856).

2. J. Volhard, J. prakt. Chem., 117, p. 217 (1874).

3. J. W. Ross, "Solid-state and Liquid Membrane Ion-selective Electrodes" in "Ion-selective Electrodes", N.B.S. Special Publication 314, R. A. Durst, Editor, November, 1969.

Table 1
Analysis For Salt In Cheese

Sample	% Salt By Electrode	% Salt By Titration
Ricotta	0.41	0.42
	0.38	0.42
	0.37	0.42
Mozzarella	1.6	1.64
	1.6	1.66
	1.5	1.67
	1.5	1.62
	1.5	1.62
	1.5	1.64
Parmesan – A	4.2	3.98
	4.2	4.04
Parmesan – B	3.8	3.86
	3.8	3.86
	3.8	3.86

The following paper was presented by Mr. William R. Thomas,
Food Market Manager, FMC Corporation, Food and Pharmaceutical
Products Division, Philadelphia, Pennsylvania, 19103, espe-
cially for the 17th Annual Marschall Invitational Italian
Cheese Seminar held at the Dane County Exposition Center,
Madison, Wisconsin, on September 10 and 11, 1980.

MICROCRYSTALLINE CELLULOSE - AN ANTI-CAKING
AGENT FOR GRATED AND SHREDDED CHEESE

By E. J. McGinley and W. R. Thomas

Caking and flow difficulties are common problems in industries
producing or utilizing grated and shredded cheese. High tempera-
ture stability, changes in relative humidity, pressure packing,
and the composition and particle configuration of the cheese
itself are some of the important factors affecting flowability.

A number of ways of overcoming flow problems, to some extent,
are employed commercially. These include: selection of cheese
by composition, controlling particle size, drying to a low
moisture content, and the addition of anti-caking agents.

The purpose of this study was to characterize the use of micro-
crystalline cellulose (MCC) as an anti-caking agent and flow
aid for grated and shredded cheeses.

Cellulose, and particularly microcrystalline cellulose, may
not be familiar to you. MCC is a non-fibrous form of cellulose
in which the cell wall of the plant fiber has been broken into
fragments ranging in size from a few hundred microns to a few
tenths of a micron in length (Figure 1). MCC is chemically
identical to native cellulose and has the same x-ray diffrac-
tion pattern. Only the physical form of the cellulose raw
material is changed in the course of manufacture of MCC; cellu-
lose in fiber form is converted to cellulose in particle form.
It occurs as bland, white, odorless, crystalline flour.

The unique ability of MCC to convert cheese and other pasty
oleaginous materials to a granular free-flowing form was demon-
strated in 1959. The Swift Company, with the support of the
National Cheese Institute, Inc., petitioned the federal govern-
ment to allow the use of MCC as a flow aid for grated cheeses.
The Federal Standard of Identity for grated cheese was formally
amended on June 11, 1973 to include the optional use of MCC
as an anti-caking agent not to exceed two percent by weight
of the finished food (21 CFR 19.791).

The functionality of MCC (Avicel® - FMC trademark) as a flow
aid for certain types of grated cheese blends has been proven
in commercial situations and can be demonstrated visually
simply by comparing a cellulose-based product to a control
product. However, to instrumentally assess flowability by
conventional methods is difficult due to the unusual configura-
tion of shredded cheese particles and variability in fat and
moisture contents between different types of cheese. Consequently,
we had to develop a device and establish a method and set of
conditions before we could measure relative differences in
flow.

Conventional methods of flow measurement, such as angle of
repose and angle of spatula, were not suitable for measuring
the flow of shredded cheese. Several different constant delivery
devices were constructed and evaluated in an effort to accu-
rately characterize cheese flow in near absolute terms. The
criteria in determining if a device was suitable were (1) its
ability to reasonably duplicate the flow of a given cheese
sample; and (2) its sensitivity was such that differences in
flow between samples could be measured.

A stainless steel funnel with a vibrator attachment was selected
as our delivery system. By trial and error with cheese samples
representing the extremes of flow we were able to determine
the proper orifice size for our tets. Bridging at the lip
of the funnel was minimized by cutting the orifice on a bias
to form an elliptical-shaped opening 24mm x 28 mm (Figure 2).

In addition to measuring total flow as a function of time, it
was also desirable to obtain a profile that would indicate
the uniformity of flow. The grated cheese was metered through
the vibrating funnel into an elongated container that was divided
into six in-line compartments of equal volume and spacing.
Exact alignment of the container to funnel was ensured by
two channels that served as guides. The orifice was positioned
directly on the leading edge of the first compartment of the
container which inturn was attached to a constant speed motor
with a nylon cord. Motor activation and stopper removal were
initiated simultaneously. Each compartment required 1.66 seconds
to completely transverse the orifice. When the cycle was com-
pleted, the sample deposited in each of the compartments was
weighed. Neither the first nor last compartment containing
sample was utilized in our calculations. The average of five
consecutive cycles was calculated on a cumulative basis and
represented graphically either as a flow profile or total
flow versus time.

An indication of the precision of our method for measuring flow is shown in Figure 3. Duplication of a given sample was reasonably good, and relative differences between samples of different flow were easily distinguishable. Thus, a reliable laboratory method for flow measurement of shredded cheese was achieved that is essentially the principal of the tablet weight method used in the pharmaceutical industry.

Analysis of the results of 100 different tests has enabled us to categorize cheese flow according to our method (Figure 4). Straight upright lines in the graph are representative of samples with good flow properties; broken lines are indicative of momentary bridging or interrupted flow; and, of course, in the case of poor flow, only a small amount of sample is collected in the prescribed time.

The flow profiles of various types of grated cheeses without flow aids is shown in Figure 5. Commercial blends A, B and C consist of Parmesan and Romano dehydrated to a 14-28% moisture content and grated to a fine particle size. Conventional Parmesan and Romano grated to medium size particles exhibited a fair-to-good flow. The high moisture varieties such as Mozzarella, Cheddar, and a processed Gruyere exhibited very poor flow properties.

Except where cheese particle size was a variable, all samples were hand grated to an intermediate size consisting of irregular shaped particles 1mm x 15mm. Total sample amount was confined to 100 grams. Blending of the MCC powder with the grated cheese was accomplished by hand tumbling for a few minutes in a bowl. Different methods of blending were investigated with no significant differences noted between gentle tumbling methods. However, it would be advisable to avoid blending operations that exert pressure on the sample, resulting in compaction of the particles.

MCC has an affinity for both moisture and free fat contained on the surface of cheese particles. The large particle size of the MCC in comparison to the micro fine size of other anticaking agents allows for a uniform distribution of the cellulose on the cheese.

Figure 6 indicates that sufficient cellulose to cellulose contact rather than cheese to cheese contact will greatly minimize caking. Even when pressure is exerted during blending or storage and compaction results in a cheese to cheese bond between the cellulose particles, the surface area involved is small enough and the bonds weak enough that gentle agitation will quickly break them apart.

Grated Cheddar or Mozzarella cheese particles are very moist, cake readily and exhibit a poor flow profile (Figures 7 and 8). When MCC is added to the cheese at gradually increasing use levels, the slope of the curve sharply increases, resulting in more product being delivered per given time unit at a more uniform rate.

The size and configuration of the particles are an important consideration when evaluating the flow of any food product. Generally, the smaller (up to a point) and more uniform the particle size the better the flow. Cheddar cheese was grated to three different particle sizes: namely, (a) small uniformly shaped particles 1mm x 2mm; (b) intermediate particles 4mm x 15mm; and (c) large, irregularly shaped particles 5mm x 30mm (Figure 9). Due to the poor inherent flow properties of the Cheddar, we were unable to determine the effect of particle size on the flow of the control sample; however, the application of 2% MCC to the same cheese made the effect of particle size on flow quite apparent. In addition to functioning as an anti-caking agent, MCC also facilitates the flow of large, irregularly shaped cheese particles.

Four one-hundred-gram samples of grated Cheddar cheese blended with two percent MCC were conditioned at 40, 70, 85 and 105 degrees F for twenty-four hours then immediately subjected to the flow test to determine the ability of MCC to counteract high temperature flow problems (Figure 10). Caking at 40 degrees F is primarily due to surface moisture, and the effect of the cellulose anti-caking agent is readily apparent. At 85 degrees F the grated Cheddar cheese containing the anti-caking agent is far superior in terms of flow than Cheddar containing no MCC at 40 degreees F. Above 85 degrees F a gross separation of the melted butterfat occurs which even MCC is unable to contain.

Two percent MCC was applied to a blend consisting of equal parts high moisture Mozzarella, Cheddar, and Romano cheeses. Initial moisture content of the blend was 37%. Samples of the blend were conditioned at 15, 33 and 97% relative humidity for 24 hours prior to evaluation. Changes in sample moisture content were as follows:

```
        Control blend @ 15% RH    - 25% moisture loss
        Control blend @ 33% RH    - 4.5% moisture loss
        Control blend @ 97% RH    - 1.1% moisture gain

        MCC/cheese blend @ 15% RH - 23% moisture loss
        MCC/cheese blend @ 33% RH - 3.2% moisture loss
        MCC/cheese blend @ 97% RH - 0.45% moisture gain
```

As can be observed in Figure 11, MCC will counteract the effects of high relative humidity on the flow of this cheese blend.

In conclusion, MCC is an ideal anti-caking agent and flow aid for certain types of grated high moisture cheeses; namely, Cheddar and Mozzarella. MCC blends easily with the shredded cheese particles without creating the dusting problem associated with the micro fine anti-caking agents. MCC can be easily distributed on the surface of the cheese so as not to distract from product appearance. Adverse temperature, humidity and particle size conditions can be overcome when MCC is applied to grated or shredded high moisture cheeses.

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Structure of Fibrous Cellulose and Avicel PH

Avicel PH
375X

Fibrous Cellulose from Wood Pulp
375X

Figure 1

Apparatus Used to Evaluate Free Flow Characteristics of Shredded Cheese
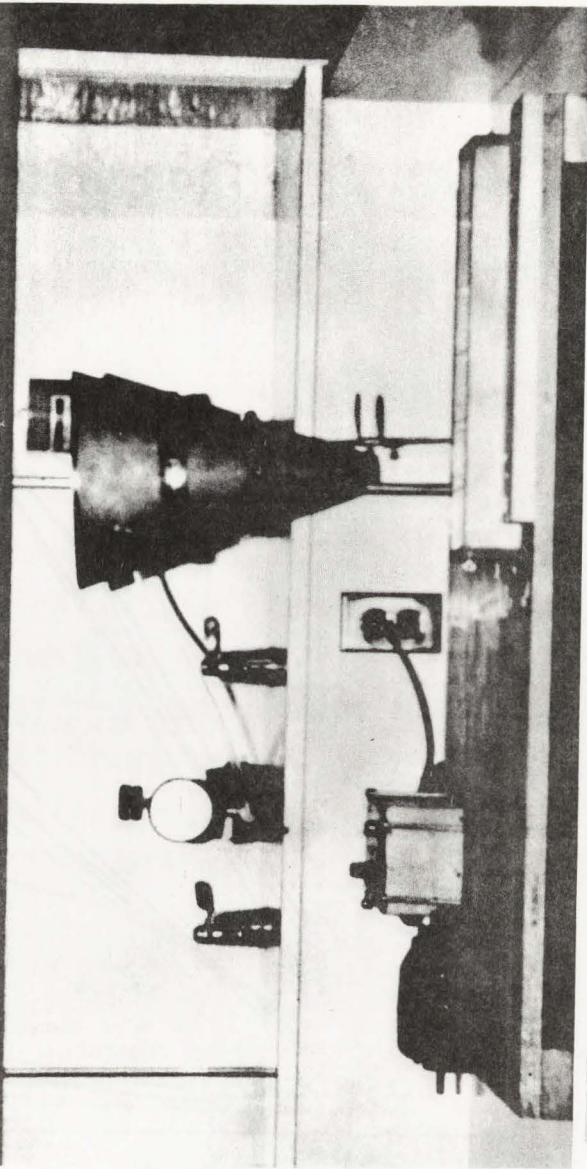
Figure 2

Indication of Precision of Our Method
for Measuring Flow

CUMULATIVE
PERCENT

2% AVICEL
PH·101

1% AVICEL
PH·101

CONTROL

TIME IN SECONDS
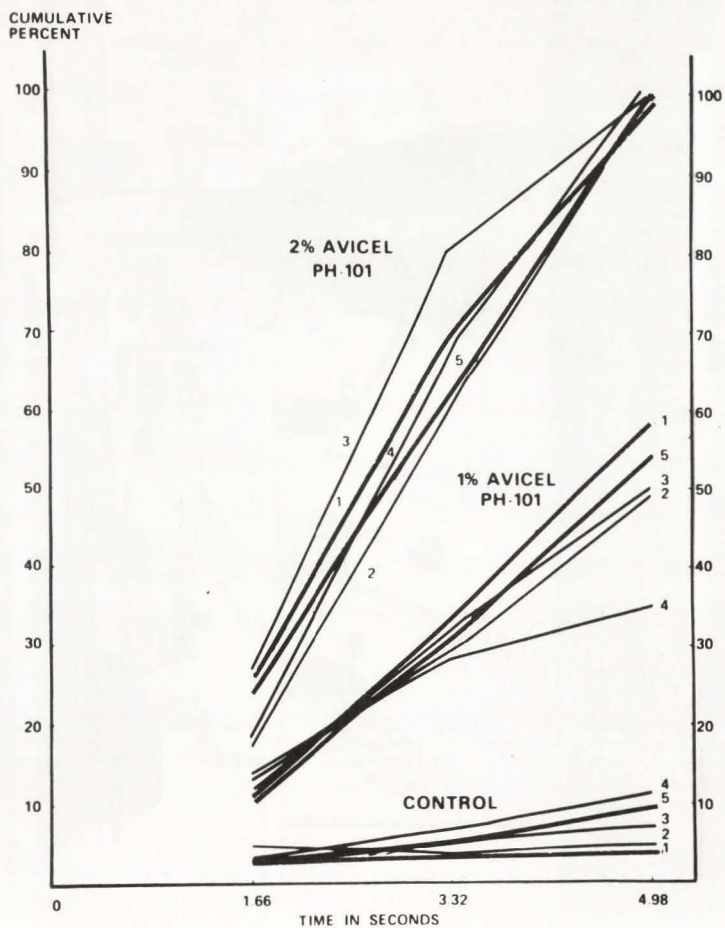
Figure 3

Measurement of Flow as Determined by Categories

CUMULATIVE PERCENT

EXCELLENT

GOOD FLOW
STRAIGHT LINES

FAIR FLOW
USUALLY ERRATIC DUE TO
MOMENTARY BRIDGING

POOR FLOW

TIME IN SECONDS
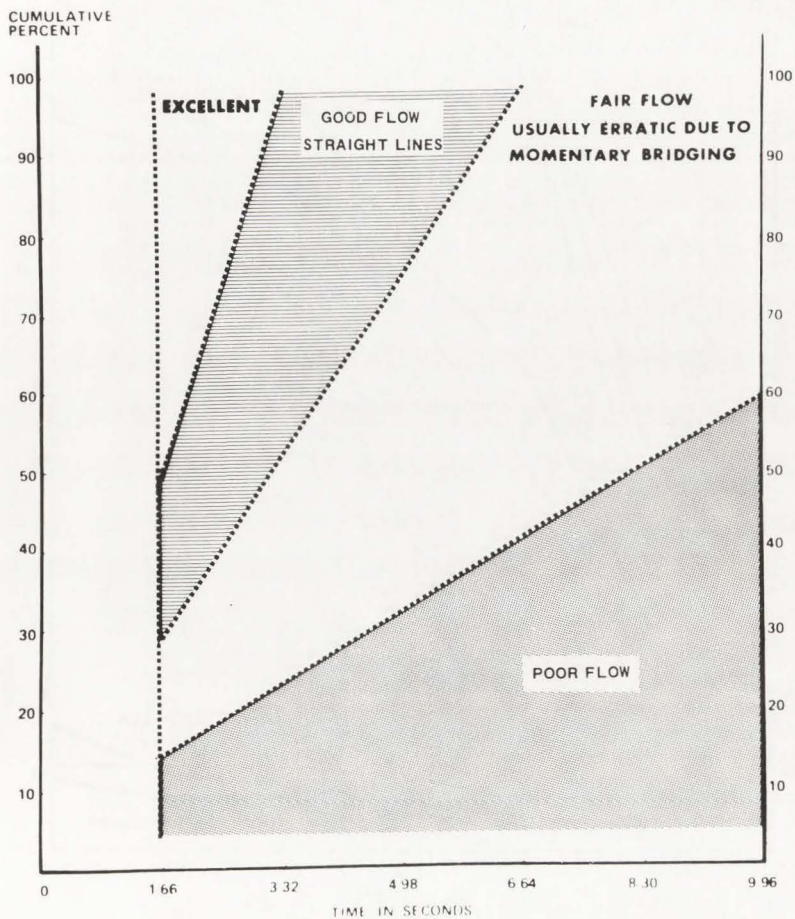
Figure 4

Flow Profiles of Various Types of Grated Cheeses

TEST CONDITIONS
40%RH
75 F
MODERATE VIBRATION

Figure 5

32
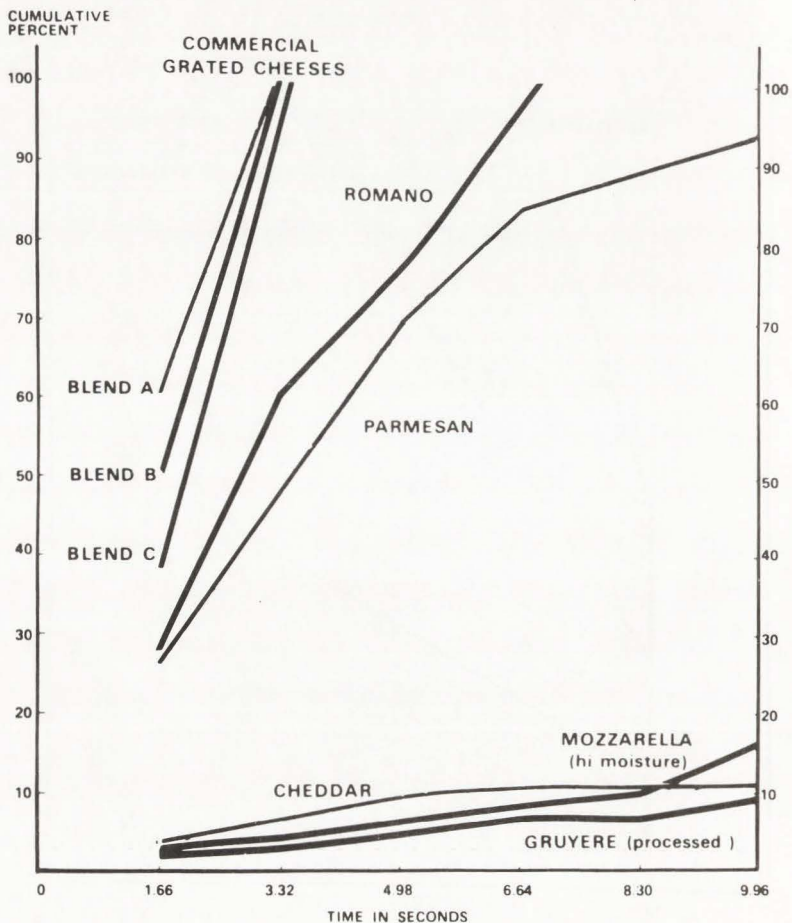
Shredded low moisture, part-skim mozzarella
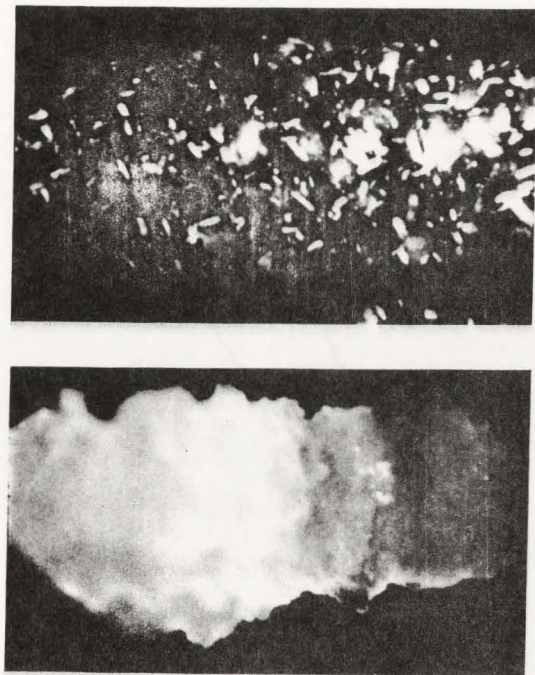
With 2% Avicel PH-101
2.5X

Control
2.5X

Figure 6

Effect of Avicel PH-101 on the Flow of
Grated Low Moisture Part Skim Mozzarella
Cheese as a Function of Time

TEST CONDITIONS
40% RH
75 F
MODERATE VIBRATION

Figure 7

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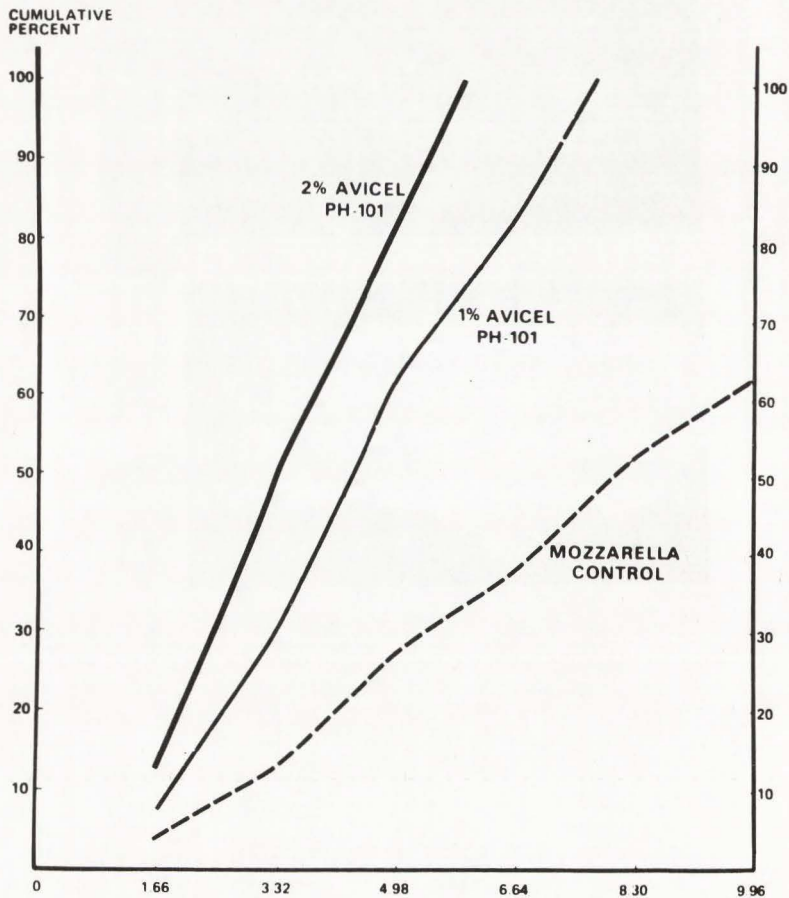
Effect of Avicel PH-101 on the Flow of
Grated Cheddar Cheese as a Function of Time

TEST CONDITIONS
40% RH
75 F
MODERATE VIBRATION

Figure 8

35
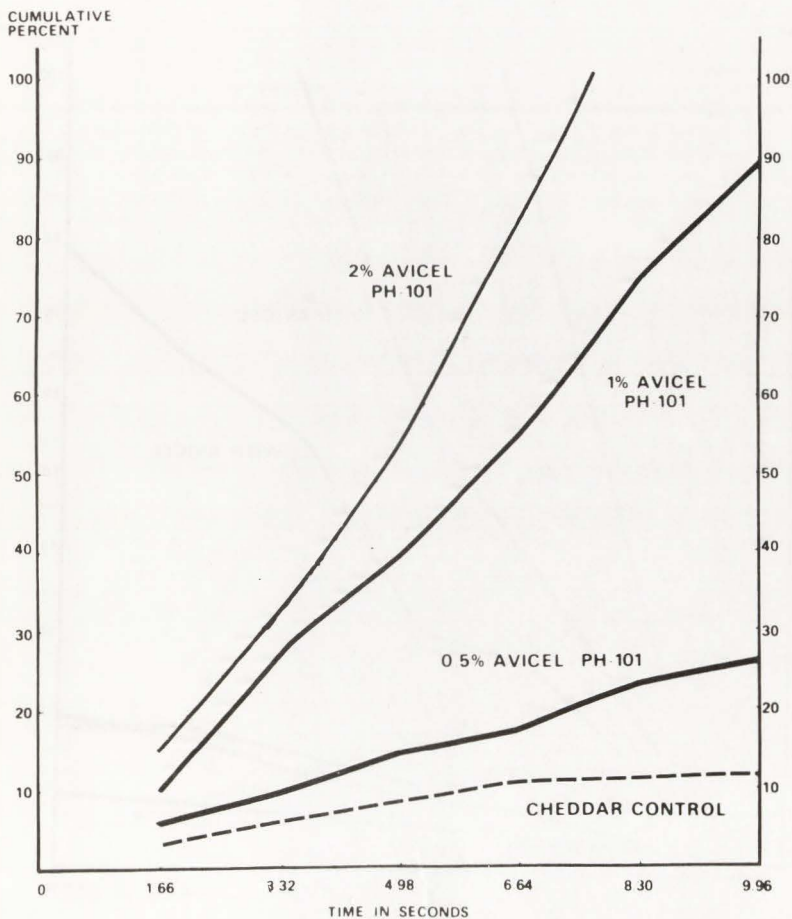
Effect of 2% Avicel PH-101 on the Flow of Grated

Cheddar as a Function of Particle Size and Time

TEST CONDITIONS
40% RH
75 F
MODERATE VIBRATION

Figure 9

36
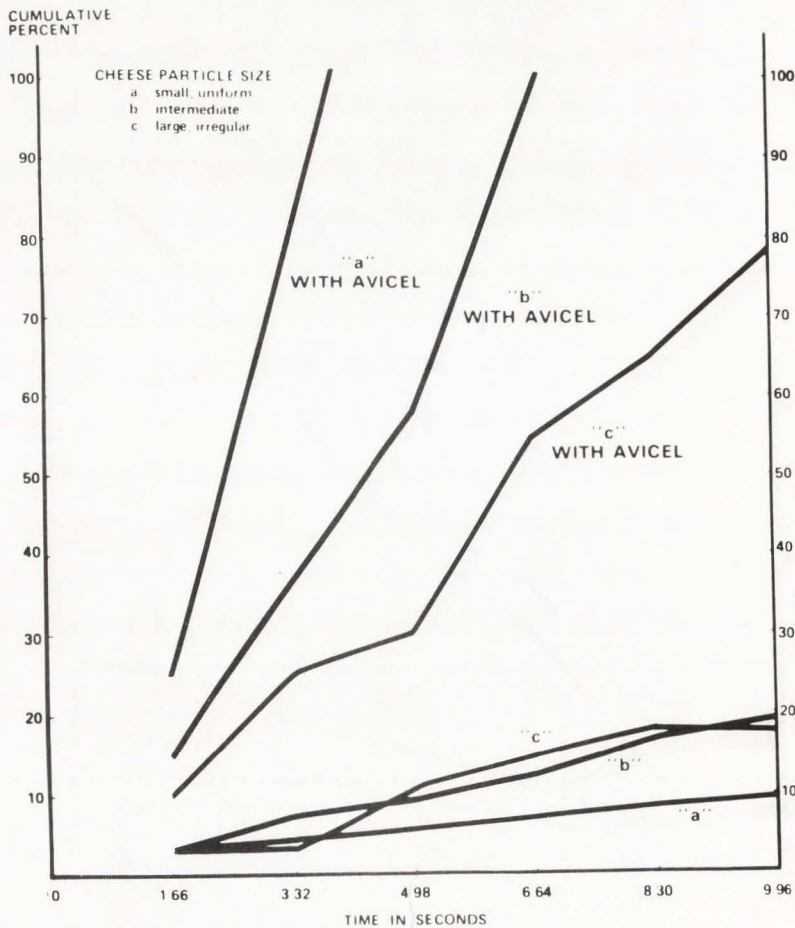
Effect of 2% Avicel PH-101 on the Flow of Grated Cheddar Cheese at Various Temperatures as a Function of Time

TEST CONDITIONS
40% RH
MODERATE VIBRATION

Figure 10

37
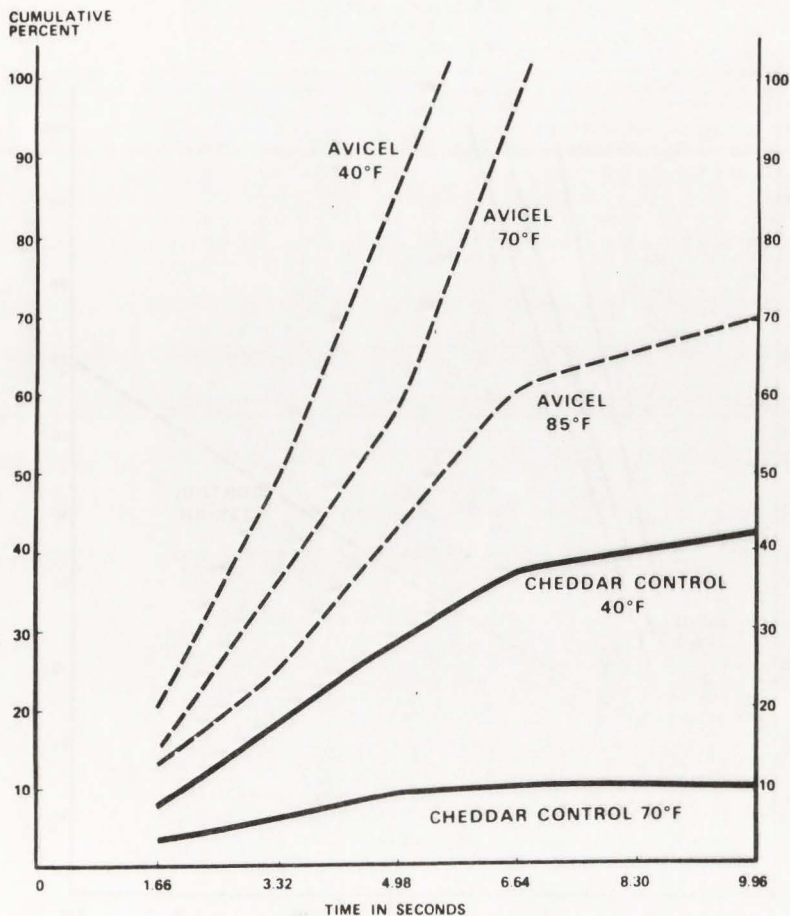
Effect of 2% Avicel PH-101 on the Flow of a Grated Blend of High Moisture Mozzarella, Cheddar, and Romano Cheeses at Various Relative Humidities as a Function of Time

Figure 11

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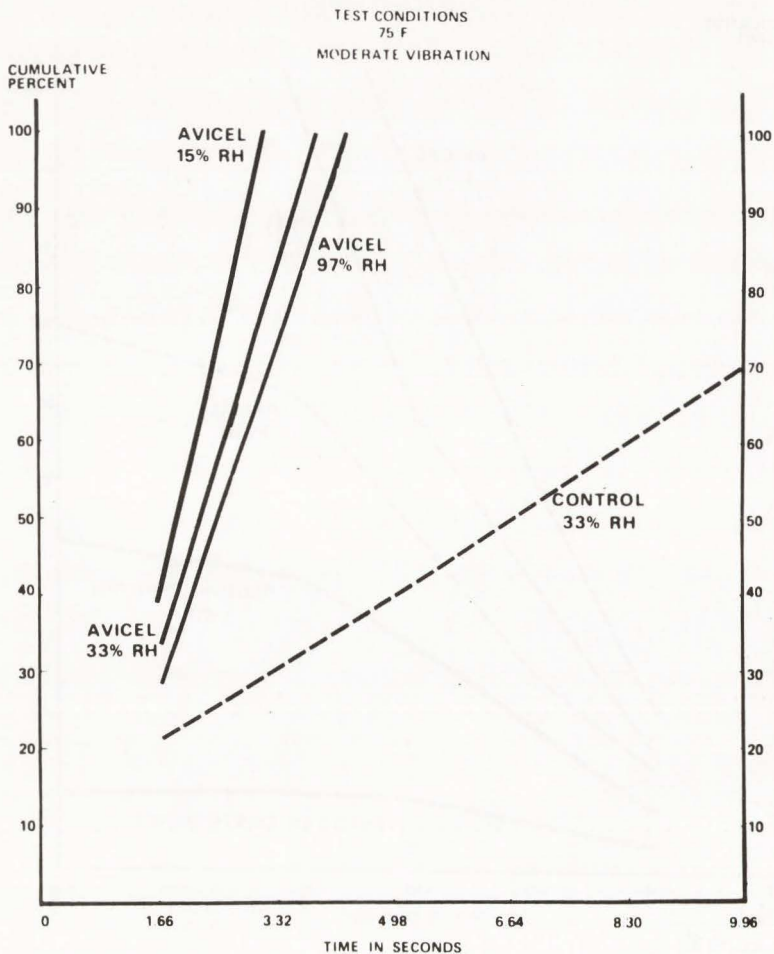
The following paper was presented by Mr. Joseph Calabro, President, Calabro Cheese
Corporation, 580 Coe Avenue, East Haven, Connecticut 06512, representing Guido Rota
Co., Via Primo Maggio, 3, 29017 Fiorenzuola D'Arda, Province of Piacenza, Italy,
especially for the 17th Marschall Invitational Italian Cheese Seminar held in the
FORUM of the Dane County Exposition Center, Madison, Wisconsin, on September 10 and
11, 1980.

THE NEW, CONTINUOUS AND AUTOMATED PROCESS FOR MAKING RICOTTA CHEESE

By Joseph Calabro

Back in May of this year, looking over a monthly magazine, I was trying to decide
whether to renew or not renew the subscription, when an advertisement caught my eye.
Within minutes I was on the phone to Italy and within a week I was in Italy, partly
resting and vacationing, but mostly to visit Guido Rota's mechanical invention. I
was impressed on the spot. I purchased one of the machines, and I convinced Guido
Rota to participate in this seminar. That was when my problems began, because Guido
said to me, "Well, it is a good idea to show my machine in the U.S.A. However, I do
not know anyone in the U.S.A. and if you will handle the affair I am ready to agree
to your suggestion. Without thinking of the consequences, I said "yes" and today I
am here in front of you with the very difficult task of talking about Ricotta in
general and with the more difficult task of talking about mechanization of the Ricotta
to an audience like you with many years of experience and with a vast knowledge of the
cheese business.

Seated in this room or represented by their company are the most skilled Ricotta
makers in the Italian Cheese Industry, and for this reason it has been very hard for
me to write a speech in mechanization of Ricotta; and while I am attempting to describe
the new automated process, please bear with me and have patience with my Italian accent.
Before I proceed with this presentation, let me give credit where credit is due, and
I would like to introduce to you the two men that designed and made the machine,
Mr. Guido Rota and Mr. Vittorio Gasparotti of Fiorenzuola D'Arda, Italy.

A New Era For Ricotta Making

Up to now the making of the Ricotta cheese has been an art, where experienced people
were needed to use their good judgment; and the entire process has been very critical
and time consuming in order to obtain good results. Few plants, however, have other
automated systems in the U.S.A., but those systems are not available to anyone at
present, and we do not know much about it. The new machine made by the Guido Rota
Company, the P.R.C. 50, is the beginning of a new era for the Italian Cheese Industry,
and I believe that this machine will do for the Ricotta cheese what mechanization did
for the Mozzarella cheese. The machine was designed for the Cheese Industry of Italy,
where Ricotta is made from whey, with the addition of 15 to 20% of milk. However,
under the guidance of the University of Piacenza, Ricotta was made entirely from whole
milk, with excellent results. And so we can say that the P.R.C. 50 is a versatile machine
because it can make Ricotta from whey and milk, can make Ricotta from whole milk, or
can extract proteins from the whey. It is also labor saving because it takes out all
the hard work connected with the process of making Ricotta, it is easy to operate
because unskilled labor can be used, it is economical because fewer people are needed,
it is efficient because the yields are highly improved over the regular method, and
finally, it is a solid and easy to maintain machine that provides the Cheese Industry
with a continuous and automated process for making good quality Ricotta.

Components of the Machine

The P.R.C. 50 is made all in stainless steel and has the following 4 major sections:

A.) The two vats section, each vat with a capacity of over 2000 lbs. of milk or of whey.

B.) The control panel, the real heart of the machine, that regulates each operation from the pumping of the milk to the discharging of the Ricotta.

C.) The mixing section, where the acid is mixed with the incoming milk or the incoming whey and milk, and where the Ricotta starts to adhere together.

D.) The separation section, where the Ricotta will separate from the whey and it is carried by a conveyor to the receiving point.

The amount of flow, the amount of acid, the velocity of the draining conveyor, the product temperature and the timing of the system can be regulated by the Control Panel in order to produce a Ricotta that is very close to the quality wanted. From this description you can see that all the guess work has been eliminated as has been eliminated the mood of the Ricotta makers and the temperament of the Ricotta dippers.

View of the Machine and Analysis of the Ricotta

A few slides will show the machine in general and most of all will show the analysis of 4 different types of Ricotta.

Slide   #1   Overall view of the machine

"   #2   A view of the vats

"   #3   An inside view of one vat being refilled

"   #4   Frontal view with the Control Panel

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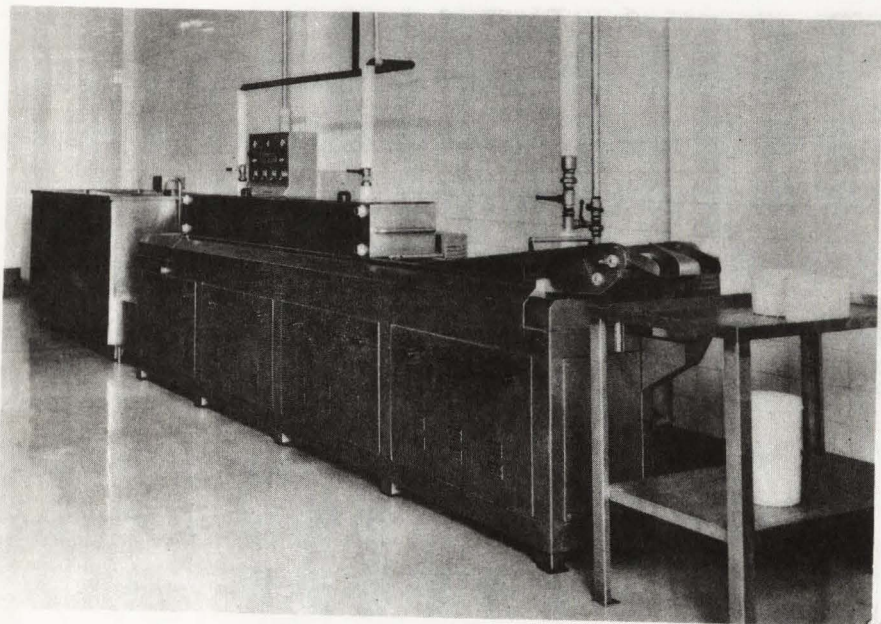
TABLE A

RICOTTA CHEESE MADE FROM	15%	Milk
	85%	Whey from soft cheeses
	Butterfat	1.25%
	Total Solids	8.46%
RICOTTA ANALYSIS	Butterfat	10.41%
	Moisture	73.30%
	Yield	12.00%
ANALYSIS OF LEFT OVER WHEY	Butterfat	0
	Solids	5.01% mostly lactose

TABLE B

RICOTTA MADE FROM	20%	Milk
	80%	Whey from Mozzarella cheese
	Butterfat	1.4%
	Total Solids	8.98%
RICOTTA ANALYSIS	Butterfat	11.2%
	Moisture	71.45%
	Yield	12.45%
ANALYSIS OF LEFT OVER WHEY	Butterfat	0 (traces)
	Solids	5.3%

TABLE C

RICOTTA MADE FROM	100%	Whey from Skim milk cheese, No Milk Added
	Butterfat	0
	Total Solids	6.03%
RICOTTA ANALYSIS	Butterfat	0
	Moisture	73.7%
	Yield	4.2%
ANALYSIS OF LEFT OVER WHEY	Butterfat	0
	Solids	5.42%

TABLE D

RICOTTA MADE FROM	100%	Whole milk
	Butterfat	3.3%
	Solids	11.10%
	Protein	2.86%
RICOTTA ANALYSIS	Butterfat	18 %
	Moisture	65.6 %
	Yield	23.03%
ANALYSIS OF LEFT OVER WHEY	Butterfat	0
	Solids	4.05%

As you closely inspect the machine in the Guido Rota Booth, you can see that it is
well built, it has a clean looking line, and it will be an asset to any cheese plant
that wants to make Ricotta the new simple way. It is a machine designed with simplicity
that almost follows the traditional method of making Ricotta and yet it is continuous
and automated; and I cannot understand the reason why no one has made up to now a
similar machine. Also, this system offers an opportunity for the cheese plant that at
this time is not making Ricotta, but wants to enter the market of a growing industry
or wants to take proteins out of the whey.

The analysis of the 4 different types of Ricotta shows very little left in the whey
and this is a guaranty of more profits, because of better yields.

Conclusion

With the help of Mr. Rota and Mr. Gasparotti I will have time to answer any questions.
Please do not hesitate to ask them, because by raising questions we can learn together
from the ingenuity of these two experience gentlemen. Concluding, this new process,
continuous and automated, will open the doors to better opportunities, to safer working
conditions, to more productivity, to higher yields, to uniform quality, to cleaner
plants, and more important of all, it will enable the small and the large cheese plants
to share the profits of the new technology and to begin the progress of automation in
the Ricotta cheese business.

<div align="center">Thank you.</div>

The following paper was presented by Mr. Norm R. Maier, Executive director of Wisconsin Dairy Products Association, Inc., 2805 East Washington Avenue, Madison, Wisconsin 53704, especially for the 17th Marschall Invitational Italian Cheese Seminar held in the FORUM of the Dane County Exposition Center, Madison, Wisconsin, on September 10, 1980.

THE LATEST IN CHEESE LEGISLATION

By Norm R. Maier

Legislation for cheese, and other dairy products can be classified, as many other topics, into three (3) categories, Past - Present - and Future. I would like to touch base on all three today, particularly with emphasis on what is happening today, its effects upon the future, with specific reference as to how it came to happen, the past. From the time this paper is written, much could happen on the home front, changing the picture slightly, moderately, or tremendously. At any rate, you will be kept abreast of the latest happenings, with sufficient background information to give you the entire story of the latest happenings in legislation pertaining to the cheese Industry.

I would like to zero in on a few specific areas of legislation, namely that of 1) the John's Pizza Case, as it applies to Wisconsin and Imitation Mozzerella Cheese, 2) the subject of Imitations themselves, 3) what's happening in the PMO (Pasteurized Milk Ordinance and finally, 4) a comment or two on the labeling issue as it pertains to cheese.

John's Pizza Case

Let's look at the John's Pizza Case first. It started a few years back, when the Wisconsin Department of Agriculture, Trade and Consumer Protection issued a holding on specific quantities of John's Pizza that contained "other than natural cheese" as a portion of the ingredients.

We must initially take stock of the pure simple fact that there is no standard dictating the minimum amount of cheese in a pizza. The standards on the books today simply say that pizza is a "bread base food product with tomato sauce and cheese." Picture yourself in this position answering the question that if the standards state that a minimum of 12% of the pizza must have cheese present, does this mean that it must contain 12% cheese of the meat sauce portion, or 12% of the total pizza?

One can easily see three arguments in this case. Number one, in that Federal Pre-emption misinterprets the law and regulations, and thus allows it to become the "law of the land." This is exemplified by the fact that if 12% meat is a requirement of a pizza standard, what does that specifically mean? Does it mean 12% of the flavoring, or 12% of the total pizza? So what is a pizza? Thus you can readily see where misinterpretation can cause confusion on the part of many, particularly those who must enforce the standards, as vague as they are.

The National Milk Producers Federation, and others, filed a law suit in District Court in November 1979, seeking to obtain judicial relief from 21 CFR 101.3 (b), and also seeking the withdrawal of the "nutritional equivalency" concept for purposes of labeling Imitation foods. The hearing was held in June 1980, and a decision rendered at the end of June, when the District Judge supported the agency's interpretation of the FDA in its concept of nutritional equivalency for the purpose of food labeling. It is our understanding at this time, an appeal to this decision is being considered.

Thirdly, we can say unequivocally, that the Food and Drug Administration has not been flexible in its interpretation of standards of identity. They have continued to resist

in assisting any new developments of new varieties at this time. Understand, however, that this is the voice of the cheese industry speaking from their point of view.

So it is most readily seen how, with no specific standards of identity, and with the force of economic persistance, substitutes creep into the picture, take a strong foothold, and continue to thrive and grow in a slow, steady fashion. This leads to consumer deception and the war has begun. However, it appears to take forever and a day to launch any offensive undertaking in Washington, D.C. In Wisconsin, action in the John's Pizza Case will be reaching a crescendo sometime this fall. The plaintiff, Anthony J. Pizza Food Products Corporation replied on July 25, 1980. The activity will be taking place in the U.S. District Court for the Western District of Wisconsin, sometime later this year.

Imitations

On the subject of Imitations in the dairy industry today, one does not have too much difficulty in identifying those already on the market. We have our non-dairy creamers, cool whip, margarines, imitation milk, etc. "Imitation" and "Substitute" cheese is the latest to appear on the scene, and we like to feel that it is the most difficult product to reproduce. Or should we be asking ourselves the question that, if there are so many varieties of cheese, with as many different characteristics as there are nationalities of people, is it no wonder then how difficult it is to produce one synthetic product to satisfy all palates?" Regardless of the answer to that particular question, we know that "substitutes" are here to stay. Even though they do not measure up to the "Real McCoy" in flavor, texture, etc., these characteristics can easily be masked in the highly flavored arena of pizza sauces.

What has happened to the industry to allow the latest addition in the field of substitutes to obtain such a foothold? It is my sincere belief that major contributors are economics, imports of casein, and lack of full cooperation from our beloved regulatory agencies in Washington, D.C.

Economics is perhaps the most clearly understood factor that allows substitute products to come on the scene. Trying as hard as they can, the cheese industry is constantly fighting the battle of high labor costs, OSHA, EPA, inflation, etc. With all the modern laboratories that exist today, and the new technology available, is it any wonder that we would not expect a new product to be born as a result of all this? In simple defense however, we should in the same breath, continue to rededicate our efforts to make certain that our industry keeps pace in researching new developments. We are blessed that the Cheese Research Institute is moving into "second gear" now. But it still has a long way to go. It requires your support if we all are to survive.

The subject of casein is a result of this technology that I just mentioned. Previously used as a key ingredient in the manufacture of glue and plastics, somebody finally determined that it could be used as a substitute to replace some or all of the dairy ingredients formerly used. As a result, we have seen the imports of caseinates steadily increase, and there is a constant request to USDA to study this effect and put the lid on the amounts allowed to be imported. We ask that you assist us in petitioning the USDA to take a very close look at Section 22 of the Agricultural Adjustment Act of 1935 which allows quotas to be put on imports which affect a support program. If this is not done, the situation will only become worse. The fire must be put out now, not after the building is completely burned down.

The agencies in Washington, D.C. that control our destiny need to have input from those on the front lines of the battlefield. Oh, we can all say that we have tried, and many times with little or no success. However, there is as much turnover in personnel in Washington as there is on the homefront. So if you have told the same story several times, there is always the possibility that someone has not heard it for the first time. United

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efforts on the part of all associations should not be overlooked either. Instead of one particular group stating their cause and concern, and seeking identification, would it not be far better to ask assistance from other groups to support the common cause? In numbers, there is strength.

PMO - Pasteurized Milk Ordinance

A good example of this very subject, unification of effort, has been accomplished here in Wisconsin when the Pasteurized Milk Ordinance (PMO) undertook several major changes in adopting itself to the proposed standards of the Food and Drug Administration. Many key sections had to be updated, changed, or in some cases, completely deleted, or new ones added. In appointing a 22 man Advisory Council to assist the DATCP, Secretary Gary Rohde was extremely careful in seeking assistance from all facets of the industry. Representation came from producers, industry, associations, suppliers and the education field. Result? We now have an acceptable draft that is in its final stages of approval, and ready to be enforced in late 1980 or early 1981.

Just to mention a few of the important changes:

a) The milk on the farms must be cooled to 45°F within two hours after milking, and with additions of the 2nd, 3rd, or 4th milkings not to exceed the 50° mark.

b) Each milk house must be equipped with a ring and removable basin for hand washing, or a separate sink for this purpose.

c) Each tank that stores milk for more than 48 hours must be equipped with a recording thermometer.

d) Pesticides other than those approved for use in the milkhouse or room shall not be stored in the milkhouse or room.

e) All vehicles used for the transportation of pasteurized milk and milk products shall have fully enclosed bodies and be equipped with adequate refrigeration to maintain a temperature of 45°F or less.

f) The OK to use approved flexible plastic or other sanitary material as a pipeline if they do not exceed 25 feet in length where rigid pipelines are not practical, for the transfer of cheese products during manufacture, and the unloading/loading of bulk tank trailers.

g) The OK to have a separate area of the finished product cooler for isolation and holding of returned products.

In making the changes of the PMO, the DATCP conducted hearings throughout the state, heard testimony on each proposed change, and in some instances, incorporated the changes in the final draft. This final draft was presented to the Assembly Ag Committee for review, and at this writing, has not been totally accepted.

It was extremely gratifying to observe how, with full cooperation of all the agencies or associations in Wisconsin, whether totally supporting the changes or only partially supporting them, at least united their efforts in obtaining final approval. This effort demonstrated that working together as a team can produce acceptable results.

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Labeling

This discussion of legislative changes in the cheese industry would not be complete with-
out a comment or two on labeling. Much has been said lately of the "hot" item - what
shall the imitation or substitutes be called? This subject has been in the limelight
for at least four years if not more. From the initial proposal of categorizing all
substitutes into one general classification and identify this field as Golana (analog
spelled backwards) came the launching of several other proposals. At one time, to even
consider using the nomenclature of cheese in association with the artifical product was
a No - No.

WDPA, as an Association, did attempt to call the industry together two years ago in
Fond du Lac. Try as they might, no conclusive decisions could be agreed upon, and the
meeting was dismissed with no unified effort or agreement. The question arises today,
that if individual groups or associations had been able to reach a compatible agreement,
and express itself as an industry, united in its decision, would this not have been far
better than no expression at all? With each group seeking to carry out their own
individual beliefs, a lack of cooperative effort was displayed, and we have the same
problem today as we had two years ago. Hearing this, the regulatory agencies in
Washington could not help but realize that the industry was uncertain as to what the
product should be called.

Then along came a suggestion taken up by ADA of Wisconsin who asked themselves, "Why
don't we ask the consumer herself, what are her thoughts on this subject?" Result, a
true appreciation of values of recognition, the simplest form of identification might
be to actually come right out and say imitation or substitute.

So it is easily observed that we have made a complete circle. We're right back where
we started on what to call our enemy. However, all of this has not resulted in someone
not hearing the voice of industry and consumers in Washington. Through the Federal
Register, we have been informed of the efforts being conducted to research further
identification of the labeling issue. Official hearings have been conducted by a joint
effort of the FDA, USDA, and the FTC. We are accomplishing something, whether it is
to our liking or not. One can always relate back to the age old expression that it is
better to have a plan, and change it, than to have no plan of action at all.

Today the dairy industry has collectively directed its energies and resources to provide
comprehensive ingredient and nutrition information. The results indicate that more
nutrition and ingredient information can now be found on most milk product packages than
on any other class of consumer food products.

Since the dairy industry is now responsive to providing the consumer with adequate
ingredient and nutrition labeling, we question the need for initiating label changes at
this time.

The potential economic impact of any proposal must be given careful consideration. This is
of prime importance because of the continuing inflationary spiral of today's economy.
Any costs attributable to label changes and nutrition label maintenance, particularly the
proposed segmented label changes, will ultimately be passed on to the consumer in the form
of higher food costs, which will escalate this inflationary spiral. Along with higher
costs of foods, additional costs will be incurred through increased hiring of government
agency personnel necessary to enforce the new labeling regulations and educational pro-
gram which will be necessary to inform the consumer of the label changes. These education-
al programs will be mandatory if the consumer is going to fully understand and utilize
the information on the label.

Labeling changes have been made by the dairy industry almost continuously since 1968. The industry, at considerable expense to themselves, and to the consumers, virtually re-labeled all of their products twice in the past 12 years because of revised governmental regulations. We do not believe any changes need to be made today.

A word or two on open date labeling.

Product quality and keeping quality is determined by many factors and therefore, dating of products will not always indicate product quality or keeping quality of a product at a given time of purchase. Thus, it will be difficult to establish a suitable length of time a given dairy product will maintain satisfactory quality which will be applicable to all manufacturers of like dairy products. If such time restrictions are adopted, it may hinder those manufacturers who want to establish the necessary quality control programs that are necessary to obtain excellent quality dairy products with shelf life beyond prescribed and mandated length of time which the product could remain marketable. These prescribed and mandated lengths of time that a given product could remain on the market could also increase the amount of energy used in processing and marketing and thus increase costs to the consumer.

We support the concept of uniform rules and regulations pertaining to open dating of fresh perishable products so there will be no burden or impediment to interstate commerce. However, we also believe open dating should be voluntary and manufacturers or processors should establish their own length of time the products could remain in the market place.

We therefore, support the development of uniform federal regulations for open date labeling, which could be adopted voluntarily by states and which would allow the processing industry to choose its own length of time that products could remain on the market and choose its own method of providing open date labeling information to the purchaser.

Summary

We have reached many milestones in the history of cheese legislation in the past. Some have been extremely valuable to the industry, some have been unkind, harmful, and down right difficult to swallow.

But on the whole, with the degree of technology that exists today in the field, the communication that exists between the producers, processors, and the legislators, whether in our own state, or in Washington, D.C., one cannot help but feel optimistic that our voice is being heard and the welfare of the cheese industry is taken into consideration. With this unified effort on the part of all of us uniting our voices, pursuing our goals, and communicating efficiently, we can hold our heads high and know that legislation is protecting our products.

The following paper was presented by A. Hill and D.M. Irvine, Department of Food Science, University of Guelph, Guelph, Ontario, Canada, especially for the 17th Marschall Invitational Italian Cheese Seminar, held in the Dane County Exposition Center, Madison, Wisconsin, on September 10 and 11, 1980.

THE MANUFACTURE OF A RICOTTA TYPE CURD FROM WHEY CONCENTRATED BY REVERSE OSMOSIS

By A. Hill and D.M. Irvine

Ricotta cheese is a generic term applied to cheese that is made from sweet whey to which a small portion of milk may be added. This mixture is than heated to 85-90°C in an open kettle, usually by direct steam. The whey protein, principally albumin, coagulates and rises to the surface where it is scooped off, placed in perforated stainless steel hoops and allowed to drain. The resultant fresh product is sold as fresh Ricotta in our larger metropolitan cities. Canadian cheesemakers make an excellent Ricotta and have developed a large market in both the Italian and non ethnic communities.

My discussion today is not concerned with the manufacture of this fresh Ricotta, but rather with some of the factors affecting the coagulation of whey proteins from the whey of Italian, Cheddar and other types of cheese.

The Water Resources Commission of Ontario enforces very strict regulations in regard to the disposal of whey or dairy wastes into the environment. You are also faced with similar regulations. It is therefore necessary to reduce the BOD of the whey and provide a valuable protein food.

Large amounts of whey are converted to whey powder. This is a good method for the disposal of whey if you happen to be located adjacent to drying plant and if that drying plant has a cheap source of energy. The high costs of energy necessitate the use of a condensing system that requires less energy. Reverse osmosis is the answer to concentrating the whey solids without the use of heat. Basically, energy is only required to power a high pressure pump.

We obtained concentrated, sweet whey from a plant producing soft-ripened cheese. The commercial Reverse Osmosis equipment was manufactured by the Danish firm 'Pasilac'. The batch type system can concentrate a 100,000 lb batch of whole whey to 20% total solids each 24 hour period. Although the whey could be concentrated to 25% solids, it is more efficient to concentrate to about 20% solids.

Let us consider some of the factors affecting protein recovery from whey and condensed whey.

The yield of protein from whey is influenced by pH, temperature, the length of the heat treatment and the mechanics of processing.

Shulkamy (9) obtained maximum precipitation of whey protein by acidifying to pH 3.5 and heating at 95°C for 20 minutes. Pien (6) patented a continuous process for extracting whey protein in which the whey is acidified to pH 4.7 and heated to 90-100°C for 10-30 minutes with agitation. Modler and Emmons (5) obtained an 85-97% recovery of protein nitrogen from condensed whey by acidifying to pH 2.5

and heating at 95°C. However, when whole whey was subjected to the same process, little or no precipitation occurred. Kuipers (4) reported that whole whey may be acidified to pH 2.7 - 3.3 and subsequently heat sterilized without precipitating the whey protein.

Modler and Emmons (5) report a significant effect of iron on protein recovery from whey. However, neither the use of iron or subsequent pH adjustment had any effect on the recovery of protein from condensed whey. Amantea et al. (1) reported on the use of low pH, high temperature and iron in preparing whey protein from condensed whey (condensed 3-4 times). The highest yield of protein was recovered at pH 2.5, 92°C, with a heating time of 10 minutes and an iron concentration of 224 ug/ml of whey. As the pH was reduced from 4.5 to 2.5, the protein recovery increased from 42 to 60% with the highest level of iron.

There is little definative work on the conditions required for the maximum yield of fresh or pressed Ricotta. Sanders (7) describes a typical make procedure in which whey with not over 0.20% acid is heated to 93°C. He also reports the typical composition of fresh and dried Ricotta (see Table 1).

Streiff et al. (10) studied the yield and quality of Ricotta cheese from whey and condensed whey. They found that increasing whey solids causes rapid increases in yield. Yield increased four-fold while the whey solids were increased from 6.7 - 20.86% and decreases in cheese protein and moisture.

Kosikowski (2, 3) recommends pH 5.4 at 87°C for Ricotta manufacture from fluid whey.

Shahani (8) neutralized whey to pH 6.8 with sodium hydroxide before heating and reacidification. This treatment consistently gave maximum yields irrespective of the initial pH. He also obtained higher protein recovery with the use of 500 - 2000 ppm $Ca^{++}2$. There was no mention of the effect of sodium hydroxide and calcium on cheese flavour.

The following test tube scale experiments were conducted to clarify some of the perplexing aspects of protein coagulation of concentrated whey (reverse osmosis). Buffer capacity of whey and whey powder was determined by measuring the amount of citric acid required to change the pH of reconstituted wheys made to differing concentrations (8-24%). The titration data for the 20% solids level is shown in Appendix 1. The combined data represents the relationship between buffer capacity and percent whey solids as shown in Appendix 2, where buffer capacity if the percent citric acid per weight of solution required to lower the pH to 3.5. The relationship is positive and linear. A similar equation was derived to show the relationship between buffer capacity and percent solids for condensed sweet whey, as shown in Appendix 3. The effect of percent whey solids on whey pH is shown in Appendix 4.

The Effect of Temperature and Acid on the Recovery of Solids:

An experiment was conducted using reconstituted whey powder and four levels of citric acid at each of 82.5°C and 95°C. The curd was separated by filtration. These data are presented in Table 2.

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Table 1. Composition of fresh and dried Ricotta (7).

	Fresh	Dried
Moisture	68-73	60
Fat	4-10	5
Protein	16	19
Lactose	3	4
Ash	-	3.6
Salt	1.2	1.5

Table 2. The effect of acid and temperature on pH and solids recovery.

% HCAM	Expected pH	Observed pH		% Solids Recovery	
		$82.5^{\circ}C$	$95^{\circ}C$	$82.5^{\circ}C$	$95^{\circ}C$
0.000	5.9	5.68	5.55	30.51	34.44
0.133	5.1	5.10	5.01	25.09	29.16
0.467	4.3	4.31	4.30	25.70	26.67
1.667	3.5	3.49	3.47	23.27	28.29

(Note: the data in Table 1 represents the average of duplicate results).

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Analysis of variance of the results showed highly significant effects of temperature and acid on solids recovery (see Appendix 5). The best treatment with respect to solids recovery is 95°C with no added acid - in this case 'no added acid' represents a pH range of 5.1 - 5.9. This is in contradiction to the work of Shulkany (9) who recovered the maximum recovery of protein at pH 3.5 and 95°C. In these trials it was observed that the drainage time decreased as the temperature of heating was increased.

In our trials with condensed whey, it was observed that the first flocs of curd appeared at the surface at 76°C and the greatest portion of the curd rose between 81 and 88°C. The curd was dipped off and the whey was then pumped to a drain table lined with cotton cloth. The whey would not filter and the cloth was removed allowing the whey to drain through a 40 mesh screen. The cheese was sweet with good flavour but was off white in colour. The analysis of the cheese for moisture, fat and protein was 69, 1.4 and 14% respectively.

A further experiment at the pilot plant scale was designed to study the effects of differing levels of acid on various cheese parameters, using condensed whey of 20% solids (reverse osmosis). The results show no significant effect of acid on solids recovery. This is in contradiction to our earlier work at the test tube scale. The results do show a significant effect of acid levels on protein recovery. The highest protein recovery was obtained with no added acid (see Appendix 6).

Some early experimental evidence revealed that there was a chalkiness in some of the samples. It was thought that this might be correlated with the ash content of the curd. There is a highly significant correlation between percent citric acid and cheese ash content. This relationship is defined in the equation in Appendix 7. The lack of ash in some of the samples with high added acid content might account for the smoothness and creaminess of these samples as contrasted with the chalky character of the cheese without added acid.

Time and Temperature Effects:

Test tube studies indicated greater yields at 95°C than at 82.5°C. In large scale experiments, four temperatures of 82.5, 85°C, 90° and 95°C were used to further test the effect of temperature on protein and solids recovery. The samples were held for varying lengths of time, 0, 5, 15 and 30 minutes. The samples at 82.5°C could not be drained and were eliminated from the data analysis.

Analysis of variance showed significant effects of temperature and time. The means within significant treatments were treated for significant difference by Duncan's multiple range test. Treatments at 95°C gave higher protein (see Appendix 8) and lower moisture (Appendix 9) than treatments at 85° and 90°C. Treatments at 90° and 95°C had lower pH values than those at 85°C (Appendix 10). Treatments at 90°C drained more rapidly than those at 85° and 95°C (Appendix 11). Treatments at 90° and 95°C gave higher protein recovery than at 85°C (Appendix 12). Treatments held for 5, 15 or 30 minutes gave higher protein recovery than those which were drained immediately (see Appendix 12).

The data in Appendix 13 indicates the effect of pH on cheese moisture which reflects the isoelectric point of the protein at pH 4.5 or the point of minimum hydration.

Conclusions:

1. It is possible to make a Ricotta type curd from sweet, 20% whey concentrated by reverse osmosis.

2. For the maximum protein recovery, the condensed whey must be heated to at least $90^{\circ}C$ and held at this temperature for 5 minutes.

3. The addition of acid tends to lower protein recovery although low levels of acid are required for sweet whey. It is believed that the maximum protein recovery occurs within the range of pH 5.5 - 5.9. Other investigations found increased yield with added salts. Our studies indicated that levels of $CaCl_2$ above 0.06% caused the flavour to be bitter.

4. The addition of acid affects cheese moisture and texture. Minimum moisture occurs at pH 4.5 and increases sharply on either side of this value. At high pH, the cheese is chalky and crumbly while at low pH, the cheese is smooth and spreadable.

5. The addition of acid lowers ash content which may be related to texture effects.

6. The addition of cream to Ricotta before pressing eliminates chalkiness and improves flavour. The use of a lactic culture with cream greatly enhances cheese flavour and character.

7. Cheese made from reverse osmosis whey is darker in colour than traditional Ricotta.

8. This Ricotta protein is already in commercial use in a food plant in Canada.

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Equation 1

$$pH = -0.65x^3 + 2.63x^2 + 3.79x + 5.745$$

where $x = \%$ HCAM

$$r = 0.994$$

——— = estimated regression line
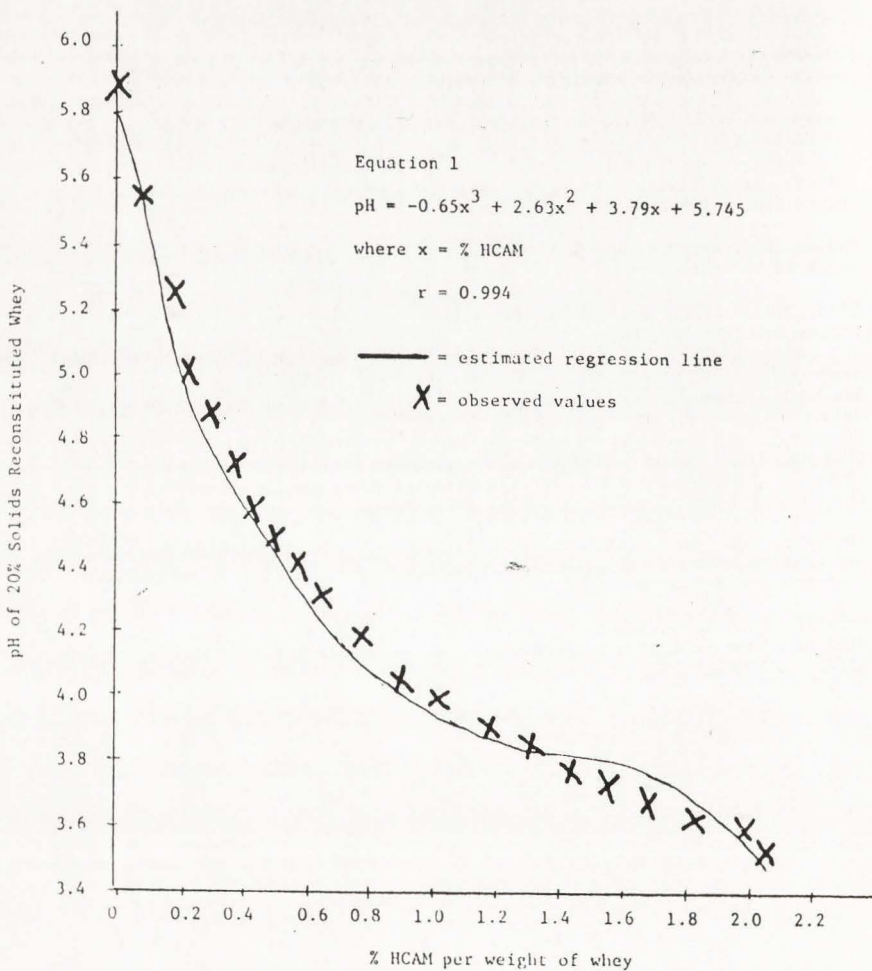
X = observed values

Appendix 1: REGRESSION: % HCAM on pH of 20% RECONSTITUTED WHEY.

Equation 2

$y = 0.08675x + 0.286$, $r = 0.99999$

y = Buffer capacity

  = % HCAM per weight of solution

x = % Whey solids
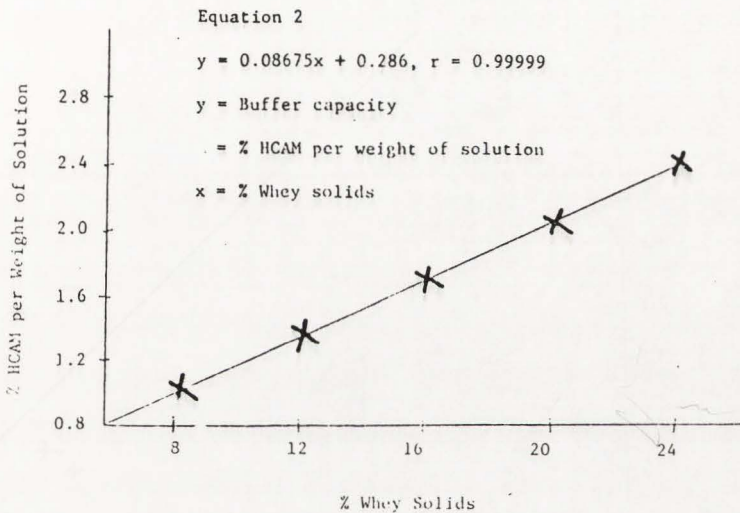
% Whey Solids

Appendix 2: REGRESSION: BUFFER CAPACITY (% HCAM per weight of solution) ON % WHEY SOLIDS.
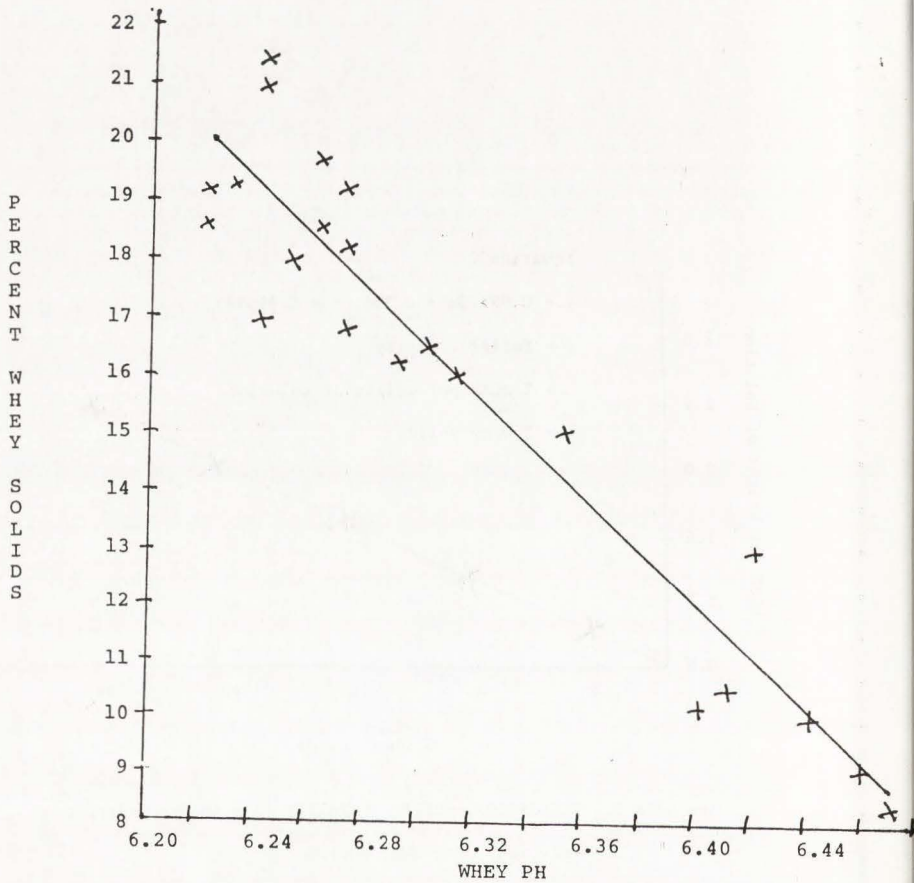
Appendix 3.   PERCENT WHEY SOLIDS VERSUS WHEY PH

LEGEND:

X   X   OBSERVED VALUES
O———————O   ESTIMATED VALUES
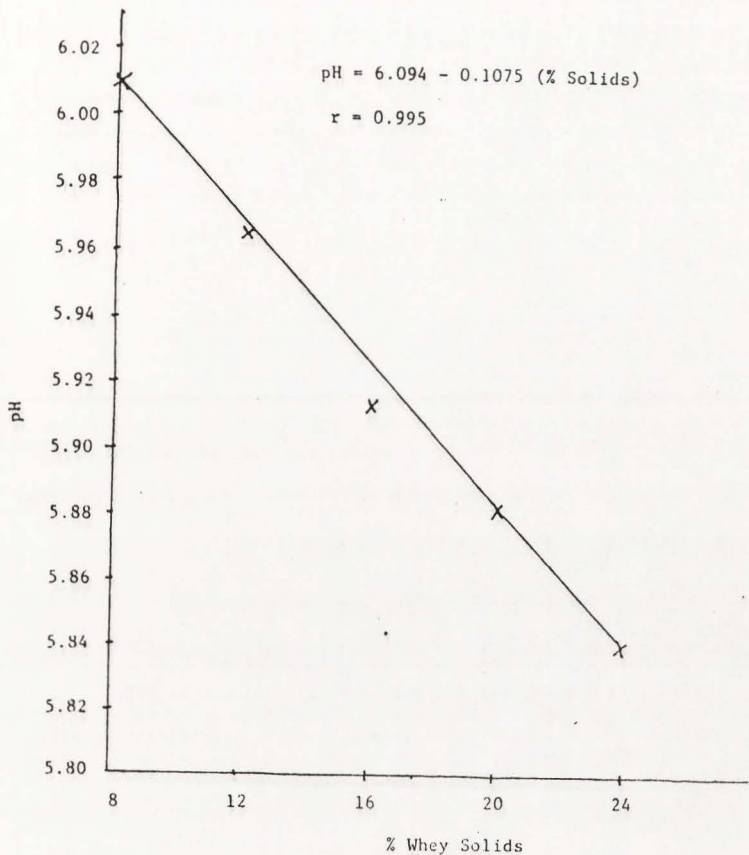
Appendix 4: REGRESSION: pH OF RECONSTITUTED WHEY POWDER ON % TOTAL
SOLIDS.

Apppndix 5.   EFFECT OF ACID AND TEMPERATURE ON SOLIDS RECOVERY

Analysis of Variance and Duncan's Multiple Range Test

% HCAM	Temperature 82.5^{o}C	95°C	Means	Duncan
0.000	30.51	34.44	31.98	a
0.133	25.09	29.16	27.13	b
0.467	25.70	26.67	26.18	b
1.667	23.27	28.29	25.78	b
Means	26.14	29.39	27.77	
Duncan	a	b		

Table of raw data, treatment means, and Duncan's Multiple Range
Test, for significant difference between means: (Means with the same
letter designation are not significantly different).

Analysis of Variance

Effect of Acid on Solids Recovery: significant at 99%.

Effect of Temperature on Solids Recovery: significant at 99%.
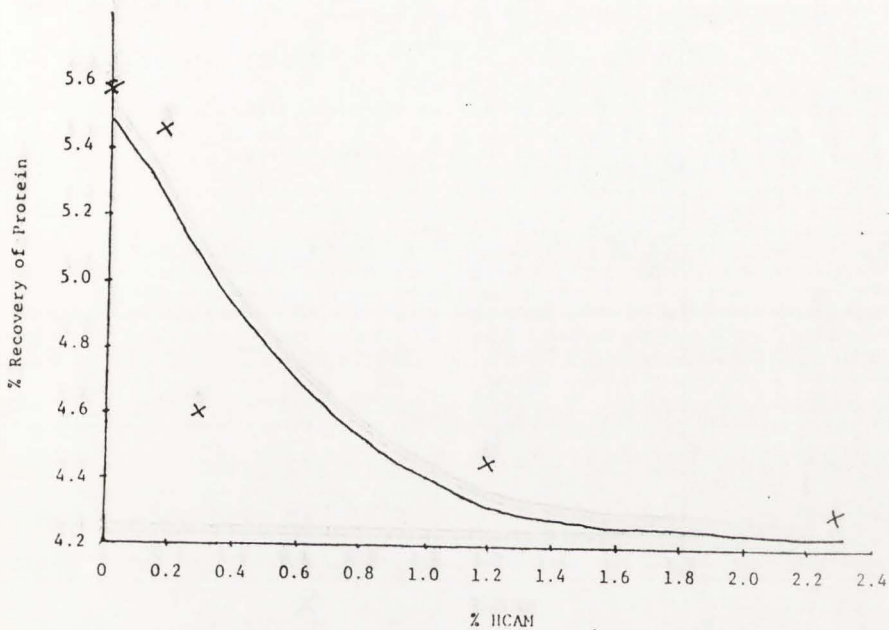
Appendix 6.   EFFECT OF HCAM ON PROTEIN RECOVERY

Regression Equation 5

% Protein Recovery = $4.156 \ (\% \ \text{HCAM})^2 - 14.98 \ (\% \ \text{HCAM}) + 55.024$

$r = 0.88$, $SD = 3.9$

———— regression line

✕ observed values
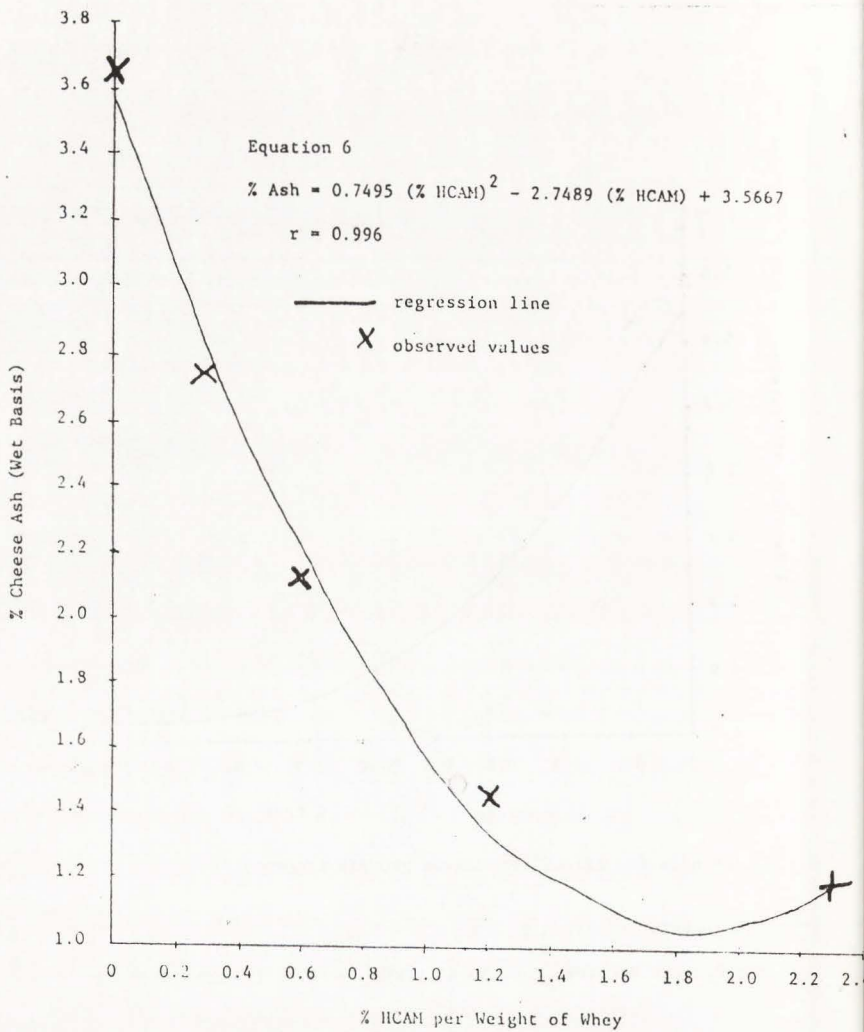
Appendix 7: EFFECT OF HCAM ON CHEESE ASH CONTENT

The figure shows a plot of % Cheese Ash (Wet Basis) versus % HCAM per Weight of Whey.

Equation 6

$$\% \text{ Ash} = 0.7495 \ (\% \text{ HCAM})^2 - 2.7489 \ (\% \text{ HCAM}) + 3.5667$$

$$r = 0.996$$

——— regression line

X observed values

Appendix 8: EFFECT OF TIME AND TEMPERATURE ON CHEESE PROTEIN

Analysis of Variance and Duncan's Multiple Range Test

Temper- ature (^{o}C)	0	5	15	30	Means	Duncan
85	13.99	14.03	16.47	13.32	14.45	a
90	13.55	15.86	16.87	16.51	15.60	a
95	18.60	16.98	18.87	20.91	18.84	b
Means	15.38	15.49	17.40	16.91	16.30	
Duncan	a	a	a	a		

Table of raw data, treatment means and Duncan's Multiple Range Test for significant difference between means (Means with the same letter designation are not significantly different).

Analysis of Variance

Effect of Temperature on Cheese Protein: significant at 99%

Effect of Time on Cheese Protein: not significant.

Appendix 9: EFFECT OF TIME AND TEMPERATURE ON CHEESE MOISTURE

Analysis of Variance and Duncan's Multiple Range Test

Temper-ature (°C)	Time 0	5	15	30	Means	Duncan
85	71.08	71.39	67.76	72.17	70.60	a
90	70.11	70.07	67.68	67.97	68.96	a
95	66.35	67.52	64.91	63.23	65.50	b
Means	69.18	69.66	66.73	67.79	68.35	
Duncan	a	a	a	a		

Analysis of Variance

Effect of Temperature on Cheese Moisture: significant at 98%

Effect of Time on Cheese Moisture: not significant.

Appendix 10: EFFECT OF TIME AND TEMPERATURE ON CHEESE pH

Analysis of Variance and Duncan's Multiple Range Test

Temper- ature (^{o}C)	Time				Means	Duncan
	0	5	15	30		
85	5.68	5.70	5.65	5.64	5.67	a
90	5.43	5.44	5.45	5.44	5.44	b
95	5.44	5.43	5.40	5.37	5.41	b
Means	5.52	5.52	5.50	5.48	5.51	
Duncan	a	a	a	a		

Table of raw data, treatment means, and Duncan's Multiple Range Test. (Means with the same letter designation are not significantly different).

Analysis of Variance

Effect of Temperature on Cheese pH: significant at 99%

Effect of Time on Cheese pH: not significant.

Appendix 11: EFFECT OF TIME AND TEMPERATURE ON DRAINAGE TIME

Analysis of Variance and Duncan's Multiple Range Test

Tempera-ture ($^\circ$C)	Time 0	5	15	30	Means	Duncan
85	125	90	47	95	89	a
90	437	204	144	121	227	b
95	95	98	40	25	65	a
Means	219	131	77	80	127	
Duncan	a	a	a	a		

Table of raw data, treatment means and Duncan's Multiple Range
Test for significant difference between means. (Means with the same
letter designation are not significantly different).

Analysis of Variance

   Effect of Temperature on Drainage Time: significant at 96%

   Effect of Time on Drainage Time: not significant.

Appendix 12: EFFECT OF TIME AND TEMPERATURE ON PROTEIN RECOVERY

Analylis of Variance and Duncan's Multiple Range Test

Tempera- ture (^{o}C)	Time				Means	Duncan
	0	5	15	30		
85	42.40	46.86	43.56	46.18	44.75	a
90	43.79	49.46	48.17	49.59	47.75	b
95	47.40	48.38	50.13	48.28	48.55	b
Means	44.53	48.23	47.29	48.02	47.02	
Duncan	a	b	b	b		

Table of raw data, treatment means and Duncan's Multiple Range Test for significant difference between means. (Means with the same letter designation are not significantly different.)

Analysis of Variance

Effect of Temperature on Protein Recovery: significant at 97%

Effect of Time on Protein Recovery: significant at 93%.

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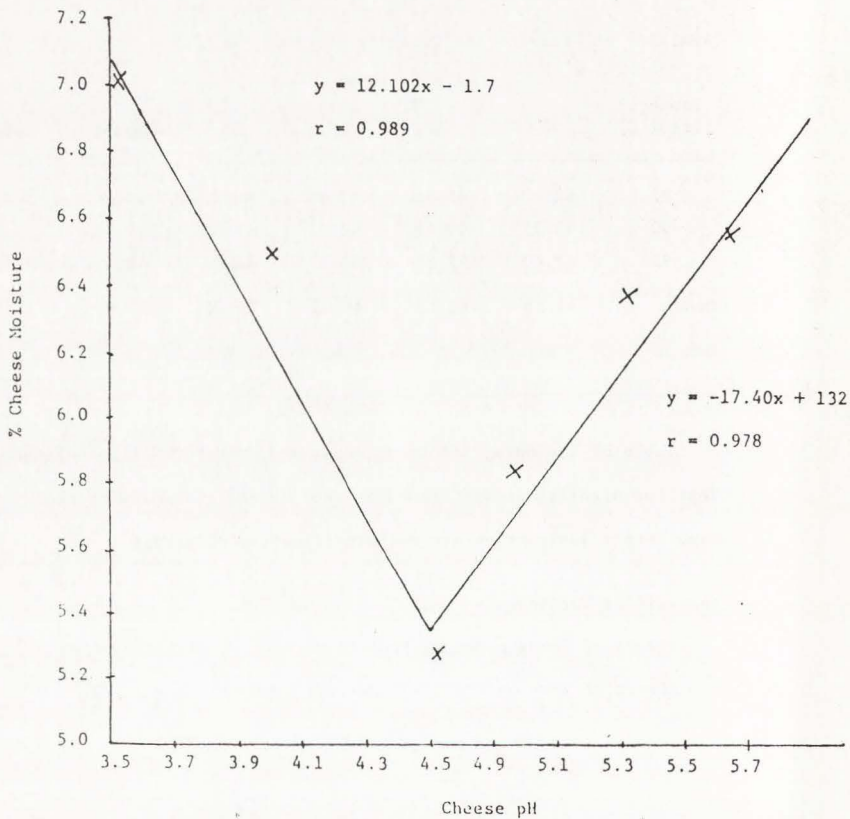
Appendix 13: THE EFFECT OF pH ON CHEESE MOISTURE

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The following paper was presented by Dr. C.L. Hicks, Associate Professor of Animal Science, Department of Animal Science, University of Kentucky, Lexington, Kentucky 40546, especially for the 17th Marschall Invitational Italian Cheese Seminar held in the forum of the Dane County Extension Center, Madison, Wisconsin on September 10 and 11, 1980.

EFFECT OF LOW TEMPERATURE STORAGE OF MILK ON CHEESE YIELD

By C.L. Hicks, J. O'Leary, E. Aylward and B.E. Langlois

Factors affecting cheese yield are a major concern to the dairy industry. Often all profits derived by cheese plants result from good management practices in which little or no yield losses occur during the manufacturing process. Historically yield studies have been initiated with the development of new processing procedures. However, with the advent of refrigeration and the development of current milk trans-porting procedures, a new factor has crept into the cheese yield picture. This factor is the growth of psychotrophic bacteria in stored milk. Although much re-search has been done to characterize their effect on milk, little has been done to determine how they effect cheese yield.

As Table I indicates, the number of days that raw milk can be stored depends on its initial bacterial count and storage temperature.

Table I. Influence of storage temperature on shelf life of raw milk.

Milk Quality	Time milk can be stored before coagulation (Days) Storage temperature (^{O}C)		
	5	7.5	10
High < 20,000 CFU/ml	12	11	9
Low > 10^6 CFU/ml	4	2	2

However, the conclusion should not be made that high quality milk can be stored for prolonged periods of time without any effect on cheese yield. Considering that most milk is picked up from the farm on an alternate day schedule, some portion of that pickup is at least 36 hrs old. Many cheese plants that operate under optimum con-ditions store enough milk for the following days operation. Therefore, under optimum conditions some of the milk would be 60 to 72 hrs old. Also some cheese plants purchase surplus grade A milk that is pumped and chilled through a transfer station before it is shipped to the cheese plant. This practice often adds more than 48 hrs to the storage time before the milk can be manufactured. Therefore, surplus grade A milk is often greater than 5 days old before it reaches the cheese vat. Obviously these storage practices can increase the final bacterial count tremendously. As Figures 1, 2 and 3 show, both high and low quality milk reaches bacterial levels of approximately 100 million before coagulation occurs. Since low quality milk contains higher initial bacterial populations, the time required to reach this end point is greatly reduced. Figure 2 indicates that after a few days of storage the bacterial population is predominantly psychotrophs that are proteolytic (Fig. 3) in nature. During the logrithmic growth phase of psychotrophic bacteria, both proteolytic and

lipolytic exo-enzymes are produced, resulting in degradation of the casein and fat in milk. The degradation caused by these enzymes may be monitored by changes in acid degree value and casein N. Researchers (3, 6, 8) have documented the proteolytic and lipolytic nature of these psychotrophs.

Pasteurization may only partially destroy these proteolytic and lipolytic enzymes. Some researchers (2, 5) suggest these enzymes are active in the cheese curd thus lowering the quality of the manufactured cheese. Milk with high initial bacterial counts result in natural cheeses that are predisposed to gassiness and unclean flavors. Apparently pasteurization of milk is insufficient to completely destroy all psychotrophs and their spores.

Cheese Yield

Stored milk at the University of Kentucky has been used to manufacture direct acid set (4), cottage (1), and cheddar cheese (7). In all varieties of cheese, yield on a dry matter basis decreased with storage time. Solids losses were equivalent in the direct acid set and cheddar data. Rate of yield loss was dependent on the initial bacterial quality of the milk as depicted in Figure 4, for cheddar cheese. Note that the initial difference in cheese yield was due to a difference in total solids. However, the rate of yield loss and days that cheese could be manufactured from raw stored milk before coagulation occurred depended on the initial milk quality. Certainly as stored time increased to where bacterial population reached 10^6CFU (see Figures 1, 2 and 3) yield losses were apparent. Extremely high quality milk shows a lag period of 3 to 4 days from time of milking before heavy yield losses occur. Low quality milk had a linear yield loss. Most cheese milk tends to be of such low quality that some yield losses would occur by manufacturing time. Cheese manufactured from stored surplus grade A milk would generally have greater yield loss than manufacturing grade milk used under optimum conditions.

Moisture Content in Cheese

Proteolytic degradation of casein by psychotrophs caused additional water to be bound by the altered casein. Thus, when cheese is manufactured by using pH end points and no adjustments are made in cooking time and temperature or knife size, moisture increases with storage time (Fig. 5). Cheese manufactured from stored milk often incorporates moisture in excess of legal and plant standards. Note that low quality milk retains more moisture than high quality milk under the same manufacturing conditions indicative of the increased protein degradation.

Fat Loss

Lipolytic enzymes cause the hydrolysis of triglycerides increasing the milk's acid degree values. Free fatty acid are lost in the whey resulting in a greater fat loss as storage time increases (Figure 6). Note that initial differences between milk qualities are due to differences in total solids, but rate of decrease is due to lipolytic activity of psychotrophs.

Cheese Quality

Cheddar cheese quality decreased with storage time (Fig. 7). Cured cheese graded at 6 mo. of age which was manufactured from stored milk as compared to fresh milk, had gassy textures with fruity and unclean flavors. Quality losses in cheddar cheese may be greater than those in Italian cheeses that are processed through a

mixer-molder. However, a local cheese company that was using both stored manu-
facturing milk and surplus grade A milk had similar quality defects in both their
cheddar and Italian cheeses.

Calculation of Yield Loss

Yield losses incurred from high quality milk may be calculated from the following
expression:

$$\text{Yield loss} = \frac{.526 \ (d) - .160 \ (d)^2}{6.1}$$

Where: Yield loss = Kg cheese per 100 Kg milk at 39% moisture

d = Storage time in days from time of milking

This equation assumes an average milk storage temperature of $5^\circ C$ and that the
manufacturer knows the age of the oldest milk in the farm bulk tank. This formula
would be applicable to surplus grade A milk if storage time factors are known.
Rough estimates of apparent storage time may be taken from Figure 1 once total
counts have been enumerated.

A more realistic equation for calculating yield losses for manufacturing milk is:

$$\text{Yield loss} = \frac{.368 \ (d)}{6.1}$$

Where: Yield loss is defined as above

d = Storage time after milk enters manufacturing plant

This equation allows the manufacturer to calculate the yield loss he will incur
if he stores the manufacturing grade milk for an additional day.

Economic Losses

The equation for calculating yield losses from manufacturing milk suggest that 0.6%
of the maximum yield is lost per day. Cheese plants which store milk for an
additional day before manufacturing would lose 7.5¢ per cwt of milk being stored
(assumes a cheese price of $1.25/pound and a cheese yield of 10 pounds/cwt of milk
at 39% moisture.

Using the formula for high quality milk and above cost figures, the yield loss from
surplus grade A milk that was stored and transported for 5 days would be 0.2 pounds
of cheese/cwt milk and a loss of 24¢/cwt of milk handled.

Conclusions

Loss of cheese solids increases with storage time. To reduce these yield losses
manufacturers must reduce their milk storage time, encourage the production of higher
quality milk, which has been quickly cooled, pick up milk on a daily basis if herd
size is large enough, and reduce ripening time.

The incorporation of these management tools will certainly reduce the effect of psychotrophs in milk, give manufacturers additional income from higher yield and improve cheese quality.

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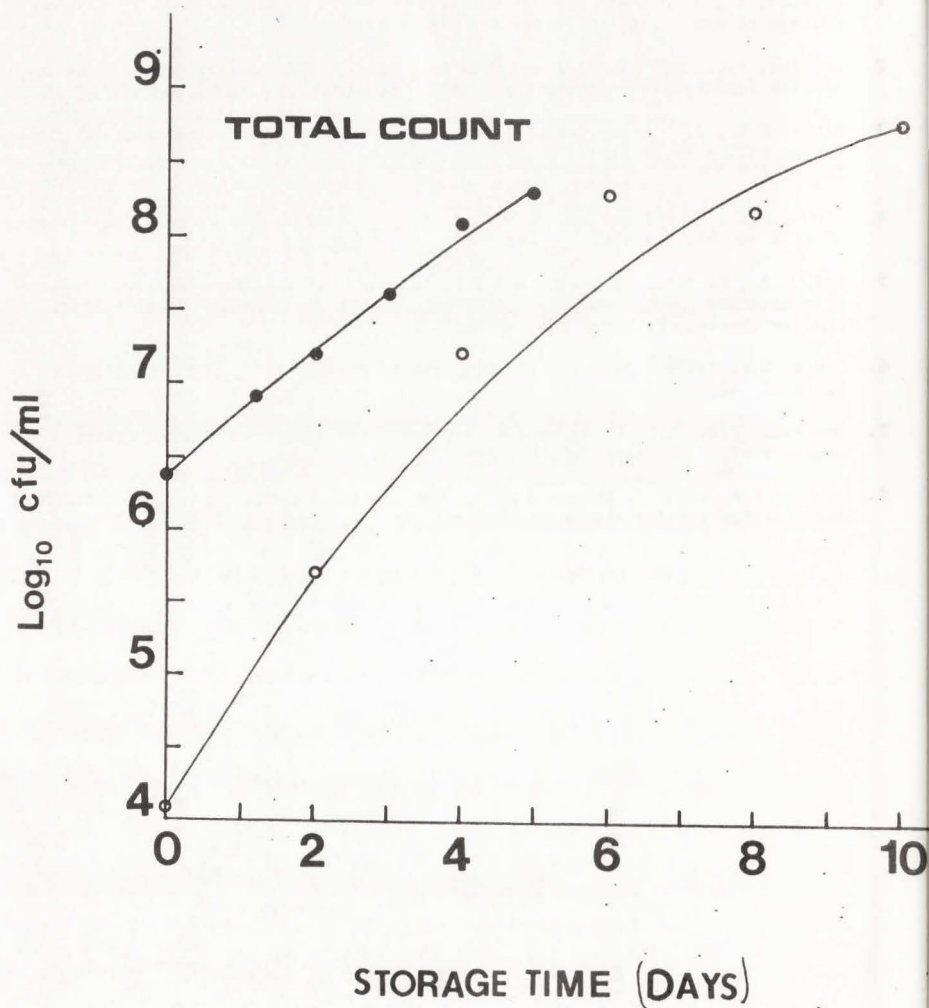
FIGURE I.   Effect of Storage Time on Total Counts in Raw Milk.

○ Grade A Milk;   ● Manufacturing Grade Milk
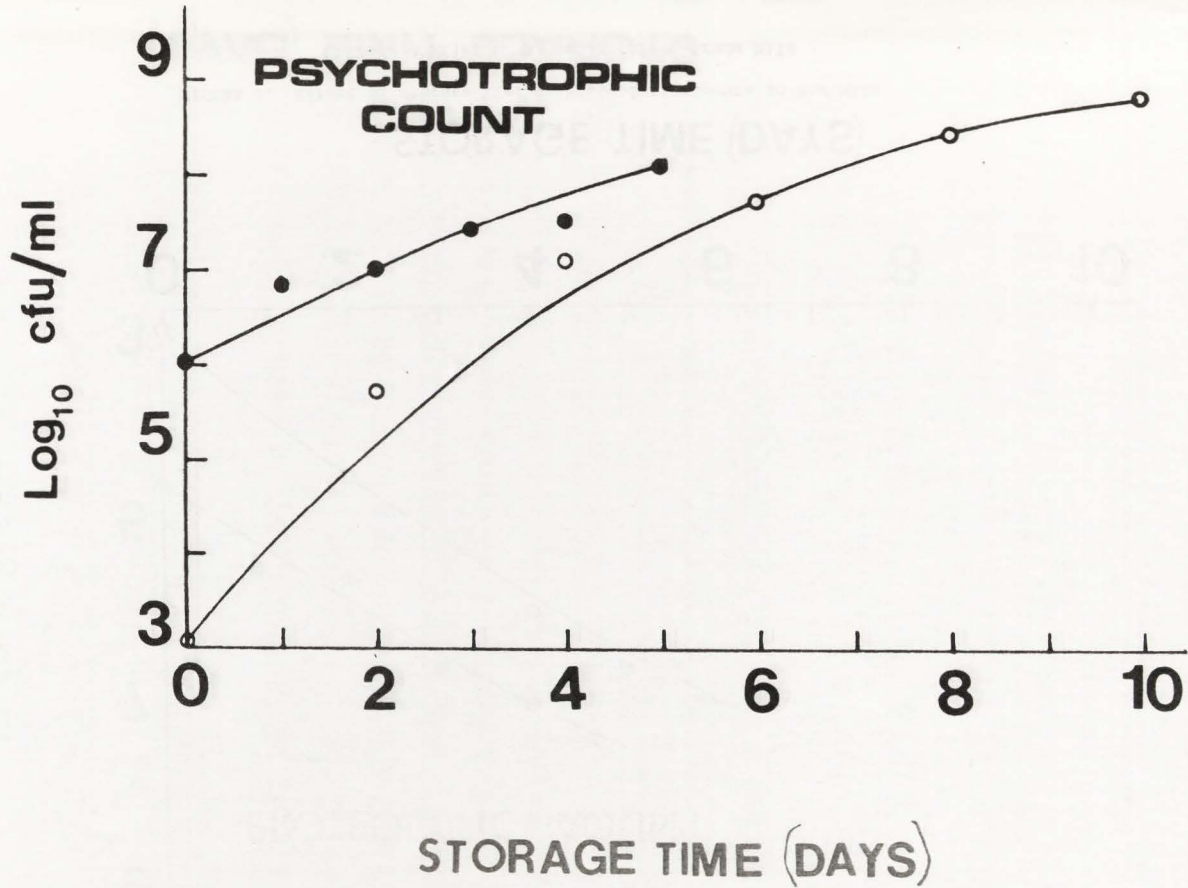
FIGURE 2.   Effect of Storage Time on Psychotrophic Counts in Raw Milk.

○ Grade A Milk;   ● Manufacturing Grade Milk
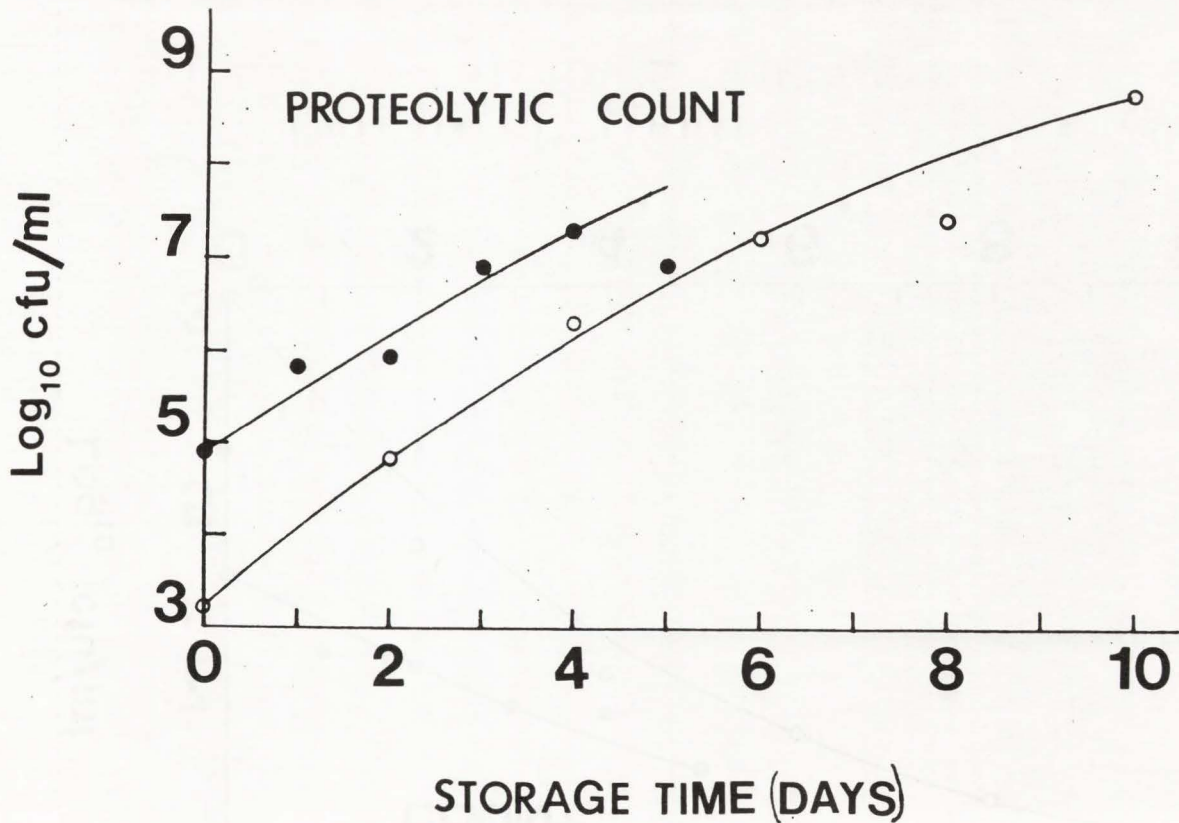
FIGURE 3. Effect of Storage Time on Proteolytic Counts in Raw Milk

O Grade A Milk;   ● Manufacturing Grade Milk
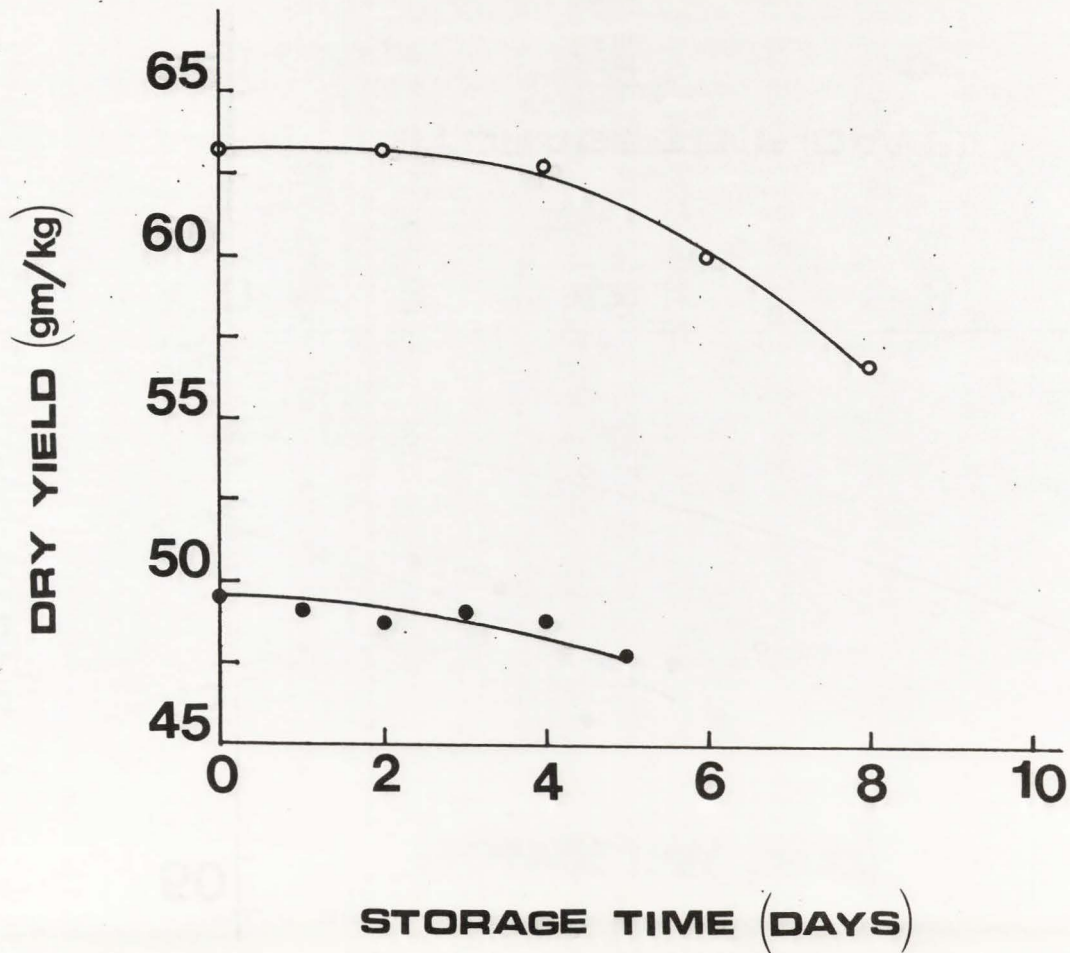
FIGURE 4. Effect of Milk Storage Time on Cheese Yield.
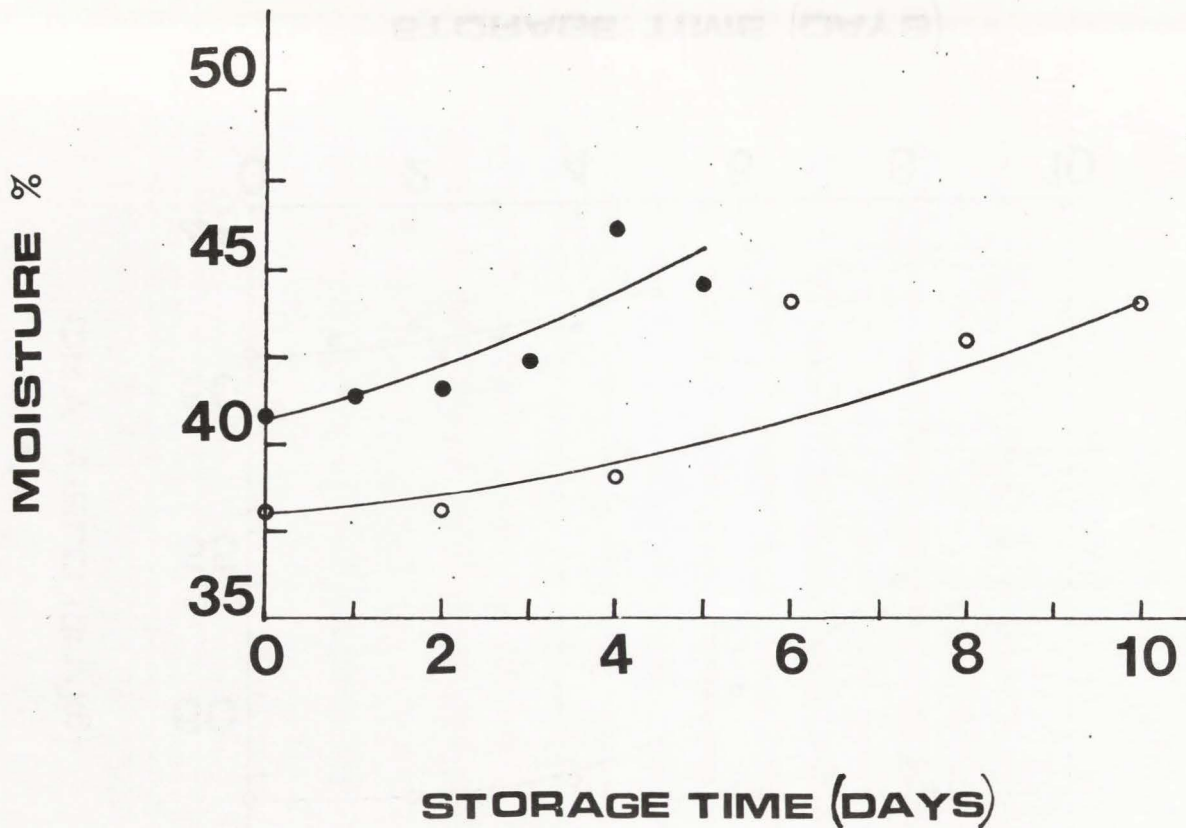
FIGURE 5. Effect of Milk Storage Time on Cheese Moisture

O Grade A Milk; ● Manufacturing Grade Milk

80 margin="80"
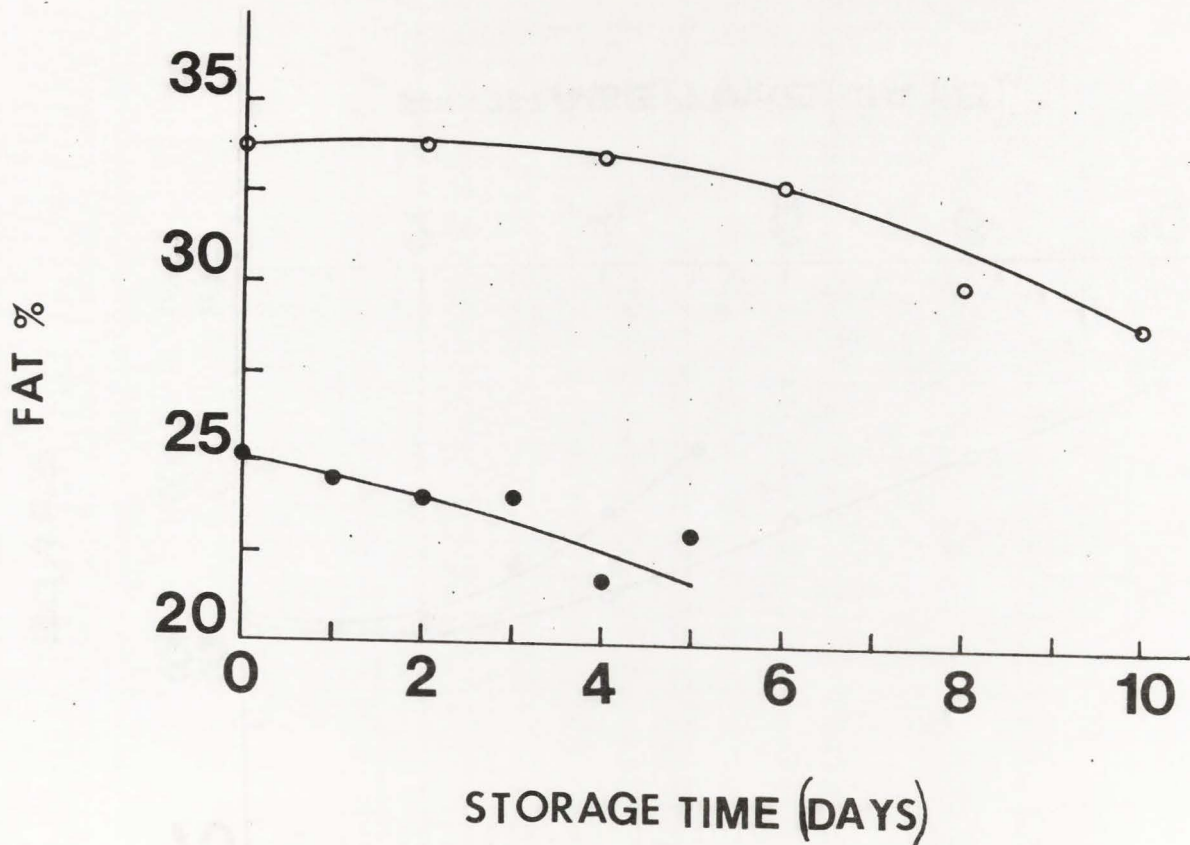
FIGURE 6.   Effect of Milk Storage Time on Fat Concentrations in Cheese.

○ Grade A Milk;   ● Manufacturing Grade Milk
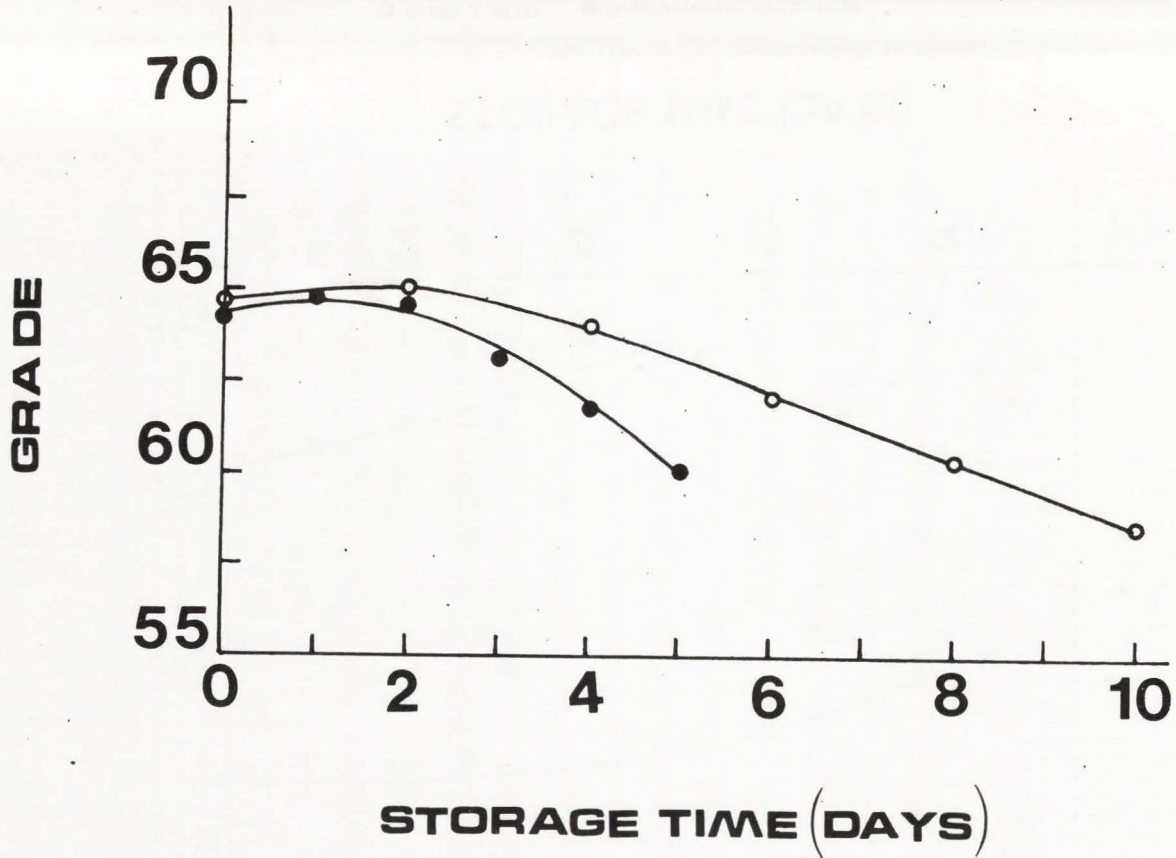
FIGURE 7. Effect of Milk Storage on Cheese Grade.

○ Grade A Milk;   ● Manufacturing Grade Milk

The following paper was presented by Dr. Daryl Lund, Professor of Food Process
Engineering, Department of Food Science, University of Wisconsin, Madison, WI
53706, especially for the 17th Marschall Invitational Italian Cheese Seminar held
in the FORUM of The Dane County Exposition Center, Madison, Wisconsin, on September
10 and 11, 1980.

ENERGY EFFICIENCY IN ITALIAN CHEESE MANUFACTURE

By Daryl B. Lund

Evaluation of food processes has generally been made on the basis of product quality
and cost. In either case, if the product does not meet the expectation of the
consumer or the level of the competition, the product and possibly the company
cannot survive. Included in the cost of production and marketing is the cost of
energy. Although energy prices have increased dramatically in recent years, the
driving force for energy conservation and process improvement is not the absolute
cost of the energy but rather the absolute availability of energy. For the food
industry, including the dairy industry, energy costs in the processing sector are
on the order of 1-5% of gross sales. Raw Product procurement, labor and packaging
generally account for nearly 70% of the cost. Thus if a company has capital to
invest in process modification, it will generally consider projects which increase
yield, decrease labor or save packaging costs with a higher priority than energy
projects. Fortunately many energy projects are not capital intensive and therefore
can be included in the operating budget. Because of the relatively low cost of
energy in relation to other cost factors, companies need to evaluate their energy
projects on different criteria for return on investment than other capital projects.

There are many opportunities for energy conservation in the dairy industry. Several
publications give examples of energy conservation opportunities (ECO's) (c.f. 1,6,9,10).
Examples include checking the steam generation and distribution system for leaks,
faulty steam traps, insulation, boiler efficiency, and potential condensate return.
Utilizing other water sources such as cow water from evaporators or permeate from
reverse osmosis systems as boiler feed water can reduce energy. Space heating
requirements should be evaluated based on air infiltration rate, insulation,
and temperature control. Finally processing methods and equipment should be
evaluated on the basis of energy. Examples include using 90% regeneration in fluid
milk pasteurization, covering vats where feasible, reducing energy to idle equipment,
and using thermostatic mixing valves for inline heating of clean-up water. Most
of these ECO's can be evaluated by simply calculating the energy requirement with
and without the improvement and performing a simple payback period analysis, that
is, an economic evaluation which indicates the length of time required using the
modified process for the project to generate a savings equal to the investment cost.
For the food industry, the payback criterion for a project generally ranges from
6 months to 4 years.

Another important opportunity for energy improvements particularly in the dairy
industry is waste heat recovery. Recently, Foell et al (2) reviewed some of these
opportunities for the food industry (including dairy). Waste heat streams include
flue gases from the boiler, air or water from cooling refrigeration and air compressors,

cow water from evaporators, whey from curd and whey cooking operations, exhaust gases from spray driers and condensate from indirect steam heating. The specific opportunity depends on the magnitude of the waste heat stream (temperature and flow rate), the number of hours it is available and concurrent with a stream that must be heated (accepter stream). Generally the waste heat is used to preheat boiler feedwater or clean-up water, to defrost freezing tunnels, or to preheat air into dryers or for space heating. Generally waste heat recovery projects involve larger capital investment (heat exchanges, pipes, tanks, etc) and therefore the economic analysis of the project should consider the life of the equipment and the time value of money. This is done in life cycle cost analysis which identifies the costs and savings in terms of present value over the life of the project. Application of life cycle cost analysis to waste heat recovery in the food industry is given by Foell et al. (2) and should be applied to more capital intensive projects.

To perform an economic evaluation of an energy project it is necessary to determine the energy requirement in a unit operation or a process. This is done through an energy audit or analysis of the plant. Two levels of analysis can be performed. The first is a general analysis which utilizes data on the purchased energy and production for the plant. This type of general energy audit or accounting indicates the performance of the plant in terms of energy per unit of throughput (either raw material or product) and can be used to quantify the impact of energy conservation projects and process improvement projects on overall energy utilization.

A general energy audit utilizes the monthly records on purchased fuels and electricity and production (input or product). To determine the total energy input the quantities of fuel are converted to equivalent heat energy using conversions factors such as those shown in Table 1. A more accurate estimate is to obtain the heat value of the fuel directly from the supplier. It is possible to use other convenient units for energy (rather than BTU's) by using conversion factors such as those given in Table 2. It should be noted that the general energy audit should be done using quantities of energy, not cost of energy. Since energy costs are increasing at very rapid rate, a good conservation effort could be masked by the escalation of energy cost if the analysis were performed on a cost basis. To get started on the general energy audit, company records going back over the past several years should be used. This allows the company to see the performance and the seasonal variability in energy utilization. Concurrently with obtaining the energy inputs, a record of production should also be obtained. Using the energy inputs and production the energy per unit of production can be easily calculated and the results can be plotted for easy visualization. Examples of this general energy analysis are given in Figures 1,2,3 for a cheese plant producing an Italian type cheese, with a daily milk intake of about 500,000 pounds and with a whey concentrating and spray drying operation. It can be seen that for this plant the production is very constant (Fig 1) but the energy input is highly variable (Fig 2). The energy per pound of milk (Fig. 3) can now be easily tracked. This general energy accounting scheme should be a required component of the record keeping for a plant and can be incorporated into the bookkeeping duties.

In addition to the general energy audit it is necessary to perform an energy analysis on the plant itself. Data generated in such an analysis can be used to identify the energy intensive operations and ultimately must be used to evaluate potential energy-saving modifications in the process. Even for the insulation of pipe, for example, it is necessary to know the heat losses so its cost can be evaluated against the cost of insulation. Several publications have detailed energy accounting procedures

TABLE 1. HEATING VALUES OF FUELS

Fuel	Approximate Weight (Lb Per Gallon)	Approximate Value
Gasoline – Regular	6.12	124,000 BTU/gallon
Gasoline – High Octane	6.06	123,000 BTU/gallon
Diesel – No. 2	7.07	140,000 BTU/gallon
Propane	4.25	92,000 BTU/gallon
Butane	4.80	102,000 BTU/gallon
LP Gas (25% butane, 75% propane)	4.40	94,500 BTU/gallon
No. 2 Oil	7.25	142,000 BTU/gallon
No. 5 Oil	8.00	149,000 BTU/gallon
No. 6 Oil	8.20	152,000 BTU/gallon
Natural Gas	----	1,050 BTU/cu ft*

*The heating value of gas varies from different sources. Obtaining the value from the supplier is suggested. A commonly used value is 1000 BTU per cubic foot.

TABLE 2. ENERGY UNIT CONVERSION FACTORS

		Btu	KgCal	Hp-Hr	Kwh	Therm
1 Btu	=	1.0	0.252	0.000393	0.000293	0.00001
1 KgCal	=	3.9683	1.0	0.00155857	0.0011622	0.00003968
1 Hp-Hr	=	2,546.14	641.616	1.0	0.7456*	0.025461
1 Kwh	=	3,409.52	859.184	1.3375	1.0	0.0005878
1 Therm	=	100,000	25,200	39.3	29.3	1.0
1 Bbl Cr oil	=	5,800,000	1,461,600	2,279.4	1,699.4	58.0

*When estimating electric energy consumed by induction run motors, an efficiency of 85% is suggested; therefore, 0.88 Kwh per HP is a practical figure.

FIGURE 1. Milk Intake as a Function of Time
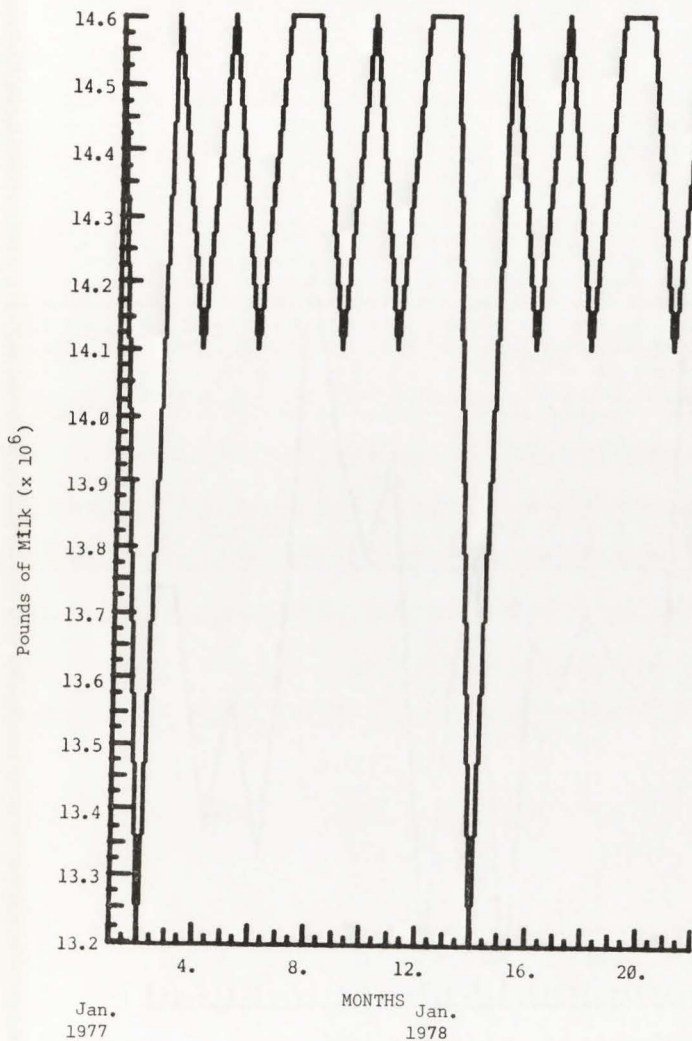
Figure 2. Purchased Energy as a Function of Time
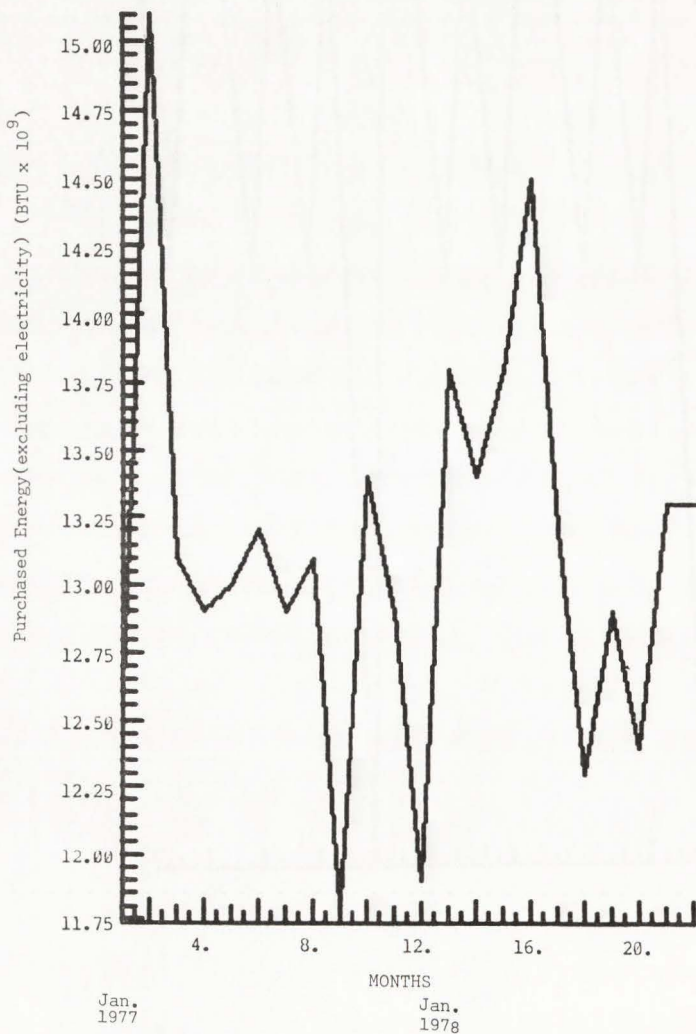
FIGURE 3. Energy per Unit of Production as a
Function of Time
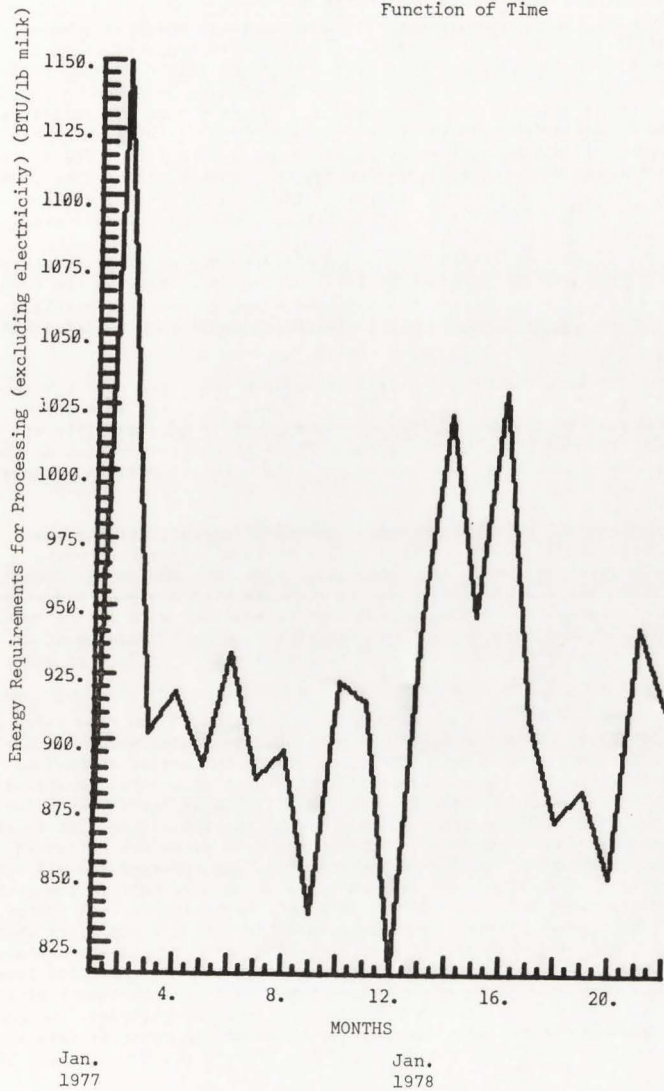
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for processes including **standardization of symbols for flow charting** (c.f. 8), instrumentation requirements and guidelines for food processes (c.f. 4) and studies on specific dairy plants (c.f. 1,3,5). In many of these studies the detailed energy analysis has been performed using capital intensive instrumentation to obtain the data. Examples include in-line flow meters (steam and liquid), temperature recording devices and data logging devices. Although these studies have served to identify some potential energy improvements for the plants in which they were completed, the methodology is rather restricted to large corporations which have several plants and the engineering staff to perform the analysis. Because these methods are generally too capital and labor intensive, we have developed a procedure for performing an energy analysis on cheese plants. Cheese plants are ideally suited for this analysis because production is quite constant. A similar approach can be used in multiproduct plants but the analysis may require more time. The analysis described here identifies the use of thermal energy in a cheese plant. The plant should work closely with the electric utility to perform an electrical energy analysis (eg. correct sizing of motors, and capacitors, peak load demand, etc.).

The basis of the procedure is to perform selected measurements on all unit operations which utilize energy originating from the boiler (ie. thermal energy in the form of steam). These data are then used in calculations which result in completing Table 3. This procedure identifies the energy intensive operations and estimates the energy use per day of operation.

From Table 3, it can be seen that the analysis is based on the fact that the thermal energy that is generated in the boiler must either appear as a heat loss in the system (eg. through surface losses in pipes and equipment) or as a sensible or latent heat gain in the product or waste stream. Thus the analysis relies on the estimation of surfaces losses and temperatures and flow rates of **various streams** in the plant.

The data can all be obtained using measurement devices which collectively cost less than $300. Temperatures can be measured with a surface temperature probe which can also be immersed in liquid (eg. John Fluke Mfg. Co., Multimeter Model 8020A with thermistor probe). Flow rates can be measured with a bucket and stopwatch. Finally equipment size and pipe lengths can be measured with a tape measure. It should be emphasized that this method does not require direct measurement of steam flow rates and furthermore does not require breaking into product or other pipelines.

The first step is to record the data on temperatures, dimensions and flow rates on a typical production day. The data sheets are presented as Tables 4-10. On Table 4 the data on the boiler(s) are recorded. The data include the boiler dimensions and surface temperatures. The surface temperature is taken at several locations so a mean temperature can be used in the calculation and if the boiler is insulated, the temperature to record is the surface temperature of the insualtion. It is also necessary to record the room temperature. Heat losses from pipes are estimated using data recorded on Table 5. Ambient temperature must be recorded and all subsequent measurements on pipes should be made on pipes which have surface temperatures higher than ambient temperature. Only those pipes will be losing thermal energy. Caution should be taken here so that measurements are taken on all pipelines which are used during the day. This requires foreknowledge of which transfer lines are in use during periods of the day as unit operations are sequenced. For pipe loses, the length and diameter of the pipe, the surface temperature and the length of time (in hours) that the pipe is at the measured temperature must be recorded. The connecting pipe within the pasteurizer (including the holding tube) should be separately identified on the data sheet. Also the time at the measured temperature can be estimated if the

Table 3. Summary Sheet

Unit Operation	Heat Required (BTU/day)	% of TOTAL
Boiler Surface Losses		
Pipe Suface Losses (excl. Pasteurizer)		
Pasteurizer - Pipe Surface Losses		
- Equipment Surface losses		
-Hot water tank		
-Sensible heat in milk		
Deaerator Surface Losses		
Cooking vat - Sensible heat in milk		
- Evaporative losses		
- Surface losses		
Evaporator - Surface losses		
- Latent and sensible heat		
Dryer - Surface Losses		
- Latent and sensible heat (H_2O)		
- Product sensible heat		
Clean-up		
TOTAL		

Table 4. BOILER ANALYSIS

Temperature of Boiler room _____ °F

Temperature on Boiler Surface

Boiler No.	Serial Number	Temperature at position (°F)					
		A	B	C	D	E	Ave.
1							
2							
3							
4							
5							

Size of Boiler
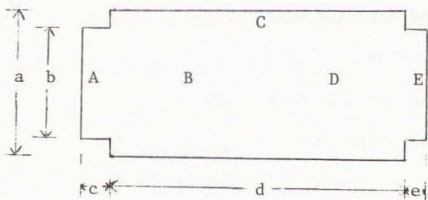
Boiler No.	Dimension (ft.)				
	a	b	c	d	e
1					
2					
3					
4					
5					

Table 5. Heat Losses From Pipes

(include all connecting pipes)

Ambient temperature _____ °F

pe Size ter dia. inches)	Length of Pipe (ft.)	Horizontal(H) or Vertical(V)	Temp. on the Surface of Pipe (°F)	$T_{pipe} \overset{\Delta T}{-} T_{amb.}$	Hours the Pipe is at Measured Temp.

eurizer Piping

Table 6. Pasteurizer

Day	Flow rate of milk through pasteurizer (lb/hr)	Temp. of incoming milk	Temp. of milk leaving pasteurizer	Time of operation (hrs)
1				
2				
3				
4				
5				
6				
7				
Average				

Dimensions of Pasteurizer and temperature on the surface

Ambient temperature _____ °F

Dimensions (ft)

Thickness (ft.)   a   b   c   d
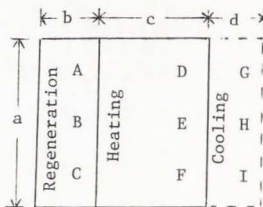
Temperatures (°F)

A _____   D _____   G _____

B _____   E _____   H _____

C _____   F _____   I _____

AVE _____   AVE _____   AVE _____

Table 7.

Temperature of Condensate (overflow) from Pasteurizer _____ °F

Flow rate of Condensate (overflow) from Pasteurizer _____ lb/hr

De-aeration Section

Dimensions & Temperature (on surface)

D (ft)	L (ft)	D_c (ft)	L_c (ft)
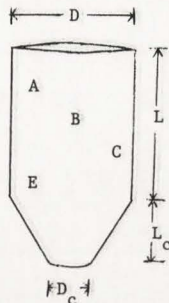
Temperature on Surface

A _____

B _____

C _____

E _____

AVE_____

Table 8. Dimension of Cooking Vats and Temperature on the Surface

Vat No.	H_1	H_2	L	W	T
1					
2					
3					
4					
5					
6					
7					
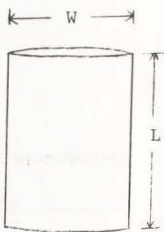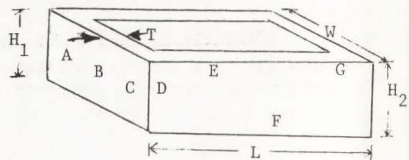
Temperatures (°F)

A _____

B _____

C _____

D _____

E _____

F _____

G _____

AVE_____

Table 9. Sensible Heat Changes in Cooking Vats

Ambient temperature _____ °F

Vat #	Time to fill (min.)	Temp. of feed (°F)	Time of cooking (min.)	Temp. of cooking (°F)
1				
2				
3				
4				
5				
6				
7				

Temperature of Condensate from vat _____ °F

Flow rate of Condensate from vat _____ lb/hr

Table 10.

EVAPORATOR:

Perimeter (πD)(ft): _____   H(ft): _____

Surface temperature (°F): A _____   B _____   C _____

AVE _____

Feed concentration (% solids): _____%

Concentration of product (% solids): _____%

Hours of operation: _____ hrs.

PREHEATER (if applicable):

Perimeter (πD)(ft): _____   H(ft): _____

Surface temperature (°F): A _____   B _____   C _____   AVE _____

Temperature of Product: IN _____°F   OUT _____°F

Hours of operation: _____ hrs.

Flow rate: _____ lb/hr

DRUM DRYER:

Diameter (D) _____

Length (L) _____

RPM (N) _____

Concentration of food (% solids): _____%

Moisture content of product (%): _____% H_2O

Rate of production of dry product: _____ lbs/day

Temperature of product (°F): _____°F

Temperature of condensate: _____°F

Flow rate of condensate: _____ lbs/hr

Steam temp./pressure: _____°F   _____ psig

Hours of production: _____ hr.
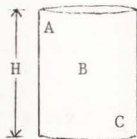
total production is known and the production rate. The total production divided by the production rate yields the time of operation.

Measurements on the pasteurizer itself are recorded on Table 6. Since the production can vary from day to day, an average figure for the week should be used. The dimensions of the pasteurizer and the surface temperature at several locations are also recorded. On Table 7 data on the condensate or water overflow from the pasteurizer are entered. In addition the deaerator system is measured including the temperature on the surfaces. Data on cooking vats are recorded on Table 8 and sensible heat added to the curd and whey are entered on Table 9. Finally data on evaporators and dryers are entered on Table 10.

The data measurements do not require skilled engineers. In our experience it required about 32 man hours to do all the measurements. Generally it works best to have a two-person team do the measurements.

These measurements must now be transfomed into useful data in the form of thermal energy use per day. This is done through a series of calculations utilizing Tables 11-15. Basically the calculations utilize the temperature differences and conditions for convective and radiative heat transfer coefficients to estimate heat losses. Table 11 is used to estimate heat losses from the boiler. The equations are used directly with appropriate substitutions of the values. The symbols are defined at the bottom of the table. Table 12 is used to calculate heat losses from pipes excluding the pasteurizer piping. For this calculation it is necessary to distinguish between vertical and horizontal piping since they will exhibit different heat transfer coefficients. To estimate the h-value (Column 4), Table 15 is used. The values in the body of the table are h values (in BTU/hr ft^2 °F). Furthermore, the calculation requires the use of the linear foot factor (square feet of surface per linear foot of pipe) for the appropriate diameter. Calculations on the pasteurizer and deaerator are performed on Table 12. Basically the calculation estimates the heat loss from surfaces by multiplying the surface area times the heat transfer coefficient times the temperature difference times the hours of use per day. The sensible heat in the pasteurized milk which is not recovered with regeneration is also calculated. It is important to use the temperature of the milk leaving the regeneration section as the outlet milk temperature since the temperature difference between that value and the milk inlet temperature represents the total temperature change supplied by the boiler energy. In this calculation there is also consideration for evaporative cooling which may occur in an open hot water tank in the pasteurization system. This requires that the enthalpy (heat content) of the air be obtained from a psychrometric chart. Thus the temperature of the air and the relative humidity must be known.

Table 14 is used to calculate the thermal losses associated with the cheese cooking vats. Both convective losses and evaporative losses are estimated in the procedure. The calculation in the top half of Table 14 can also be used to estimate heat losses from evaporator and dryer surfaces. Sensible heat required in curd cooking are calculated using the data from Table 9.

For evaporation and drying calculations it is reasonable to assume that approximately 1000 BTU are required per pound of water evaporated. In multiple effect evaporators, the water evaporated should only be that in the effect which is heated by boiler steam since water evaporated in the other effects is supplied heat energy from vapor generated in the boiler steam heated effect. Since steam in steam jet ejectors is usually deaerated and reused within the plant the only energy losses are in the

Table 11. Boiler Calculations

Calculate:

(1) Convective heat transfer coefficient (h_c)

$$h_c = 0.27 \left(\frac{\Delta T}{D_o} \right)^{1/4} \quad [=] \quad BTU/ft^2 \cdot hr \cdot °F$$

(2) Radiative heat transfer coefficient (h_r)

$$h_r = \left[\frac{\left(\frac{T_1}{100} \right)^4 - \left(\frac{T_2}{100} \right)^4}{T_1 - T_2} \right] \times 0.173 \quad [=] \quad BTU/ft^2 \cdot hr \cdot °F$$

(3) Area for heat transfer

cylindrical surface (A_c) $= \pi D_o L$

end plate surface (A_e) $= 2[\pi D_o^2/4]$

Heat loss rate from boiler:

$$Q_B = (h_c + h_r)(A_c + A_e)(\Delta T) \quad [=] \quad BTU/hr$$

Total heat loss:

$$Q_{TB} = Q_B \times \text{hours of operation}$$

Definitions:

ΔT = temperature difference between surface of boiler and ambient temp (°F)

D_o = Outer diameter of boiler (ft)

T_1 = Temp. of boiler surface (°R = 460 + °F)

T_2 = Ambient temp. (°R = 460 + °F)

Table 12. Heat losses from horizontal pipes:
(includes radiative and convective heat losses)

(1) pipe size (Dia. in inches)	(2) length of pipe (ft)	(3) ΔT $T_{pipe} - T_{air}$ (°F)	(4) h (from table)	(5) linear foot factor (from table)	heat loss rate (BTU/hr) (2)X(3)X(4)X(5)

Total heat loss from pipes:

(1) heat loss rate (BTU/hr)	(2) hours of production (hours)	total heat loss (BTU's) (1)X(2)

Total _____

100

Table 13. Pasteurizer and Deaerator Calculations

Heat loss from holding tube and connecting pipes:

(1) pipe size (Dia. in inches)	(2) length of pipe (ft)	(3) ΔT $T_{pipe} - T_{air}$ (°F)	(4) h (from table)	(5) linear foot factor (from table)	(6) heat loss rate (BTU/hr) (2)X(3)X(4)X(5)

Total heat loss from holding tube and connecting pipes:

(1) heat loss rate (BTU/hr)	(2) hours of production	total heat loss (BTU) (1)X(2)
	Total	

Heat loss from deaerator:

Calculate:

(1) Convective heat transfer coefficient (h_c)

$$h_c = 0.28 \left(\frac{\Delta T}{L} \right)^{1/4} \quad [=] \quad BTU/hr \cdot ft^2 \cdot °F \begin{cases} L = \text{height of cylinder (ft)} \\ \Delta T = T_{surface} - T_{air} \end{cases}$$

(2) Radiative heat transfer coefficient

$$h_r = \left[\frac{\left(\frac{T_1}{100} \right)^4 - \left(\frac{T_2}{100} \right)^4}{T_1 - T_2} \right] \times 0.173 \quad [=] \quad BTU/ft^2 \cdot hr \cdot °F \begin{cases} T_1 = \text{surface temperature} \\ \quad \text{of de-aerator (°R)} \\ T_2 = \text{air temperature} \\ \quad \text{(°R)} \end{cases}$$

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Table 13 (continued)

Calculate:

Vertical Wall Area (A_v) = $\pi D L$

Bottom Area (A_B) = $\pi D^2/4$

Total Heat Transfer Coefficient (h) = $h_c + h_r$

Heat Loss Rate:

$Q = hA_v\Delta T + 1.32A_B\Delta T + 1.60A_B\Delta T$ [=] BTU/hr; $\Delta T = T_{surface} - T_{air}$

Heat loss from pasteurizer surface:

Side walls and end plates:

(1) $T_{surface}$ (°F)	(2) Area (ft^2)	Heat loss rate (BTU/hr) 1.46 X Area X $(T_{surface}-T_{air})$
Total		

Top and bottom:

	(1) $T_{surface}$ (°F)	(2) Area (ft^2)	(3) h (BTU/hr °F ft^2)	Heat loss rate (BTU/hr) $[(1)-T_{air}]$ X (2) X (3)
Top			1.60	
Bottom			1.08	
			Total	

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Table 13 (Continued)

Total heat loss:

Heat loss rate X hours of operation _____

(1) Temperature of milk at inlet to Pasteurizer = °F

(2) Temperature of milk leaving the heating section = °F

(3) Milk flow rate through Pasteurizer = lb/hr

(4) Time of operation of Pasteurizer = hrs/day

(5) Energy required to pasteurize the milk = [(2) − (1)] X (3) X (4)]   BTU/day

Heat losses from hot water tank:

Diameter of tank (D) =   ft.

Height of the Tank (H) =   ft.

Time of Operation =   hr/day

Temperature on Surface of Tank (T_s) =   °F

Ambient Temperature (T_a) =   °F

Temperature of Hot Water in the Tank (T_{hw}) =   °F

Area of Cylindrical Surface (A_c) = π X D X H ft^2

Area of Bottom of the Tank (A_B) = $\frac{\pi}{A}$ X D^2 ft^2

Relative Humidity in the Plant (RH) =   %

Use Psychrometric Chart to Get H_{air} @ T_a and RH

Use Psychrometric Chart to Get H_w @ T_{hw} for Saturated Air.

Total heat loss: [1.46 X A_c X (T_s − T_a) + 1.08 X A_B X (T_s − T_a) + 6.79 X A_B X

(H_{hw} − H_{air})] X time of operation   BTU/day

Table 14. Cooking Vats

Cooking Vats

Heat loss from hot surfaces:

	$T_{surface}$ (°F)	Area of Surface (ft^2)	h $(BTU/hr \ ft^2 °F)$	Heat loss rate (BTU/hr) $[(1)-T_{air}] \ X \ (2) \ X \ (3)$
Sides and Ends	_____		1.46	_____
	_____		1.46	_____
	_____		1.46	_____
	_____		1.46	_____
Bottom	_____		1.08	_____
			Total	_____

Evaporative heat losses:

$$Q_{evap} = 6.79 \ X \ (\text{top surface area}) \ X \ (H_{milk \ temp} - H_{air \ temp})$$

$$* \begin{cases} H_{milk \ temp} = \text{enthalpy of saturated air at the milk temperature (BTU/lb)} \\ H_{air \ temp} = \text{enthalpy of air at the relative humidity of the plant and at air temperature (BTU/lb)} \end{cases}$$

*Obtained from psychrometric chart.

Table 15. Heat Losses from Horizontal Bare Steel Pipes and Flat Surfaces
In Btu per (Sq Ft of Pipe Surface) (Hour) (F Deg Temperature Difference Between Pipe and Air)

Pipe Size Inches	Linear Foot Factor*	Temperature Difference F Deg Between Pipe Surface and Surrounding Air Air at 80 F																			
		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
½	0.220	2.12	2.48	2.80	3.10	3.42	3.74	4.07	4.47	4.86	5.28	5.72	6.19	6.69	7.22	7.79	8.39	9.03	9.70	10.42	11.18
¾	0.275	2.08	2.43	2.74	3.04	3.35	3.67	4.00	4.40	4.79	5.21	5.65	6.12	6.61	7.15	7.71	8.31	8.95	9.62	10.34	11.09
1	0.344	2.04	2.38	2.69	2.99	3.30	3.61	3.94	4.33	4.72	5.14	5.58	6.05	6.54	7.07	7.64	8.23	8.87	9.55	10.26	11.02
1¼	0.435	2.00	2.34	2.64	2.93	3.24	3.55	3.88	4.27	4.66	5.07	5.51	5.97	6.47	7.00	7.56	8.16	8.79	9.47	10.18	10.94
1½	0.497	1.98	2.31	2.61	2.90	3.20	3.52	3.84	4.23	4.62	5.03	5.47	5.93	6.43	6.96	7.52	8.12	8.75	9.43	10.14	10.89
2	0.622	1.95	2.27	2.56	2.85	3.15	3.46	3.78	4.17	4.56	4.97	5.41	5.87	6.37	6.89	7.45	8.05	8.68	9.36	10.07	10.82
2½	0.753	1.92	2.23	2.52	2.81	3.11	3.42	3.74	4.12	4.51	4.92	5.36	5.82	6.31	6.84	7.40	7.99	8.63	9.30	10.01	10.77
3	0.916	1.89	2.20	2.49	2.77	3.07	3.37	3.69	4.08	4.46	4.87	5.31	5.77	6.26	6.79	7.35	7.94	8.57	9.25	9.96	10.71
3½	1.047	1.87	2.18	2.46	2.74	3.04	3.34	3.66	4.05	4.43	4.84	5.27	5.73	6.23	6.75	7.31	7.91	8.54	9.21	9.92	10.67
4	1.178	1.85	2.16	2.44	2.72	3.01	3.32	3.64	4.02	4.40	4.81	5.25	5.71	6.20	6.72	7.28	7.87	8.51	9.18	9.89	10.64
4½	1.309	1.84	2.14	2.42	2.70	2.99	3.30	3.61	4.00	4.38	4.79	5.22	5.68	6.17	6.69	7.25	7.85	8.48	9.15	9.86	10.61
5	1.456	1.83	2.13	2.40	2.68	2.97	3.28	3.59	3.97	4.35	4.76	5.20	5.65	6.15	6.68	7.23	7.82	8.45	9.12	9.83	10.58
6	1.734	1.80	2.10	2.37	2.65	2.94	3.24	3.55	3.94	4.32	4.72	5.16	5.61	6.10	6.63	7.19	7.78	8.41	9.08	9.79	10.54
7	1.996	1.79	2.08	2.35	2.63	2.91	3.21	3.53	3.91	4.29	4.69	5.13	5.58	6.07	6.60	7.15	7.75	8.38	9.05	9.76	10.51
8	2.258	1.77	2.06	2.33	2.60	2.89	3.19	3.50	3.88	4.26	4.67	5.10	5.56	6.05	6.57	7.12	7.72	8.35	9.02	9.73	10.48
9	2.520	1.76	2.05	2.31	2.59	2.87	3.17	3.48	3.86	4.24	4.65	5.08	5.53	6.02	6.54	7.10	7.69	8.32	8.99	9.70	10.45
10	2.814	1.75	2.03	2.30	2.57	2.85	3.15	3.46	3.84	4.22	4.62	5.05	5.51	6.00	6.52	7.08	7.67	8.30	8.97	9.68	10.43
12	3.338	1.73	2.01	2.27	2.54	2.83	3.12	3.43	3.81	4.19	4.50	5.02	5.48	5.96	6.48	7.04	7.63	8.26	8.93	9.64	10.39
14	3.665	1.72	2.00	2.26	2.53	2.81	3.11	3.41	3.79	4.17	4.57	5.00	5.46	5.94	6.47	7.02	7.61	8.24	8.91	9.62	10.37
16	4.189	1.70	1.98	2.24	2.51	2.79	3.08	3.39	3.77	4.14	4.55	4.98	5.43	5.92	6.44	6.99	7.59	8.21	8.88	9.59	10.34
18	4.717	1.69	1.96	2.22	2.49	2.77	3.07	3.37	3.75	4.12	4.53	4.96	5.41	5.90	6.42	6.97	7.56	8.19	8.86	9.57	10.32
20	5.236	1.68	1.95	2.21	2.47	2.75	3.05	3.36	3.73	4.11	4.51	4.94	5.39	5.88	6.40	6.95	7.54	8.17	8.84	9.55	10.29
24	6.283	1.66	1.93	2.19	2.45	2.73	3.02	3.33	3.70	4.07	4.48	4.90	5.36	5.84	6.36	6.92	7.51	8.14	8.80	9.51	10.26
Vertical Surface		1.84	2.14	2.42	2.70	3.00	3.30	3.62	4.00	4.38	4.79	5.22	5.68	6.17	6.70	7.26	7.85	8.48	9.15	9.86	10.62
Horizontal Surface Facing Upward		2.03	2.37	2.67	2.97	3.28	3.59	3.92	4.31	4.70	5.12	5.56	6.02	6.52	7.05	7.61	8.21	8.85	9.52	10.24	10.99
Horizontal Surface Facing Downward		1.61	1.86	2.11	2.36	2.64	2.93	3.23	3.60	3.97	4.37	4.80	5.25	5.73	6.25	6.80	7.39	8.02	8.69	9.39	10.14

Values are for Flat Surfaces four square feet or more in area.
* To secure losses per linear foot, multiply sq ft losses in table by this factor. The losses per sq ft of pipe surface for pipes larger than 24 in. can be considered the same as the losses for the 24-in. pipe.

Table 16. Summary of Thermal Energy Utilization for an Italian Cheese Plant

UNIT OPERATION	Heat Required (BTU/day)	% of Total
Boiler Surfaces	1.088×10^6	0.23
Pipes (excl. Pasteurizer)	4.864×10^5	0.10
Pasteurizer – Pipes	1.087×10^5	0.02
– Surface losses (a) cream pasteurizer	4.05×10^5	0.09
(b) milk pasteurizer	1.857×10^5	0.04
– Sensible heat in milk	2.40×10^7	5.13
– Cream separator (surface losses)	0.068×10^5	0.001
Cooking vat – Sensible heat in milk	1.24×10^7	2.65
– Evaporative losses	1.31×10^6	0.28
– Surface losses	8.31×10^5	0.18
Evaporator – Surface losses	1.521×10^6	0.33
– Connecting pipes	8.51×10^5	0.18
– Latent and sensible heat	3.07×10^8	65.60
Cheese dryer – Surface losses	1.57×10^6	0.34
– Connecting pipes	6.92×10^5	0.15
– Latent and sensible heat (H_2O)	1.02×10^8	21.79
– Product sensible heat	2.98×10^6	0.64
Parafin operation	6.96×10^5	0.15
Cleaning	9.76×10^6	2.09
TOTAL	4.68×10^8	

surfaces of pipes and the deaerator. Some sensible heat must then be added if it is returned to the boiler but this is usually negligible compared to other energy losses. For drying operations, the sensible heat added to the air by indirect steam heating must also be considered. If the boiler and dryer are both operated on gas, then the latent heat for the drying operation must also be included. The energy requirement is the sum of the sensible heat and the latent heat in this case. The sensible heat is calculated by multiplying the mass of material to be dried per day times the specific heat (or heat capacity) times the temperature prior to drying minus the temperature of the product coming into the drying operation. Finally the energy used in clean-up operations is estimated from the quantity of water used per day times the temperature of the cleaning water minus the temperature of the water source.

The final step in the detailed energy audit is to complete Table 3 with the calculated data. As an example Table 16 summarizes the detailed energy analysis applied to the Italian cheese plant which was illustrated in Fig. 1-3. The entire energy analysis (data collection and calculation) required approximately 64 man-hours.

Conclusions and Recommendations:

In the economic atmosphere of today it is absolutely essential that the food industry include energy as one of the parameters for evaluating processes and unit operations. To do this it is necessary to utilize data which can be generated from existing plant data on energy input and production. Energy per unit of production should become a part of the data routinely reported through management and shared with production employees. In addition, energy projects need to be identified in energy conservation, waste heat recovery and modification of process technology to increase energy efficiency. To do this, a detailed energy analysis needs to be conducted on the plant. This paper illustrates a procedure for conducting such an audit which does not require highly trained personnel or expensive instrumentation.

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The following paper was presented by Norman F. Olson, Professor of Food Science and
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A NEW METHOD TO TEST THE
STRETCHABILITY OF MOZZARELLA CHEESE ON PIZZA

By Norman F. Olson and
Deborah L. Nelson

The desirability of mozzarella cheese on pizza and in other foods depends upon its
mild acid flavor but depends to a greater extent on its body and textural characteristics.
To be acceptable, the cheese must be firm enough to slice and shred and must have the
desired meltability. Rubberiness or chewiness and the tendency to exhibit optimum
stringiness when melted on pizzas are properties that the cheese must also possess.
Increased use of mozzarella cheese in the food industry has created some problems in
communicating the properties of cheese from the seller to the buyer. Food technologists
are not familiar with the traditional grading systems used by the cheese industry
and the cheese producer is not always aware of the exact needs of the food processor.
Also, the food processor often desires objective measurements of ingredients, such
as cheese, rather than subjective grading of cheese.

These problems prompted the development of an objective measurement of the physical
properties of cheese, specifically its stringiness and rubberiness or elasticity
on pizza. The attributes which were desired in the test were: (1) simplicity, (2)
use of inexpensive equipment, (3) accuracy, and (4) lack of need of technically
trained personnel to carry out the test and to maintain the equipment. After consider-
ing several alternatives, a test based upon the Weissenberg effect was chosen for
its simplicity. This test has been used to evaluate the elasticity of "plastic"
polymers, a special string honey and gelled, sweetened condensed milk. The test
depends upon the tendency of an elastic or rubbery material to climb up a rod that is
rotated in the test material.

Success with honey and other elastic materials with the Weissenberg concept suggested
that elasticity of melted mozzarella cheese could also be measured. Preliminary
studies showed that cheese climbed a rotating rod sufficiently high to allow measure-
ment.

Test Methodology

The first step in the method was to shred a portion of a loaf of cheese and distribute
30 grams into a tared aluminum pan (C in Figure 1). A rod (A in Figure 1) wrapped
in filter paper (D) and having a wire screen (B) attached to one end was centered
in the pan. The rod was solid aluminum with a diameter of 1.9 centimeter (cm) and
the height of 13.0 cm, and the wire screen had a diameter of 4.0 cm. The design of
the rod evolved from preliminary trials. The filter paper was needed to overcome the

effects of fat in cheese which was released as free oil upon melting of the cheese. This free oil reduced adherence of the cheese to the rotating rod. Rough surfaces were created for the cheese to "grip" the rod and pan by attaching this piece of filter paper around the rod and placing metal screen (E) on the inside of the pan. After placing the rod in the pan, 60 grams of shredded cheese was added around the rod. The pan with the cheese and rod were set in a fixed position in a water bath at 63°C (145°F). This temperature was chosen to melt the cheese sufficiently for the test. Other temperatures might be necessary for other types of cheese. A plexiglass cover (J) was placed over the pan to prevent the sample from dehydrating while melting during a holding period of 30 minutes. After tempering, the cover was removed and the height of cheese was measured to within .01 cm with a cathetometer (K) or travelling microscope. After taking the initial reading, the rod was rotated at 10 revolutions per minute which caused the cheese to climb the rod. The cathetometer was then used to measure the maximum height that the cheese climbed. When the softened cheese climbed the rod, it tended to wind around the rod and form strands of cheese. At the maximum height, the strands of cheese broke or fractured and further rotation caused the cheese mass to relax back down the rod.

Test Criteria

Testing a number of samples of Mozzarella cheese indicated that several attributes could be evaluated with the test that would characterize the suitability of cheese on pizza. These criteria were: (1) the height that cheese climbed the rod, (2) the time required to fracture the cheese, (3) place of fracture of the cheese mass in the pan, and (4) texture of cheese as it climbed the rod.

The first criterion, the height that cheese climbed the rod, can be used to designate rubberiness or elasticity of cheese into various categories: 0.0 to 1.0 centimeter (cm) denotes cheese with no to little elasticity, 1.0 to 2.0 cm indicates moderate to definite elasticity, and greater than 2.0 cm was indicative of pronounced elasticity. Pronounced elasticity was usually not desirable since it effected the other textural characteristics in a detrimental way.

The second criterion, the fracture time, can be classified as short (less than two minutes), intermediate (2-4 minutes), or long (greater than four minutes). Samples with a short fracture time usually were described as being tough, extremely chewy, and/or rubbery on pizzas. This cheese would form thick strands and required more force to pull it away from a pizza than a less elastic cheese. Cheese exhibiting an intermediate fracture time had acceptable characteristics which include good stringing properties and a slightly chewy eating texture. A long fracture time indicated that the cheese was losing its elasticity and the eating texture was described as soft and tender. This cheese could be pulled from a pizza with little force to form thin strands of cheese that broke quickly.

The third criterion, the place of fracture, occurred at the rod, intermediate between the rod and edge of the pan, or edge of the pan. Fracturing at the rod occurred when there is no apparent constriction of the cheese so it did not climb the rod. This is an indication of one of two extreme undesirable situations which are the absence of elasticity or incomplete melting of the cheese. The second place of fracture was between the rod and edge of the pan. Such samples had fair to good stringiness with acceptable eating texture depending on the other criteria. The third place of fracture was at the edge of the pan and samples which fracture here are tough and rubbery and exhibited pronounced rubberiness or elasticity.

The fourth criterion used in the test was the texture of cheese as it climbed the rod. Texture was classified as being smooth or not smooth and gave good indication of the meltability of the cheese. Samples that had a smooth texture had fair to good meltability and stringing properties on pizzas. If the texture was not smooth, meltability of the sample usually was poor and the cheese was described as tough and rubbery when eaten.

Characteristics of Cheese

Several samples of mozzarella cheese were tested and the attributes from the test were compared with the performance of the cheese on pizza. The samples of cheese could be categorized according to their degree of elasticity as shown in Table 1. Samples with no elasticity did not climb the rod, had no fracture time since there was immediate fracturing at the rod with an extremely smooth texture. This cheese would melt readily on pizza but would exhibit very little stringiness on pizzas. The cheese may also be difficult to shred since it is likely to have a weak body. Sample two with little elasticity had a height climbed of less than 1 cm, a fracture time less than 2 minutes, fractured at the inside and had a smooth texture. This cheese would exhibit greater stringiness on pizza and would shred easier than the first sample. Cheese with good elasticity climbed more than 2 cm with a fracture time of 2-4 minutes, fractured at the edge of the pan and had a smooth texture. Samples with pronounced elasticity climbed more than 2 cm, fractured in less than 2 minutes at the edge of the pan and did not have a smooth texture. The latter cheese would not melt readily on pizza and would be tough and rubbery when eaten. It may not exhibit a great deal of stringiness, because of its tough and rubbery body.

Imitation or Substitute Cheese

Imitation or Mozzarella substitutes were also evaluated with the test; the results are shown in Table 2. The characteristics of the three mozzarella cheese substitutes were similar in some respects but differed in a number of characteristics as compared to most natural mozzarella cheeses evaluated in the preceding studies. The cheese substitutes possessed extremely good textural characteristics as evidenced by a smooth to very smooth texture while climbing the rotating rod (Table 2, column 5). The characteristics of the substitutes during fracturing of the structure differed from the natural cheese. The fracture time and place of fracture (columns 3 and 4) were hard to determine since few of the samples fractured clearly. After the samples fractured, the cheese did not relax down the rod back to the edge of the pan like natural cheese but continued to rotate with the rod at the maximum height. The fracture times (column 3) for the cheese substitutes (> 3 min) were longer than most natural cheeses used in the preceeding studies; this indicated that samples had good stringing properties and, based on evaluations of natural cheeses, the cheese substitutes would probably have an acceptable eating texture. Overall, the elasticity of the cheese substitutes was comparable to natural mozzarella.

The characteristics of sample B were very different from the characteristics of samples A and C. Sample B behaved like an aged mozzarella cheese with little elasticity and would form thin strands when pulled apart on a pizza. The meltability of the cheese was very good indicated by the very smooth texture but it was observed to be sticky like an aged mozzarella which would make shredding more difficult. Sample A and C showed good elastic characteristics but were quite dry as observed by the firmness and absence of cheese on the cutting knife and shredder. This dryness should

result in good shredding properties but reduces meltability of the sample. Slow meltability was seen in samples A and C but the rough texture usually associated with poor meltability of natural mozzarella was not observed.

In summary, the Weissenberg Test satisfactorily measured the elasticity of molten mozzarella cheese and was capable of predicting the performance of the cheese on pizzas. Accuracy and reproducibility of the test was good as indicated by a coefficient of variation of 4% for five replicate tests. These results suggest that the method would make a good quality assurance tool since it is sensitive, accurate, reproducible, and very simple.

Figure 1   Schematic representation of the equipment
         for the Weissenberg Test

         A - rod, B - wire screen attached to rod,
         C - pan, D - filter paper attached to rod,
         E - wire screen placed on inner circumference
         of pan, F - water bath, G - water bath
         shelf, H - shaker clamp, I - variable
         speed motor, J - plexiglass cover, K - catheto-
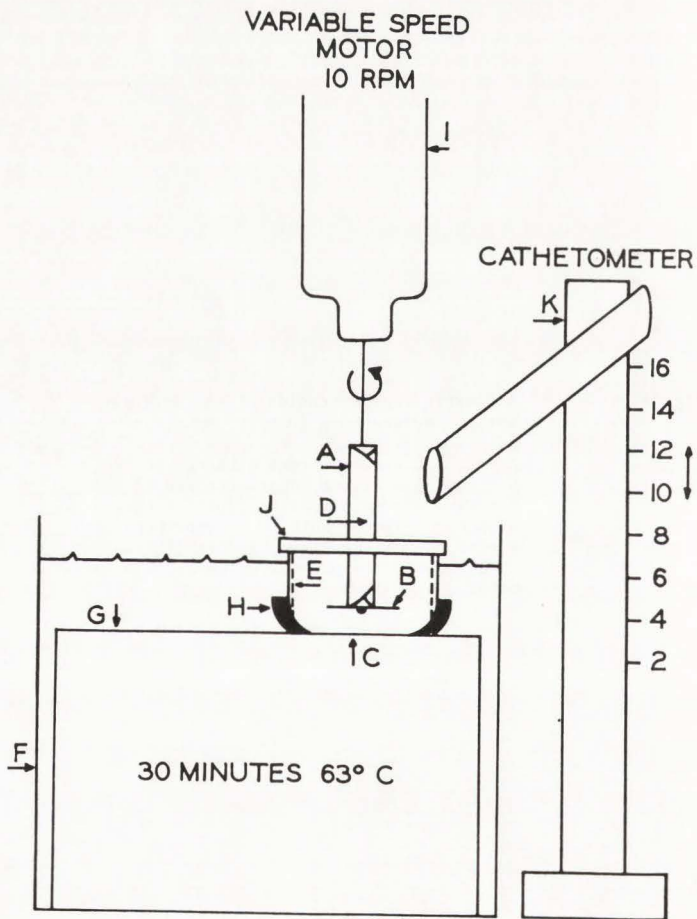   meter

VARIABLE SPEED
MOTOR
10 RPM

I →

CATHETOMETER

K →

16
14
12
10
8
6
4
2

A →

J
D →

E
H →
G ↓
B
C ↑

F →

30 MINUTES 63° C

Table 1   Measurements and Observations from the Weissenberg
           Test Used to Place Cheese in Four Elasticity
           Categories

Sample	Height Climbed	Fracture Time	Place of Fracture	Texture
	(cm)	(min)		
No elasticity	0	0	rod	extremely smooth
Little elasticity	<2	>4	intermediate	extremely smooth
Good elasticity	>2	2-4	edge	smooth
Prounounced elasticity	>2	<2	edge	not smooth

Table 2   Evaluation of the Four Criteria from the Weissenberg
           Test for Three Mozzarella Cheese Substitutes

Sample	Height Climbed (cm)	Fracture Time (min)	Place of Fracture	Texture
A	2.30	5	edge	smooth
	2.10	3.5	intermediate	smooth
B	.46	2	intermediate	extremely smooth
	.42	>5	intermediate	extremely smooth
C	1.38	>5	edge	extremely smooth
	1.67	3.5	intermediate	smooth

September 9, 1980

TO WHOM IT MAY CONCERN:

The paper entitled "MICROBIOLOGICAL SPECIFICATIONS FOR CHEESE---SIGNIFICANCE AND MEANINGFUL APPLICATION," by Dr. James J. Jezeski, Department of Dairy Science, University of Florida, Gainesville, Florida 32611, is temporarily being withheld from our MARSCHALL PRESS KIT although it will be presented to the audience of the 17th Marschall Invitational Italian Cheese Seminar on Thursday, September 11 about 12:05 P.M.

This paper is an excellent presentation about a subject that is being widely discussed in the cheese industry in the United States. However, this paper cannot be released for publication until it has been properly approved.
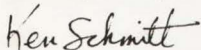
We therefore, regret that we cannot give you a copy of this paper in our Marschall PRESS KIT for this seminar, but if you are interested in getting a copy of this paper and approval of this paper for publication, it will be necessary for you to contact:

> Dr. James J. Jezeski
> Department of Dairy Science
> University of Florida
> Gainesville, Florida 32611

We are sorry for any inconvenience this may cause you.

We think this paper is worthy of consideration for publication in some future edition.

Sincerely yours,

Ken Schmitt

Ken Schmitt, Co-Chairman,
Marschall Italian Cheese Seminar,
Madison, Wisconsin 53701

THE PROCEEDINGS FROM THE 18TH (1981) ARE BOUND AS