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Proceedings from the 14th Annual Marschall Invitational Italian Cheese Seminar 1977

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Editor's Note: The 14th Annual Marschall Invitational Italian Cheese Seminar was held in the Congress Centre, Hotel Michelangelo, Via Scarlatti, 33, 20124 Milan, Italy on Monday, May 16, 1977.

Paper Numbers 1977-4; 1977-5; 1977-6; 1977-7; 1977-8 and 1977-9 were originally presented in Italian with simultaneous translations into English. Paper numbers 1977-1; 1977-2 and 1977-3 were originally presented in English with simultaneous translations into Italian.

The papers in Italian (except 1977-7) were translated into English in Italy by experienced translators. We cannot vouch for the accuracy of these translations but feel sure they have done a good job. Please excuse any errors that may have found their way into translated materials. We do not have access to the papers written in Italian, to make any corrections— if necessary. No. 1977-7 was written in English and then translated into Italian by the author.

We have found the papers to be most helpful. They contain a lot of very interesting information. We recommend you read them, then file them for possible future reference.

We apologize for our delay in printing papers from our 1977 Marschall Italian Cheese Seminar due primarily to translation problems.

June 7, 1978

Marschall Division
Miles Laboratories, Inc.
Madison, Wisconsin 53701
The following paper was presented by Mr. Carlo Re, General Manager, Marschall Divisione, Miles Italiana, S. p. A., 20040 Cavenago Brianza, Italy, especially for the 14th Annual Marschall Invitational Cheese Seminar, held in the Hotel Michelangelo, Milan, Italy on May 16, 1977.

WELCOME - INTRODUCTION

by Carlo Re

It is indeed a great honor and a pleasure for me to welcome you to the 14th Annual Marschall Invitational Italian Cheese Seminar.

We of Miles Italiana are especially proud to be able to host here in Italy, for the first time in the history of this seminar, our many distinguished guests and we sincerely hope that your visit to Italy will be both rewarding and meaningful in helping you to gain a first-hand understanding of the Italian cheese industry.

As you all know, Miles Laboratories has for many years sought to serve the manufacturers of Italian cheeses in the United States not only by continuing its efforts to improve the products and technology involved, but also by providing an accurate and up-to-date source of information on all facets of cheese production in Italy and the United States.

For 13 consecutive years, this seminar has served as a "reference point" for U.S. producers of Italian cheeses, giving them not only the opportunity to meet and discuss together, but also encouraging a vivacious exchange of ideas and techniques in an effort to stimulate and improve the vitally important lines of communication among everyone involved in the field of cheese production.

For these and other reasons, I think it permissible to say that Miles Laboratories and, in particular, this seminar, have played an active role in assuring the continued growth and development of the production of Italian cheeses in America.

However, Let us not forget that, in order to ensure also in future years, the positive trend which has been clearly verified in the past, both with regard to the quality and to the popularity of Italian cheeses in America, it is of absolute importance to seek ever-new ideas, techniques, and machinery which constitute the key elements necessary for renewing and stimulating the industry to ever greater heights.

And where would be a better place to find these new ideas, if not in the country where these fine cheeses originated -- that is, here in Italy?

It was, therefore, with this thought in mind that we decided to transfer this year's seminar from its traditional home in Madison, Wisconsin to Milan, Italy. We find ourselves here, then, because of our desire to bring together, under one roof, the major producers of Italian cheeses -- both Italian and American -- so that you, the experts of these two countries, may join together in a mutual effort to improve the business which you share.

(over, please)
I am sure that you all join me in wishing every success for this seminar, which will depend certainly on the combined efforts of everyone present today. We have done our best to create that kind of atmosphere which lends itself to productive thinking and we ask you now to help us in ensuring a profitable experience for all involved.

I would like to take this opportunity to thank everyone who has contributed in the organization and realization of this seminar. As you can imagine, the difficulties involved were not few, but I feel certain that you will agree, at the end of your brief visit to some of the cheese producers in Italy, that our goal of a profitable exchange of ideas has been more than satisfied.

Again, let me welcome you to our seminar and, on behalf of everyone at Miles, let me thank in advance our panel of speakers who have generously agreed to share with us their expertise in the field of cheese production.

I am also very pleased to note that it will be possible for you to mix business with pleasure in the next ten days - you've already had the opportunity to visit our city and the beautiful Como Lake and it looks like you'll be able to get at least a brief glimpse of some of Italy's most beautiful sights and cities.

Lastly, I would like to take this opportunity to personally thank Mr. Stan Ferris, the founder and promoter of the Italian Cheese Seminars, without whose invaluable experience and help, we could not have realized this meeting.

Thank you for your kind attention and best wishes for a successful stay in Italy. Thank you.
The following paper was presented by Mr. Stan Ferris, Manager, Italian Cheese Sales, Marschall Division, Miles Laboratories, Inc., P. O. Box 592, Madison, Wisconsin 53701, especially for the 14th Annual Marschall Invitational Italian Cheese Seminar, held in the Hotel Michelangelo, Milan, Italy on May 16, 1977.

WELCOME - RESPONSE

by Stan Ferris

Speaking on behalf of everyone in our group, we are very pleased and happy to be here with you today. Our "Field Trip To Italy In 1977" is the culmination of several years of work and a dream we originally had back in 1973.

We have had to overcome several problems in making arrangements for this meeting. It has been necessary for us to change the format of our meetings as they are ordinarily held each year in Madison, Wisconsin. We are sure we will encounter further changes and problems we did not anticipate, but our spirit is high and our intentions are most sincere. We hope this meeting will be a step forward, in the right direction, to develop more friendly relationships with the cheese people in Italy. Italy is the oldest producer of Italian cheese in the world. Italian cheese production in America, Canada and Australia is just getting started. So, we have much to learn and in the years ahead we hope a friendly relationship will work to our mutual benefit. We invite and encourage the friendship of the Italian cheese industry in Italy.

We are especially pleased to be able to hold this meeting in Milan, Italy --- in the very center of Italian cheese production in Italy. We cannot think of a more desirable location to hold our first Marschall Italian Cheese Seminar outside of the United States, than in Milan, Italy. Yes, we are very happy to be here with you today. We hope our visit to Italy will encourage future visits to the United States from cheese people in Italy. We assure you we will do everything possible to help you visit cheese plants in the United States, if you plan a trip to America.

Although we are visitors to Italy, the original idea for the Annual Marschall Italian Cheese Seminars came from us. Under these circumstances, we would like to extend a warm and cordial welcome to our guests from Italy who are present in this audience today. We hope you find this meeting interesting and helpful. We are glad you are here.

(over, please)
We hope further that you will join us as our guests at our noon luncheon today and that you will return to hear our program this afternoon. You are also invited to take part in our "Cheese and Wine Tasting Festival" which will give you an opportunity to socialize with the Americans, Australians, and Canadians and perhaps have an exchange of ideas --- buy cheese --- sell cheese, visit, or do whatever you would like to do with your counterparts in the Italian Cheese industry throughout the world.

As a spokesman for Miles Laboratories, Inc., we would like to take a minute to pay special tribute to our Miles associates from Miles Italiana, who have cooperated with us in the planning, organizing, and staging of this meeting. Without their help and excellent cooperation, this meeting would not have been possible. Several people from Miles Italiana have helped to make this meeting possible. However, I would like to introduce the three men who did the most to make this meeting possible, and a success.

First, Dr. Dino Sabato, who has been our main contact in setting up and organizing this meeting. Dr. Sabato traveled to the United States in 1976 to attend our last Italian Cheese Seminar --- to learn how we conducted our meetings so he could employ the same planning when arranging for this meeting. Dr. Sabato has been most cooperative and helpful during the past several months and I would like to pay special tribute to him, for an outstanding job, well done. Will Dr. Dino Sabato please stand to be acknowledged! Let's give him a good round of applause for his efforts to make this meeting possible! Thank you most sincerely Dr. Sabato.

Next, I would like to introduce Mr. Luigi Rossi of the Marschall Divisione, Miles Italiana, S. p. A., who also worked diligently to help us organize and stage our 1977 "Field Trip To Italy." Mr. Rossi is manager of enzymes, dairy ingredients and chemicals for the Marschall Divisione of Miles Italiana. If you have an interest in any of our Marschall products, Mr. Rossi would be the man to contact. Would Mr. Luigi Rossi please stand to be introduced? Let's give Mr. Rossi a nice round of applause for his efforts to make this a successful meeting. Thank you, Mr. Rossi.

The third man who is responsible for the success of this meeting is Dr. Adalberto Villa, Marketing Manager for the Marschall Divisione, Miles Italiana, S. p. A., Cavenago Brianza, Italy. Dr. Sabato and Mr. Rossi both report to Dr. Villa.

Dr. Villa traveled to the United States to take part as a speaker at our 1974 Marschall Italian Cheese Seminar. At that time he presented an excellent paper entitled "A 1974 Report On Cheesemaking and the Cheese Industry In Italy." The information in this paper has been most helpful to prepare us for our trip to Italy this year.

Dr. Villa has also been of great assistance in organizing and preparing this Seminar for our pleasure. Would Dr. Adalberto Villa please stand to be acknowledged? How about a good round of applause for Dr. Villa? Thank you, Dr. Villa.
I would like to personally thank these three gentlemen for their help. It has been a pleasure to work with our associates from Miles Italiana. We stand ready to assist them in any way we can. Likewise, we plan to call on them if they can be of help to us.

At this time I would also like to introduce my associate at Miles Labs., Inc. in Madison, Wisconsin, Mr. Norman Wood, who has helped to plan and organize this trip to Italy. Let's have a good round of applause for Mr. Norman Wood.

By way of comparison, we think it is interesting to note that the Italian Cheese business in Italy apparently dates back to the 10th Century --- the year 1000 A.D. according to information we have read. Cheese as a food product apparently dates back about 5000 years --- about 3000 years before Christ.

It is quite surprising when you consider the Italian Cheese business in America dates back to a very humble beginning in 1899 according to the best information we can get. Thus, the Italian Cheese industry in Italy is approximately 977 years old at this time, whereas the Italian Cheese industry in the United States is only about 78 years old. We do not know when the Italian Cheese industry got started in Australia and Canada.

According to 1974 production figures for the two countries, the latest production figures available, it is interesting to note that total Italian Cheese production in Italy amounted to 450,000 tons whereas Italian Cheese production in America in 1974 amounted to 276,000 tons, roughly equivalent to about 61% of the production in Italy.

Yet, when you consider that the total cheese production in 1974 in America amounted to 1,332,000 tons, you can see the importance of Italian Cheese production in America, noting that Italian Cheese accounted for approximately 21% of all cheese manufactured in America in 1974.

The first recorded production for Italian Cheese in the entire United States were in the year of 1929 when approximately 3,000 tons were manufactured.

In 1976 it is estimated that production of Italian Cheese in the United States will be approximately 376,500 tons.

A most interesting, estimated, projected forecast for Italian Cheese production in the United States was given by Professor Norman F. Olson of the University of Wisconsin in a paper he delivered at our 1973 Marschall Italian Cheese Seminar. Professor Olson predicted that Italian Cheese production in America would reach approximately 550,000 tons by the year 2000.
By the year 2000 Italy will have approximately 1000 years of experience in the manufacture of Italian varieties of cheese. By comparison, the United States will have only 100 years of experience in manufacturing Italian cheese. Yet, there is a possibility the United States might produce more Italian cheese by the year 2000 than Italy will manufacture.

It has been established for several years that Italian cheese production in America is the fastest growing phase of the entire dairy and cheese industry. Italian cheese production in the United States is the brightest spot in the dairy and cheese industry in America. It continues to show rapid growth each year, with an approximate 12% increase in 1976. A continuing, increasing demand for Italian cheese and Italian type food products, using Italian cheese, on the American market, indicates the demand for Italian varieties of cheese will continue strong in the immediate future.

As a spokesman for the Italian cheese industry in America, we are pleased to tell you business is good. Business in Italian cheese has been very good for the past 22 years and we can see continuing good demand for Italian cheese in the next 10 years according to all the information we can find.

Automation of the Italian cheese industry in America continues at a high level and will undoubtedly continue in the years ahead as more and more plants expand their production facilities to meet growing demands for their Mozzarella, Ricotta, Provolone and grating varieties.

We hope it will be possible for you to visit our Italian cheese plants in America at some future date so you can observe the growth, vigor and enthusiasm that prevails in this great industry in the United States.

We appreciate this opportunity to hold our 14th Annual Marschall Italian Cheese Seminar in Italy and we thank you for your kind attention.

REFERENCE:
The following paper was presented by Mr. Verle W. Christensen, Manager, Madison Operations, Marschall Division, Miles Laboratories, Inc., P.O. Box 592, Madison, Wisconsin 53701, especially for the 14th Annual Marschall Invitational Italian Cheese Seminar held in the Hotel Michelangelo, Milan, Italy on May 16, 1977.

MILES LABORATORIES, INC., AND OUR RELATIONSHIP TO THE ITALIAN CHEESE INDUSTRY

By Verle W. Christensen

Milk is one of the oldest foods known to man. Records exist showing that cows were being milked in the year 9,000 B.C. The bible contains many references to milk and one of the best known is from the Book of Exodus, Chapter 3, Verse 8, where the Angel of Yahweh explains the mission of Moses. "I mean to deliver them out of the hands of the Egyptians and bring them out of that land to a land rich and broad, a land where milk and honey flow."

Many have commented on the value of milk. Dr. E. V. McCollum, a well known professor of biochemistry, at John Hopkins University, in Baltimore, Maryland, in the United States, comments, "The people who have achieved, who have become large, strong, vigorous people, who have reduced their infant mortality rate, who have the best trades in the world, who have an appreciation of art, literature, and music, who are progressive in science and in every activity of the human intellect, are the people who are progressive in science and in every activity of the human intellect, are the people who have used liberal amounts of milk and its products."

Milk, however, has always been a very perishable product and until the commercial development of refrigeration and pasteurization, had to be consumed fresh on a daily basis, usually within the immediate area of production. Milk also contained large amounts of water in relation to the solids content. It was subject to bacterial contamination and rapid spoilage. Because of these factors, the consumption of milk was limited. It was only when cheese was accidentally discovered by an Arabian traveler, who on the beginning of his journey, stored some milk in a pouch made from a sheep's stomach, that dairy products became increasingly important. The bacterial content of the milk, in combination with the heat of the animal, plus the enzyme rennin that was secreted from the stomach into the milk, formed cheese curds and whey. Today, cheese manufacture enables the manufacturer to make cheese and store it, thereby giving him a proven method of preserving milk in the form of cheese, which becomes more flavorful and desirable when aged from one season to another.

As the centuries have passed, cheese has taken its rightful, important place in the history of the world as a prime source of nutrition to all of mankind.

(over, please)
Cheese is one of the world's most widely distributed foods and is produced in an almost inexhaustible number of types, with many different flavors. More than 800 different varieties of cheese are made from the milk of cows, sheep, goats, moose, buffalo, camel, reindeer and various combinations of the above named milks.

Over the course of centuries, individual communities developed their own new varieties of cheese, each of which, depending on the particular kind of animal yielding the milk, the type of feed, and the preparation, was marked by a characteristic appearance, shape and flavor, thus giving rise to the large number of cheese varieties now available throughout the world.

Unique in this regard are the Italian cheese varieties which are distinctively different from most other cheese produced throughout the world. At one time the use of Italian cheese was limited to the Italian community and a relatively small number of connoisseurs of special cheeses. This is not true today, for in the past two decades in the United States, the per capita consumption of Italian cheese has more than quadrupled, which is the largest increase of any major dairy product produced in the United States. Italian cheese is without doubt the fastest growing dairy product manufactured in the United States today.

The first commercial cheese factory in the United States was opened in New York state in 1851. It was much later, in the early 1900's, that Italian cheese was produced on a small commercial scale. Most of the Italian cheese was produced on a small commercial scale. Most of the Italian cheese produced in the early 1900's was Mozzarella and Ricotta. Most of it was produced in the Eastern section of the United States.

An important event in the development of the Italian cheese industry in the United States occurred about 1914 - 1918, during World War I, when all imports of Italian cheese from Italy were cut off because of the war. The Italian immigrants who had settled in the United States just prior to this time, were unable to buy imported cheese from Italy so they turned to domestic manufacturers and encouraged them to start manufacturing Provolone, Mozzarella, Vacino Romano and a Parmesan type as we know them in the United States. Following the conclusion of World War I, during the period from 1918 to 1930, the struggling domestic Italian cheese industry in the United States continued to grow and prosper in spite of growing pains and the many problems associated with the development of a new cheese industry in a foreign country.

Italian cheese manufacturers with names like Pollio, Stella, Frigo, Tolibia, Sartori & Rossini, Concord, Grande and Passini became familiar names in the American trade. Most of these companies remain in business today and are considered leaders in the Italian cheese industry in the United States.

It was during this early period of the development of the Italian cheese industry in Wisconsin that Mr. A. J. Marschall founded the Marschall Dairy Laboratories, Inc. in 1906, in Madison, Wisconsin. Mr. Marschall came to the United States from Denmark in 1904 where he was employed as a chemist by a Danish rennet company in Little Falls, New York. Mr. Marschall became dissatisfied with his work for the Danish Rennet Co. and most important, he
had the foresight to see that the cheese industry in the United States was gradually moving to the Middle West -- mostly to the State of Wisconsin. He organized the Marschall Dairy Laboratories, Inc. in Madison, Wisconsin in April of 1906 with $5,000 in the bank.

The production of standardized, commercial rennet extract had been introduced only a few years before in Europe. Mr. Marschall was involved with its early manufacture and introduction in the United States. It was also during this time that he patented the world famous Marschall Rennet Test Cup, which is still used widely in the cheese industry throughout the world. Mr. Marschall's plant was opened for business in September of 1906. Sales for part of the month of September amounted to only $5.00 per week. Total sales for the remainder of 1906 amounted to only $641.00.

Business was very slow for the Marschall Dairy Laboratories, Inc. in 1907. Most of this was due to the purchase of raw materials -- imported dry blown calf rennets from Europe at the relatively high price of 6¢ each. He also began to import rennet powder from Europe at this time. It was during this time that he was working on, and discovered, a new method of buying and processing green salted calf rennets for which he paid only 2¢ each.

His process for extracting green salted calf rennets was perfected by the time of World War I when dry blown rennets could no longer be imported from Europe. He was able to supply rennet extract to the cheesemakers in the United States when other rennet manufacturers had run out of the product. It was at this stage that the name Marschall came to the front and was recognized as one of the leading rennet manufacturers in the world. Sheer determination, good business ability, good salesmanship and hard work enabled Mr. Marschall to succeed.

Mr. Marschall considered his location in Madison, Wisconsin to be especially advantageous since the cheese industry in the U.S. was moving to Wisconsin so he was strategically located in the very center of this growing production area. He had the rennet extract to fill orders when others did not. His timing was excellent to get into business. Mr. Marschall was a pioneer in the cheese industry in the U.S. and he was a rugged individualist and perfectionist from modest beginnings which he never forgot. He literally forged the Marschall name that was to be promoted and known around the world throughout the cheese industry. It is the name we now use for the Marschall Division of Miles Laboratories, Inc., dating back to December, 1966 when Miles Laboratories, Inc. acquired the Marschall Dairy Laboratories, Inc.

In the days before standardized, uniform commercial rennet extract was available, a cheese manufacturer added pieces of the calves' stomachs to the milk to coagulate the milk. This was highly unsanitary and did not give a uniform coagulation to the milk for cheesemaking. It added problems to the art of making good quality cheese. By comparison, today's rennet is now defined as a highly purified, standardized extract obtained from the mucous membrane of the fourth stomach (abomasum) of milk-fed ruminants. It contains the milk coagulating enzyme rennin.

(over, please)
During the early years of the Italian cheese industry in the U.S., Mr. Marschall became an important supplier of rennet extract, rennet powder, and rennet pastes. Marschall has been supplying the Italian cheese industry in the United States since 1906. We are today considered to be the leading supplier in the United States specializing in serving the fast growing, progressive Italian cheese industry in America.

Mr. Marschall also developed world wide markets for his cheesemaking supplies. He developed a new and unique method of manufacturing a special high quality rennet powder that was in demand in every cheese producing section of the world. His initial work in the European markets helped to establish the Marschall name as a leader in the cheese industry.

The primary production of rennet extract of known standardized coagulating capacity was established in the large dairy cattle areas in the world such as the United States, France, Denmark, and Poland. For years the calf rennet (veil) was the main source of all raw materials used for coagulants for cheese manufacturing. Changes in meat consumption and in production of different types of meat throughout the world have caused a world shortage of the milk-fed calf rennets in the past 20 years. Cheese production has also increased at a very rapid rate which has created a larger demand for cheese coagulants than the supply of calf rennets allowed.

This increased demand for cheese was followed by a steady decline in calf rennets for production of rennet extract, rennet powder, and rennet pastes needed to coagulate the milk in cheese making. Available supplies of calf rennets have decreased from a high of thirteen million in 1960 to a low of three million in 1973, in the United States.

In 1960 it was estimated that 300,000 U.S. gallons of commercially standardized rennet extract was used in the United States. World usage was estimated at 1,500,000 U.S. gallons. Today we estimate the USA market needs are 700,000 U.S. gallons of milk coagulants and the world market approximately 3,500,000 U.S. gallons. Therefore, based on these figures and available calves for slaughter, there is only enough calf rennet produced to take care of approximately 25% of the cheese produced in the world today.

In order to extend the supply of rennet extract in the early 1960's Marschall scientists developed a mixture of rennet and porcine pepsin blended in a 50-50 ratio. This product performed very well at that time because of new technological advances in the production of porcine pepsin allowing for the standardization of a high quality, dependable product. Also milk quality in the early 1960's was such that porcine pepsin performed well due to higher acidity in the milk and less "aged" milk than is used for cheesemaking in the U.S. today. Recently blends of rennet and pepsin have not always performed as well in some plants as when first introduced because of two primary factors. These are the changes in the milk supplies and the changes in the rennet extract portion, which now contains larger amounts of bovine pepsin.

The production of Porcine pepsin has today resulted in another problem besides the use factor. As with rennet, the available supply of hog stomachs has diminished for pepsin manufacturing because of increased use by the United
States and other countries who find these stomachs very useful in the production of specialized meat products.

In addition many porcine pepsin manufacturers have discontinued the business. There are now only four manufacturers left in the United States. Other countries in the world are also experiencing similar supply problems.

Therefore, although porcine pepsin and pure rennet extract are still available, they continue to experience a problem with short supply. Regardless of the price one may be willing to pay in the future, it is possible porcine pepsin and pure calf rennet extract may not be available due to the limited supply factor.

To meet the increased demand for coagulants two sources will become increasingly more important. One will be the use of bovine pepsin extract which is the extract from the fourth stomach of older bovine animals. As the age of the bovine animal increases, the enzyme composition of the stomach changes from one of mostly rennin to an enzyme called bovine pepsin. Generally the extract from a young, milk-fed calf will, or rennet, will consist of 90% or more of rennin and 10% or less bovine pepsin. The mature bovine animal extract such as from cows or beef animals will consist of approximately 30% rennin and 70% bovine pepsin.

A disagreement also exists among researchers and academic people as to whether the extracted enzyme from adult bovine stomachs should be classified as pepsin or rennet. We will have to await further information from the experts to come up with a true definition of this and other coagulants.

Of course the true value of bovine pepsin does not lie so much in a discussion of its make-up but in how the product performs in cheese manufacture, and the availability and price as compared to other available coagulants.

Even though bovine pepsin works satisfactorily as a coagulant for some cheeses such as Cheddar, it has not always performed well in the "sweeter" cheeses such as Swiss, Emmentaler, and some Italian types. Therefore, it may be necessary that pure calf rennet be recommended for these types until better substitutes can be found.

A solution to the shortage of animal coagulants to coagulate milk for cheesemaking may be found in microbial enzyme preparations. Microbial coagulants can be produced in large quantities because the only limiting factor is that of providing fermentation equipment and the fermentation media.

Work was done with fungal fermentation, with the goal of all researchers to find a product that worked like calf rennet, in the manufacturing and curing of all cheeses. In addition, it should be manufactured at a cost that the selling price would be lower, or at least competitive with calf rennet extract and/or calf rennet-porcine pepsin blends.

The purchase of Marschall Dairy Laboratories in 1966 by Miles Laboratories, a world wide company founded in 1884, has enabled the Marschall Division to greatly expand its operations.

(over, please)
Miles manufactures thousands of products in 18 countries and has marketing offices established in nearly all major countries of the world. Miles Laboratories acquired the Takamine Enzyme Co. in 1956 and became heir to a tradition of innovation in commercial enzymology. That tradition is the basis for the finest line of enzyme products produced by fermentation, extracted from plants and isolated from animal sources. Dr. Takamine may be remembered for his discovery in 1901 of the secret of producing Adrenalin, a drug that is important for its ability to stimulate heart action and reduce bleeding during surgery.

Miles expertise in deep tank fermentation was applied to the development of a microbial coagulant manufactured from Mucor miehei which was introduced to the U.S. trade in 1972. This product, called MarzymeR, has been thoroughly investigated by most of the large Cheddar and Italian Cheese manufacturers and buyers in the U.S.A. for coagulating properties, yields, flavor, and body and texture properties. Today sales of this microbial coagulant account for approximately 50% for all our coagulants used in the United States.

The results of cheese gradings have shown that cheeses produced with MarzymeR have basically the same characteristics as cheeses produced with calf rennet. Most manufacturing processes and ripening processes need not be changed to compensate for any undesirable side effects.

There are many variables and conditions of manufacture which of course cannot be duplicated in our work. Therefore, in the U.S., Marzyme is suggested as a replacement for calf rennet for "current" or "short-hold" cheese including Mozzarella, Pizza cheese and Provolone types up to six months of age. MarzymeR is also being used in some aged cheeses such as Cheddar, U.S. Parmesan, giant Provolone and Vacino Romano. However, each plant must proceed on its own individual cheese trials before converting entirely to microbial coagulants.

It should also be noted that microbial coagulants generally contain proteases that are more heat tolerant than rennin. This could create coagulation problems in whey processing and whey powder used in other food products where casein is present.

The Marschall Division offers to the Italian Cheese trade today standardized liquid animal and microbial coagulants, rennet powder, calcium chloride and the technology for their use that is necessary for producing high quality cheese at reasonable cost.

Perhaps the two cheese varieties that lend themselves to more distinctive flavor characteristics than any cheese produced today are Provolone and Romano types. By varying the rennet pastes and lipase preparations, manufacturing procedures, cultures, making and salting methods, these cheeses can be controlled to meet increasing consumer demands.

With this growth and increased demand for these type cheeses has also come an increased interest by technical people both in industry and academic fields to investigate the reason for the unique flavor associated with Provolone and Romano. In the past 20 years, much work has been done which has
been very revealing as to the reason for the specific flavor and how they can be controlled.

In the traditional method of manufacturing Provolone and Romano cheeses, different varieties of rennet pastes have been used. For generations cheese makers in Italy have used their rennet paste preparations primarily for curdling the milk. Goat rennet paste was most commonly used for the manufacture of Romano, and a mixture of calf and goat rennet paste for Provolone.

Up until World War II most of the rennet pastes used in the USA were imported from Italy. However, when it was impossible to obtain these pastes during the war years, many of the USA rennet manufacturers tried to duplicate the Italian product but due to Federal and State regulations, were not allowed to manufacture a rennet paste from ground up stomachs and contents.

The rennet pastes we did make, did not give the piccante flavors desired. Many of you are familiar with these rennet pastes which were prepared by allowing a suckling milk-fed animal to fill its stomach with milk. Immediately after slaughtering the animal and removing the stomach with its contents, it was salted and tied off to keep the contents intact. It was then air-dried. After drying, the complete stomach and contents were ground up as a paste and salt was added. Many times other ingredients such as citric acid and pepper were added. The main difference, therefore, between a stomach used only for rennet extract preparation and one for rennet paste manufacture was in the curd and enzymes allowed to remain in the stomach, which ended up in the rennet paste product.

As one can see, the only criterion to the effectiveness of the paste was in the visual observation as far as curdling of the milk was concerned and the odor of the paste. Generally rennet pastes were not standardized for uniform production of flavor and many times varied in coagulation strengths. This problem has also been recognized by Italian scientists such as Professor Vittorio Bottazzi who in 1965 published an article "Produzione Di Formaggi Con Impiego Di Lipasi" or Lipase used in the Manufacture of Italian Cheese. Professor Bottazzi states that "the Cheese Industry is more and more feeling the need of producing cheese with physical and organoleptic characteristics that are well-defined, uniform, and that satisfy the consumers need."

The Italian Cheese Industry in the USA also encountered problems with the importation of rennet pastes from Italy when State and Federal Health authorities began examining cheese for the presence of foreign materials such as hair, straw, dirt and ground up animal stomach parts. Much of these same materials were found in the rennet pastes and it was quite obvious that the foreign material originated from the macerated stomach and contents rather than the stomach tissue itself.

United States Italian cheesemakers, therefore, turned to using a variety of standardized, edible lipase enzyme preparations once their success was confirmed that they very nearly duplicated the flavor when Italian cheese was made with imported rennet pastes. It was found that the basic piccante flavor development depended upon a fat splitting lipase enzyme system.
These lipase enzyme preparations were edible and fully approved by the United States Department of Agriculture and the Food and Drug Administration. They could be standardized to assure uniformity of flavor throughout the year.

The U.S. Italian Cheese Industry obviously needed a solution to the rennet paste problem. Various substitutes were tried with limited success such as lipase enzymes from pancreatic, bacterial, or fungal sources. However, in 1946, Wise, Miller and Anderson of the North Carolina State University published their now well-known literature on "The Changes Observed in Milk Sham-Fed to Dairy Calves."

Later work by other scientists established that oral lipases and pregastrics esterases are secreted in the area from the base of the tongue to the opening of the esophagus. These secretions have been found in the human, lamb, calf, kid-goat, and other mammals that have been investigated to date. I will not go into the many sources of information that have been gathered about these lipase enzymes but they have been investigated very extensively. Rather I will discuss briefly how we have related them to the Italian Cheese Industry in the United States.

These enzymes are processed primarily in a standardized powdered form. They are not pure crystalline products but rather exist in combination with inert material which serve as diluents. Although these products could be purified it would serve no particular advantage to the Italian Cheese Industry. One thing that does exist is the purity of the material to enzyme activity as these preparations contain only lipase activity and act only on the fats present in the milk and cheese.

Unlike the old fashioned rennet pastes, we have found that these lipase enzyme preparations can be standardized to specific lipase activities that will give uniform activity and precise flavor profiles in the cheese, that can be duplicated every time. It is now possible to add a known amount of the standardized lipase preparation to the cheese vat and be quite certain that a specific amount and type of flavor can be developed in a given period of time, when using identical curing and manufacturing procedures.

We know today that the piccante flavor development in Italian cheese is primarily due to the splitting of the butterfat by the lipase enzyme used. The lipase enzymes split the butterfat and give off flavorful fatty acids and glycerides. With our present knowledge of the free fatty acid patterns of cheese and of the enzyme flavor desired, it is only necessary to fit the flavor desired to the flavor the lipase enzyme preparation will produce. We have accomplished this using various lipase enzymes and rennet paste preparations.

Time does not allow us to go into a further discussion of this subject. However, if further information is desired I suggest you review the subject as covered in my paper "Flavor Development and Control in Provolone and Romano Cheese" given at the first annual Marschall Invitational Italian Cheese Seminar held at Madison, Wisconsin in 1964. It is printed in English.
If you would like a copy, ask one of our associates in Miles Italiana.

Today we offer to the Italian cheese industry a complete line of lipase enzyme preparations. Included are Lipase Powder No. 300 from a 100% natural kid-goat source, for the highest and sharpest "Piccante" flavor; Lipase Powder No. 400, a standardized blend of lipase enzymes from natural kid-goat and milk-fed lamb sources, which gives a desirable, rounded flavor development in vacino romano and gigante provolone, reminiscent of traditional pecorino flavor development. Lipase Powder No. 400 is also used for full flavor development in Feta cheese.

Lipase Powder No. 600 from natural veal source gives a mild piccante flavor. It can be used alone, or in combination with other lipase enzyme preparation. This powder can also be used for rapid flavor development in blue type cheese, Fontina, Asiago, and for natural rapid flavor development in other processed cheese products.

Lipase Powder No. 500, from 100% milk-fed lamb source, is used for blending with other lipase powders and for special flavor development.

For those who prefer the use of edible rennet pastes we offer to the general trade two products - Rennet Paste #12 and Rennet Paste #32. Number 12 rennet paste is an economical product, giving a mild flavor in both Romano and Provolone cheese. It contains a standardized blend of kid-goat and milk-fed lamb lipase enzymes. Number 32 rennet paste is our strongest, most popular kid rennet paste. The product is recommended when a strong, sharp, high kid "Piccante" flavor is desired.

Marschall rennet pastes not only contain lipase enzymes and other flavor producing properties but are also standardized to provide uniform coagulation properties. Some custom-tailored rennet pastes are made to exact specifications of the buyer, upon request. Lipase enzymes can be mixed with Italian rennet pastes to step up flavor producing properties.

The study and development of these lipase enzyme preparations for use in standardizing and developing Provolone and Romano cheese flavors has been very successful. However, the overall broad, complete flavor of the imported cheeses from Italy have not been entirely duplicated. We know this flavor is related to the use of proper cultures that must provide the proteolytic enzymes needed in the curing and flavor development of the cheese. A successful starter program therefore also provides an essential key to the overall flavor profile.

The study of the enzyme system involved is continuing. It is quite possible that in the near future other enzymes will be developed that are natural to the cheese process which can be standardized and used in conjunction with these lipase preparations to provide the complete flavor desired. In addition, they will aid in hastening the curing of typical aged, soft and hard type cheeses. These investigations are under study at this time.

A cheese manufacturing plant today is a large, well managed business venture, employing the skills of professional people - probably computerized and

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using every management skill known to industry today. A modern cheese plant must be considered an industrial fermentation and processing plant in the same manner and concepts as any other commercial fermentation process.

Basic to the whole cheese manufacturing fermentation process is the use of the right culture and the correct environment so that culture will grow in the cheese milk to give you the results desired. It is generally conceded that cultures and starters are the "heart" of cheesemaking and play a very important part in the success or failure of the cheesemaking process.

Failures in the culture and starter program can result in large operational losses that cannot be tolerated if the plant is to be successful.

The selection of the cultures to be used in the production of Italian type cheeses is very important. Unlike the early days of using seed culture when one general purpose culture was used, today the cheese manufacturers must select specially developed cultures to fit his specific needs.

Assuming one has chosen the best culture for the type of cheese produced, it is essential that it grows properly. Unfortunately, unlike many chemical reactions that proceed on an orderly basis, cultures are living cells which can be greatly influenced by the environment in which they are grown and used. There have been many factors reported that affect culture growth. However, if the correct, healthy culture is selected, the cheese milk is of normal composition, and the proper temperature and controls are used, then the two primary problems affecting growth are bacteriophage infections and inhibiting substances in the milk. The problem of inhibiting substances can be readily controlled if the cheese manufacturer follows recommended procedures by dairy technologists, university and government officials. However, the control of bacteriophage is not so easy to master. The presence of bacteriophage in cheese plant as a cause of starter failures has been well documented in the literature.

The following 10 slides were prepared by Dr. George Reinbold, formerly of Iowa State University, Ames, Iowa, using the electron microscope. They show actual bacteriophage from whey samples, obtained from Italian and Swiss cheese plants in the U.S.

1. S. thermophilus phage - empty head.
2. S. thermophilus phage - full head.
3. S. thermophilus phage - long tails.
4. S. thermophilus phage - long and interlacing tails.
5. L. Helveticus phage - notice tail sheath.
6. L. Helveticus phage - one partial to show the details.
7. L. Lactic phage - slender and no tail sheath.
8. L. Bulgaricus phage - notice the tail sheath.

10. L. Bulgaricus phage - this is a different phage; notice this phage does not have the tail sheath.

Our work in the study of improving cultures for cheese manufacturing was concentrated in two areas: the development of a method to prevent bacteriophage from infecting the seed culture and to improve the seed culture being used. Our initial effort was directed to the control of bacteriophage at the cheese plant level.

Through these efforts a phage resistant starter medium, MARSTAR was developed. It is still used widely today for bulk starters by Cheddar cheese manufacturers. Some of the initial academic work establishing the value of this product was done by the Oregon State University staff, Corvallis, Oregon, under Professor P. R. Elliker and W. E. Sandine. This work was published in 1965.

The success of this product has been clearly demonstrated but not without a great deal of work by our technical staff in teaching Cheddar cheese manufacturers about the care necessary for standardizing the solids level and the ripening technique involved. Further, cultures grown in this medium are exceedingly active in acid production, providing they are used according to directions. Therefore, one must be careful not to over or under ripen the culture. Since the development of the original MARSTAR product, we have developed other media which I will briefly discuss:

1. One-2-One: This product is designed for those cheddar cheese manufacturers who prefer to use their own non-fat dry milk or liquid skim-milk. A blend of solids with a ratio of one part One-2-One solids with one part milk solids is required to give bacteriophage protection at a 11.5 to 12.0% solids level. It is important to emphasize that the cheese manufacturer must set up test procedures to verify that his own milk solids are suitable for culture growth.

Some savings and advantages can be realized by some plants when the plants' own milk, skim milk, or NFDM are used. These savings are the normal costs of transportation, packaging, and drying of the liquid to a dried powder form. However, large batches of non-fat dry milk can be pretested and used for many days of starter manufacturing whereas liquid milk or liquid skim milk run the risk of daily variations which might cause problems.

2. Thermostar: In recent years much work had been done by the Marschall Division, Miles Laboratories, Inc., in studying the problems concerning the growth of the Lactobacillus bulgaricus and Streptococcus thermophilum cultures for Italian and Swiss cheesemaking. It has now been clearly demonstrated that bacteriophages are present in cheese plants manufacturing Italian and Swiss cheese in the United States. Starter failures have become serious problems in this field just as with Cheddar cheese manufacturing plants.

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We have been working for several years to develop a medium that would overcome this problem for coccus and rod cultures. However, the problem was extremely difficult because of the growth requirements for these two very different type organisms. Recently we discovered how to overcome growth problems and still have bacteriophage control. Thermo-star™ has proven to be very effective in providing the Italian Cheese manufacturers with a medium that prevents bacteriophage proliferation and allows for uniform reliable growth of both the coccus and rod organisms throughout the Italian cheese manufacturing process.

3. 412-A: This is a very specialized starter medium developed specifically as a phage resistant medium for the Streptococcus thermophilus culture only. It is used primarily in the production of Swiss and Emmenthaler type cheeses or for those Italian cheese operations that wish to prepare and add their coccus and rod cultures separately.

Our involvement in the culture business for cheese manufacturers was further increased when it was found that phage resistant media only solved one part of the problem.

Professors E. M. Foster, Marvin Speck and George Reinbold have pointed out that not only was the selection and preparation of the culture important, but that preservation for future use was equally important. Regardless of the method of preparation, whether in liquid or dried form, the culture was susceptible to loss of activity on storage using normal refrigerated and -10°C freezer storage.

Work with cheese plants by our technical service staff also confirmed that it was very difficult for inexperienced factory cheese personnel to successfully transfer and maintain cultures seed stocks uniformly on a day-to-day basis. A need existed to eliminate culture transfers at the cheese plants where all kinds of micro-organisms and bacteriophage are present in high levels.

Our research staff, using some of the techniques applied to our other industrial fermentations, developed highly concentrated, liquid nitrogen frozen, bulk set cultures that eliminated the need for seed culture transfers at the cheese plant level. The cheese manufacturer now could seed the larger bulk starter substrate directly and, after it was properly ripened, use it in the cheese vats. A new bulk set culture strain was used daily so that a good rotation program could be prescribed and followed. Therefore, two propagations at the cheese plant were eliminated along with less chance for contamination in handling. This enabled the starter manufacturer to produce several more varieties and strains to give the cheese manufacturer a wider selection to meet increasing consumer demand for the standard varieties as well as to manufacture new and different cheeses using different starters.

Since the introduction of highly concentrated, liquid nitrogen frozen, bulk-set cultures, these culture types have increased to where they now constitute the bulk of all cultures used for cheese manufacture in the United States and Canada. The system is in the process of rapid expansion in Europe and Australia.
An indication of the growth in this field of liquid nitrogen frozen cultures is shown by the great number of culture types available. Starting with the initial introduction in 1964 of our ten lactic strains available in the 300 gallon bulk set size we now offer to the trade:

1. 1cc vials
2. 100, 300 and 500 gallon bulk set cultures - These contain no leuconostoc cultures.
3. 300, 500 and 1,500 gallon direct set cultures - These contain leuconostoc cultures.
4. Special coccius and rod 150 gallon bulk set cultures.

Approximately 250 strains of cultures are maintained in 1cc vials and 125 can-strain type combinations are available for use in production of most cheeses. These include the following:

1. Lactic cultures for cheddar type cheeses and associative types.
2. S. thermophilus and L. bulgaricus cultures for Swiss and Italian type cheeses. These are available individually or in mixed combinations established at a 1-to-1 ratio.
3. Special lactic cultures for soft cheese such as camembert and brie.
4. Special lactic cultures for open type cheeses such as blue cheese and colby.
5. Special lactic cultures for flavor production including such cultures as Lactobacillus casei and Lactobacillus lactis.
6. Direct set cultures containing leuconostoc for production of butter-milk, cultured cream, cream cheese, and related types.
7. Special leuconostic and diacetilactis types for culture flavor production.
8. Yogurt Cultures.

Special culture producing plants have been designed and built for the sole purpose of producing these cultures, using the modern scientific technology of industrial fermentation previously discussed.

We must also look ahead to investigating the aspects of cultures, besides acid producing characteristics. Cultures, as well as the natural flora in milk, can release enzymes that affect the cheese ripening process and have an effect on cheese flavor. This is important for all types of cheese, especially for Italian type cheese where coccius and rod cultures are so important in flavor production.

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Studies of various lactic organisms and their enzyme systems are being undertaken to determine this relationship to cheese production and flavor. These studies show that not only can organisms be chosen for their ability to produce acidity, but also for their ability to aid ripening and development of appropriate cheese flavor for many different cheese varieties. These investigations are under study at this time.

An important product manufactured by our company for over 65 years has been pure, vegetable Annatto Cheese Color in both single and double strength. We also manufacture a complete line of vegetable Annatto Colors for the food industry other than cheese colors. We also manufacture special water, oil, and water and oil soluble Annatto Colors used to color Process cheese products. However, since cheese color is rarely used in the manufacture of Italian cheese, we will not discuss these products in this paper.

In concluding our presentation, we would like to suggest that if anyone from Italy attending this meeting today is interested in any of our Marschall products, or in learning more about the Marschall Division of Miles Laboratories, Inc., you contact Dr. Villa, Dr. Sabato or Dr. Rossi, our associates in Miles Italiana, S.p.A., who have done such an excellent job in helping us organize this meeting. We are sure they will be glad to discuss your questions and problems and if there is any way we can cooperate, we will be pleased to do so.

It has been a pleasure for me to speak to you today about the Marschall involvement in the Italian cheese industry. We hope that we can be a continuing factor in discussing and aiding in the production and marketing of these delightful Italian cheese products.

Thank you for your kind attention.

REFERENCES


The following paper was presented by Dr. C. Ghitti, Technical Director, Invernizzi, S.p.A., 20066 Melzo, Italy, especially for the 14th Annual Marschall Invitational Italian Cheese Seminar - "A Field Trip to Italy" held at the Congress Centre, Hotel Michelangelo, Via Scarlatti, 33, 20124 Milan, Italy, on May 16, 1977.

HOW CHEESE PRODUCTION HAS EVOLVED IN RELATION TO THE MARKET DEMAND

by Dr. C. Ghitti

To introduce the subject of this report, Italy can be said to produce a limited number of cheeses, but it must not be forgotten that it is one of the very few countries that produces clearly differentiated kinds of cheese, each being characterized by its own body, structure, composition, caloric value and taste.

As it is known, they are important products in our diet, thanks to their digestibility and their high nutritious value. Cheese was already known in ancient times, and history and legends have dealt with that. Everything started when man began farming the land; in fact, he grew also forage, thus he could breed livestock and obtain milk and meat.

Let’s consider milk: it was the direct aliment of each family and, its production rising, there have been more and more problems about its utilization. In fact, when man did not need any more milk, he used to put aside the left milk, which formed a natural gelatinous, slightly sour clot. By delicately breaking the clot and separating it from whey, you could obtain curd, which could be stored, if drained and dried carefully, for a longer time than milk: it was the first step in milk processing.

Another kind of cheese could be simply obtained with clot taken from the stomach of killed suckling animals: you had only to smoke clot and to wrap it up in aromatic leaves.

Cheese is often dealt with in history and literature books: the Etruscans considered it a very important aliment and the Latins called it "Caseum", that is, cheese.

In milk processing to obtain cheese, the first products were soft kinds, because they could be easily made at home.

But the amount of left milk continued to increase and a new problem could be coped with: how to produce cheeses that could be stored for a longer time than soft ones. So the first hard cheeses were produced. A distinction between hard and soft cheeses was not made in ancient times. Only in 1200, a famous hard cheese, grana, was mentioned for the first time and it began to be distinguished from another soft cheese: quartirolo because among the enjoyment terms of leases for land, there was often the payment in kind with "quartironem caseo et unum formagi".

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These historical references explain why "formaggio" generally meaning cheese, means only grana commercially speaking, while soft cheeses are called "stracchini" in several production areas near Novara.

The evolution of society, costumes and manners, together with new requests from consumers of the different kinds of cheese has sometimes led to change the original, structural and organoleptic features of these products, thus favouring the production of other kinds, more or less differentiated from the old kinds.

The technological pattern has been improved by great technological changes, such as milk pasteurization as for soft cheeses, the use of improved cultures of milk enzymes and of whey inoculations, the control of acidification curves, the processing of large amounts of milk, stored and made more homogeneous, particular thermical and hygrometric conditions created in production places. So the goal of an extreme standardization of kinds has been reached, qualities have been improved, rejects have been decreased and ripening times have been shortened.

As for cheese consumption, since the end of the Second World War, there has been a slow but progressive evolution in the demand for products with organoleptic and structural characteristics and shades of colour that are very different from those preferred in the past. That means that the public demands cheeses with flat taste and softer body, which are preferred to be whiter. The most typical example is quartirolo, one of the oldest soft cheeses, that, during the centuries, has shown a lot of changes connected both with production areas and its own features. Nowadays old quartirolo is almost impossible to be found and, considering both the production importance and the market demand, it has been replaced by taleggio, with its own different features.

Furthermore, in the past decades, one could notice the trend to demand this cheese, but with organoleptic features of sweeter taste, structurally soft and pasty: this cheese is called cooked-pasta, taleggio in the common, improper jargon.

Let us consider these differences more in detail: in ancient times quartirolo was produced with raw, just milked milk in excess. The milk was processed in wooden tubs, which made up for reduced fermentative acidity, at least partially because wood was impregnated with lactic acid and, even if at a lower degree, with the natural flora of previous processings. Then, when hygienic conditions were improved, wooden containers were replaced by metal ones.

Under such circumstances, it was thought to make up for the lack of fermentative acidity of wooden containers by making the evening milk settle and then mixing it up with the fresh morning milk. To favour lactic fermentation, it settled in cool rooms with an 18 - 20 °C temperature, but these conditions could be obtained only in summer and between seasons. It is a cheese with a thin, almost as soft as velvet surface, which is pinkish coloured with grey-blueish spots. If it is ripened in caves, it smells as a truffle, a characteristic that is much appreciated and that can be only rarely obtained, as it has been proved with attempts made in cheese dairies with artificially cooling plants.
The stuff appears slightly proteolyzed, melting in the part just under the surface and with finely granulous structure towards the core of the cheese. Very small, widespread holes can be noticed and its flavour is slightly aromatic and sweet in the part just under the crust, and slightly acidulous in the core.

Raw taleggio is the second generation cheese, that has replaced old quartirolo, being prepared with fresh milk after every milking. Classic taleggio made with raw milk is produced using cultures of milk enzymes, consisting of batches of lactobacillus and streptococcus thermophilus living in symbiosis. The first attempts in this field were made by Prof. Renko and later put into effect by the "Centro Sperimentale del Latte" (Milk Research Institute) in Milan, to produce enzymes for the Italian and foreign dairy industries on an industrial level. Undoubtedly, the introduction of such cultures is an important step towards technological progress in Italian dairy industry as for the taleggio production.

The differentiation of this kind of cheese from old quartirolo is marked both by its outer aspect, because the part just under the rind is more melting, sweet and creamy than in old quartirolo, while the core is slightly harder, more crumbly and more acidulous.

There are no small holes, but they can be found in the raw kind, in which they are irregularly spread.

As for the so-called cooked taleggio, which is the third generation of this series, its technological trend is of the rennet type, much more marked compared with the others, because it is more similar to Italico. It is made of pasteurized milk and with the same cultures of lactic enzymes, using them at a reduced acidity value. From a technological point of view, it is different also because of the higher curdling temperature and the greater amount of used rennet, so sweeter and calcium richer stuffs are obtained. Also, the breaking of curd is more considerable and frequent settlings during processing improve syneresis. The rind is subtler, soft, reddish with light greyish spots. Inside, its structure is compact, elastic, pasty, light straw coloured and without small holes. The taste may make one think of a "cooked type" and it has not the aromatic, acidulous characteristics of classic taleggio. In short, it is the new kind with a flat taste, a more standardized kind, which is increasing the group of consumers continuously.

Another soft cheese, "La crescenza" is getting more and more important and its expansion can be increased. At the beginning, it was produced with raw milk in Valsassina and then in areas near Lodi, during a very limited period (November - February). Its name probably comes from the fact that it ripened in a short time (5 - 7 days) and it became as soft as the buns the Milanese people liked a lot in old times, and that were called "Carsenza". It was a much softer kind of cheese than the present kind and it was so soft that it was necessary to eat it with a spoon.

Just milked, still warm milk was curdled in wooden or metal lined tubs, sometimes adding some saffron in order to have a light straw colour, typical of fat milk. The means were very simple; in fact, moulds were made of wood,
and straw layer was laid on draining tables. Dry salting was used and it took about 48 hours. Its marked softness was due to the particular technique with natural fermentation, without the use of starters, because, in this way, the curd drainings were much limited. In fact, stuff contained a lot of whey, so, when casein began to be slightly solubilized, its texture loosened and the cheese, rich in humidity and fat, became a sweet, semi-liquid paste.

Nowadays everything has changed. It is produced throughout the year, and its body is requested to be thicker to meet storing needs and demands from zones that are very far from production areas, and to make easier dividing it into portions and mechanical packing. Used milk is to be pasteurized to prevent pathogenic microbes from being present: in fact they could be in the cheese, owing to its very short ripening cycle, and to favour fermentation, since the use of natural cultures (the so-called inoculations) and appropriate improved cultures of thermophile lactic ferments.

Artificially obtained cool conditions have permitted us to carry it even to very far away places, and have made longer its shelf-life, thus letting the consumer have a fresher product, because nowadays refrigerators are available for everyone. This cheese is getting more and more important, thanks to all these facts together with a massive advertising, the increasing demand for sweet, soft cheese, and its being suitable for poor-in-fat diets.

It is necessary to say something about the evolution of the so-called "robiolini" or "caprini", which can be eaten fresh or can be ripened, and which are clearly different from other kinds owing to their almost completely sour flavour.

Generally speaking, they are still produced on an artisan level, according to a technique that is linked to technological tradition, but in factories their production has changed so deeply that they have become similar to French "pâte fraiche" cheeses, such as Petit Suisse, Demisel, Gervias, and so on.

They are produced according to a traditional technique in the Lombard Pre-Alps and in particular in Valsassina and in Brianza, where Lecco and Montevecchia cream cheeses are very well known. They are cylindrically shaped and 40 - 60 gr. heavy; when they are fresh, they have granulous, quite sour taste, while, when they are ripened in caves, they become grey-reddish and rather spicy. Cow milk was used, but also a mixture of cow and goat milks was possible; it was made acid by adding naturally sour whey and by using very little amounts of rennet.

Industrial production has completely become mechanized: pasteurized milk is used and it has made sour and curdle in large stainless steel tanks, using special starters composed of mixtures of mesophylic acidifying and flavouring strains.

Nowadays, the average consumer wants a particularly sweet, soft, pasty body with a fine, homogeneous structure and he likes thermowelded plastic containers which can be obtained with particular measuring-out and packing machines.
Also, the change of gorgonzola, another soft cheese, is particularly interesting and odd, not only as for its origin, but also as for its great technological evolution, which has deeply changed its characteristics. In the origin area, it was called "stracchino erborigato" owing to green veins in its stuff; in fact, these veins reminded of "erborig", the dialect Lombard word meaning parsley; it could and can still be considered the soft cheese best known and loved abroad.

Its true name is "Gorgonzola", which comes from the homonymous village in the surroundings of Milan. In ancient times, about in the twelfth century, this great village was crossed by several herds that Pre-Alps mountaineers led to spend winter on the plain, where the cattle could graze. According to history, this is the origin place of gorgonzola, produced by mixing curds, the evening cold one with the morning warm one; hence the name "two stuff gorgonzola", which was characterized by a loose structure and which could let green moulds or penicillium form.

The natural insemination of these moulds was due to production rooms, which are more or less polluted with these hyphomycetes, and these rooms were to be like that, otherwise the cheese could not show green veins in its stuff. Ripening took place in Valsassina, using caves or dairy farms widespread here and there on the mountains. They were made of stratified dolomitic limestone and were characterized by cold downward draughts, so there was always a temperature very fit for the cheese ripening. Drained and salted cheeses were carried from several Lombard zones such as the areas near Novara and Vercelli, in wagons pulled by oxen or horses, and, when it was possible, by railway as far as Lecco.

After two months, holes were made in cheeses with big copper pins to favour the development of moulds, and then they were left for another two or three months to ripen, until the rind became red and began cracking. At that time the cheese tasted very spicy and slightly bitter, and it smelled as ammonia (this smell was particularly noticeable in the most ripened cheeses).

Most of the product was exported to a lot of countries, but above all into France, Great Britain and North America.

To prevent the rind from losing shape or from breaking, it was plastered with barium sulphate, a lot of pits which can be still found in Valsassina. The mineral was ground and the powder diluted in melted pig fat, and was used to prepare a homogeneous and sticky paste that was spread all over the surface of each cheese. To favour the natural colour of the rind, cheeses were painted with melted fat mixed with a red dye and, at last, they were dusted with barium sulphate powder. Generally the amount of used substance ranged from 800 gr. to 1 Kilo, but somebody spread even two kilos to speculate, not observing customary tare limits.

At the beginning of this century, France, where there was a difficult situation for Roquefort production, vetoed Gorgonzola imports, saying that barium sulphate damaged health. This affected also the other importing countries, thus worsening the crisis of the demand for this cheese. It must be admitted frankly that, even if barium sulphate did not damage health because it was not eaten, it sometimes hid serious rind defects and, when out of customary tare limits, it was a real example of speculation.
(then a lot of Valsassina dwellers were said to have become rich, thanks to barium sulphate). However, in the first years immediately after the Second World War, Gorgonzola was out of date as for not only production technique, but also changed demands. In fact, abroad, similar green-veined kinds were produced at more competitive prices, even if their quality was lower than that of our kinds; moreover, new consumers wanted a softer, less spicy and green-veined cheese: so, producers were compelled to meet these new needs and to create a new kind of Gorgonzola.

Prof. Renko and the "Centro Sperimentale del Latte" (Milk Research Institute) in Milan introduced a new technique based on cultures of lactic ferments, such as lactobacillus bulgaricus and streptococcus thermophilus, and improved cultures of penicillium. Here are some advantages:

a) Softer, creamier and less spicy stuff.
b) More regular but slightly green veins.
c) Further standardization.
d) Accelerated ripening (50-60 days), thus avoiding a long capital locking.
e) Decreased rejects.
f) More earnings, since the new technique permits avoiding a complete draining, thus decreasing the risk.

Let us consider its effects as for the market demand; there is still a limited number of gourmets regretting old gorgonzola, exports have decreased, but the home consumption has been decoupled since 1938, thus making up for reduced exports.

Researches about penicillium roquefortii of the Weidemannii fuscum type have been made at the "Centro Sperimentale del Latte" (Milk Research Institute), thanks to Mr. & Mrs. Salvatori: these studies have not been limited to a mere botanic classification and evolution, but, above all, they have been about biochemical activity shown by several batches on protein and lipidic compounds of cheese. While in the past, green veins were due to fate and could not be controlled by man, thus obtaining different cheeses in the same lot, the new technique permits us to determine the features of the product through the control of proteolytic and lipolytic activity of each used batch.

Very precise ways of control, such as chromatography, the gauging of the Warburg coefficient and the determination of proteolytic and lipolytic features have made possible selecting several kinds of penicillium with different but steady characteristics. The new technique implies not only the use of cultures of lactic ferments and penicillium, but also, it must be supervised by specialized technicians who can exploit new devices as well as possible.

Also, pasteurization (nowadays most of cheese milk is pasteurized) has played an important role in improving the technological pattern, by standardizing cheese more and by giving more guarantees about healthiness of the product.

We must remember also, cheese with hard spinned body such as provolone and similar kinds, with softer body, such as so-called silani, silanetti, cacetti,
etc., and with soft texture such as mozzarella (this last kind can be stored for a very, very little time). These cheeses began to be produced in Southern Italy in an artisan way, and in relatively recent times, its production spread also into Northern Italy.

Their consumption has soared and, as for provolone and similar cheeses, also exports have increased, especially into North America, Australis, France, Switzerland, Germany, Belgium and the United Kingdom.

There have been important technological and mechanization improvements in Northern dairy plants. In particular, the introduction of the technique of the whey inoculation has made possible processing fresh milk or milk that has been stored and cooled in one cycle. Old wooden containers are out of date and they have been replaced by polyvalent automatic tanks with devices to break and to shake curd. Work has been organized according to fixed shifts and times, so it has been necessary to keep the whey from ripening the curd, which was typical in origin areas, but which did not permit controlling spinning. As for the other kinds of soft pasta filata, their production has been increased by the new demand from the public, which wants less spicy, soft and rapidly ripening cheeses of the same kind.

They have a small or an average size and they may be paraffined; they are packed with plastic film or vacuum-packed to make easy their preservation. Compared with the classic technique to produce provolone, technological changes are less fermentation, the breaking of the bigger curd and its warming at lower temperatures (45 - 46°C); this processing can be more easily mechanized than the one of harder spinned stuffs.

The other kinds of pasta filata similar to Mozzarella are produced in Southern Italy with cow buffalo milk or with a mixture of buffalo and cow milks. At present, they are made of cow milk more and more also in Southern Italy, especially where improved agricultural conditions have led to replacing buffalo's with cow's milk. Nowadays, they are produced also in Northern Italy because of the immigration of labour from the South, and because typical Southern products such as pizza (which need fresh pasta filata to be done) have met Northern consumers' favour too.

Technological changes can be noticed in milk pasteurization, the use of special starters, curdling with microbial rennet and acid solution, and the chance of a completely mechanized technique. They are packed in thermowelded plastic bags together with special liquids, so that they can be kept fresh, which is an indispensable feature of this cheese, and undoubtedly this assures better hygienic conditions.

At last, let us consider something about the origin and evolution of one of the most important Italian cheeses, grana.

Its name comes from its characteristics granulous body, which breaks in chips being cut, and which shows very, very small widespread holes. There is unprecise and contradictory news about its origin. Carlo Cattaneo writes in his book "Il caseificio e la fabbricazione del formaggio" (Dairy and Cheese Production) that for the first time, grana was produced in the surroundings of Codogno, in Lodi plain, and it was called Parmesan, because Parma was its commercial centre.

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Later grana was called Lodigiano since Codogno passed under the administration of Lodi. But other authors disagree: for instance, Besana says in his "Compendio tecnico-pratico di caseificio" (Technical-practical dairying epitome): "Grana reggiano or Parmesan began to be produced before grana lodigiano, and its origin place was in the area between Enza and Crostolo, two of the right affluents of the Po river, from the foot of the Appennines as far as Via Semilia".

Later it was produced also in other zones and it was called different names. However, grana is the Italian best cheese, well-known all over the world, and it is unique thanks to its long ripening, its difficult production and the chemical changes: in fact, all of this emphasizes its flavour.

According to historical records, it must have been sweeter than the present cheese, and it must have had a body with more evident holes, that did not tend to chip when being cut.

A very fragrant, oily liquid oosed from its holes, and since this liquid reminded people of tears, it was called the "tear cheese". These features are clearly noticeable in long ripened grana lodigiano, which cannot be still found. The most important factor in the evolution of this production technique was the introduction of the whey inoculation method, made by Prof. Notari in the first decade of this century; this method has permitted us to make more similar the different kinds of grana.

The main reasons for this improvement of the technique have been changed agricultural and zootechnical conditions, such as in cattle breeding of highly selected milk cows, crop rotations, new market demands for more standardized cheese, the need for accelerated ripening times to cut production costs.

All of these changes have made the production technique of grana more similar to the one of Parmesan, and the features of the two cheeses are nearly the same, thus satisfying present consumers' request.

At the end of this report, we would like to make you notice that technicians and scientists have studied and are still studying grana, together with Emmenthal, and therefore there are difficulties in the grana production that cannot always be overcome even with the best technique. Furthermore, the traditional technique cannot be changed, owing to these following reasons:

1) It is impossible to use hypoacid milks, milks that have no homogeneous physical and chemical compounds, and mistitis milks.
2) Milk cannot be pasteurized owing to chemical, physical and bacteriological reasons.
3) Whey inoculations cannot be standardized because they depend on the features of the milks produced in the different areas, and there are other problems also in continuing to use these inoculations because they require the fittest milk.
4) Milk settling cannot be replaced, because it is very important to kill bacteria present in the substrate, that is to reduce milk bacteria power (in fact, fat cells can agglutinate microbic flora when they surface), thus permitting a partial skimming by centrifugation.
5) The research of the best fat-casein ratio of milk in boilers.
6) The difficulty of the fat substance to surface (it has been already overcome, but only in part, thanks to Prof. Bottazzi's particular techniques, that unfortunately still present problems for their application.

Perhaps we have no other time for our report, so we would like to remind our guests of only another fact, that, as for packaging portioned cheeses with vacuum or inert gases, Italian dairy factories have reached a fair production level, which could be improved by following the example of the Americans, pioneers and experts in the sector.

The sales trend has been better than expected, thus proving that the average Italian consumer likes this way of packing, very useful from a hygienic point of view and also useful for longer preservation.
The following paper was presented by Professor Bruno Battistotti, Catholic University of Sacred Heart, 29100 Piacenze, Italy especially for the 14th Annual Marschall Invitational Italian Cheese Seminar - "A Field Trip to Italy" held in the Hotel Michelangelo, Via Scarlatti, 33, 20124 Milan, Italy, on May 16, 1977.

TECHNOLOGY AND TYPIFICATION OF SOME KINDS OF ITALIAN CHEESE

by Prof. Bruno Battistotti

The subject of this report suggests a question which can be interesting for each of us. Do the types of Italian cheese, which are produced abroad, present the same characteristics of classical grana, provolone, fontina, italic cheese, gorgonzola, etc., or do they differ because of the organoleptic and structural characteristics, which are a consequence of different compositions and of a marked mechanization and rationalization of the dairy industry?

I think the answer can be clear and precise, if we make a comparison: Italian cheese undoubtedly presents a more marked flavour, a more armonic and defined taste, so that people can easily distinguish it and define it typical. So, what elements determine this typicalness, how is it obtained, and what do we do to preserve it?

In accordance with the law 10/4/1954 n. 125, the denominations of origin refers to cheese produced in geographically limited areas observing local and constant uses, and whose characteristics of the study of commodities mostly come from typical conditions of the production background. The "typical denominations" refer to cheese produced on the national territory observing local and constant uses, whose characteristics come from particular methods of the production technique.

The D.P.R. of 30/10/1955 n. 1269 acknowledges the denomination of origin for fontina, gorgonzola, granella - padano, parmigiano - reggiano (Parmesan cheese), roman pecorino, sicilian pecorino, and the typical denominations for asiago, caciocavallo, fiore sardo, montasio, pressato provolone, ragusano, taleggio.

Out of orientation and knowledge, we shall report here below the characteristics which refer to "grana parmigiano-reggiano" (Parmesan cheese).

**Parmigiano - reggiano**

Single cream cheese with hard, cooked stuff produced with fermentation acidity from cow milk which generally comes from animals at seasonal lactation period, whose diet basically consists of grazing forage or herb.

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The milk used is milked in the evening and in the morning, and partially skimmed, after the cream has appeared to surface. It is produced between the 1st of April and the 11th of November.

The curdling is made with calf rennet. The use of anti-fermentative substances is not allowed. After a few days, it is salted; this lasts for 20 or 30 days.

The ripening is natural and lasts until the end of the summer of the year following the one of production, even if the ripening resistance is greater. The seasoned cheese can be either eaten or grated, and presents the following characteristics: cylindrical form with slightly convex slope or nearly straight and plate, slightly edged sides; Dimensions: diameter-from 35 - 40 cm. slope height-from 18 to 24 cm. minimum weight of a whole cheese - 24 Kg.

Stuff colour: from slightly straw-yellow to straw-yellow
Characteristic stuff flavour: fragrant, delicate, non-hot flavoured
Stuff structure: minutely granulous, splinter break; minute, hardly visible eyeing.

Crust thickness: about 6 mm.

fat on the dry substance: minimum-32 %

Production area: near Bologna on the left side of the river Reno, Mantua on the right side of the river Po, Modena, Parma and Reggio Emilia.

At first sight only product characteristics and production areas do result practically defined. It is also true that certain technological rules must be observed to obtain products with determined requirements.

From what we said, one could think that for the most qualified and well-known types of Italian cheese, we must observe rules, which limit the technological evolution process.

But even under codified conditions, we must consider the progress of science in the different branches of agriculture, which reflect on the quality of milk, and we must also consider the different socio-economic needs. However, if the typicalness is really linked with irreplaceable environmental factors and with the quality of milk, it is clear that the technologist must overcome, without great changes, the problems caused by the evolution of situations linked with the production and transformation of milk, in order to maintain products of quality and to avoid mistakes.

Let us take for example, "grana", because it is the most typical Italian cheese and also because particular rules have to be followed for its production. These rules are characteristic of most Italian cheeses.

Now it is thought that technology and organoleptic characteristics have not sharply changed from the origins to the end of the last century. Since then, it has been gradually changing and in 1911 Mr. Montanari (1) wrote: "It is
thought that modern processing has deprived the classical type of some of its excellent favour qualities; this is a questionable assertion. What is true is that the new processing systems have led to a decline in waste, a considerable constancy of type, a quick ripening, a greater market-ability". This assessment is current even if it really seems to have two different kinds of cheese in front of us, if we compare cheese produced today with the documents of that time. For example, apart from the macroscopic variations, such as the weight increase of the cheeses or the variation of the sides-slope ratio, the structure is very different because the "partridge's eye" feature, which was so appreciated at that time, has now completely disappeared. In the meanwhile, new cattle breeds have spread and this has affected both the quality and quantity of milk. Technology, after having introduced the whey cultures use has generalized its employment with precise and definite characteristics. In the grana-padano area, the double daily working has become a general phenomenon.

The rennet quantity variations, the halving of the processing time can be considered as devices suggested by the dairy science in order to overcome problems caused by continuous improving production and transformation conditions.

All of these factors have undoubtedly weighed upon cheese qualities. On the other hand, this evolution also results from a work which aims to preserve the possibility of a certain production in economically sound terms. The consumer's taste, which is more and more influenced by the market and advertising, imperceptibly adapts itself to this evolution.

Do we consequently have to attribute the reduced mechanization of the sector to backwardness and slowness of the evolution process? Even outside the typical "parmagiano reggiano" area, where the production is on industrial scale, the traditional vats and basins are used.

The present level of studies appears to be insufficient and the Institute of Dairy Microbiology of the University of Piacenza has been facing the problem under different aspects with experimentations on large scale, which allow us to assert that it is not possible to produce grana cheese of quality, if we leave out of consideration some characteristic processing aspects.

Without insisting very much on the function of the irreplaceable environmental conditions, a good processing of dairy products is first of all conditioned by the quality of milk, and by the treatments undergone before the processing. The quality, intended as chemical compound and attitude to this processing, comes from their genetic characteristics. But with the suitable devices, it is possible to overcome also negative innovations; for example, in the grana-padano area, it is possible to produce good grana-cheese even supplying cows in lactation with insilates. (3)

The milk for grana-cheese has always got high microbiotic contents (see table n.1 (4), which consists of groups including the classical milk enzymes, lipolictic, thermo-resisting, coliform germs, etc. This abundant microflora, which is a contamination at level of milking and transportation to the cheese factory, brings proteolytic or lipolytic enzymes which, associated to those naturally present in milk, carry on their activity before curdling, producing a fermentation or pre-ripening milk.

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It is impossible to produce a quality "grana-cheese" with milk at very low charge (10-20,000 germs/ml.) or destroying the microflora with thermal treatments of pasteurization. The enzymes would be inactivated and the armonic microbial development of milk produced in average hygienic conditions would be irremediably compromised.

For this reason, the refrigeration of milk for grana-cheese at barus or in cheese factories is not applicable, although the reasons of social, economic, technological and hygienic nature, which recommended its diffusion, are becoming more and more pressing in Italy too.

At low temperatures (4-5°C.), milk reduces its capacity of separating fat, the curdling time increases, the structure of dairy micelles changes, the syneresis of the produced clots is reduced. Above all, it is possible to notice an imbalance in the microbial groups with an anomalous development of psychrotrophic germs, which irremediably affects the cheese characteristics. (5)

Among the different temperature/cooling time combinations, that we have experimented, only the one applied to milk cooled at 8°C. for 12 hours and mixed with milk later, has resulted to be utilizable.

In these conditions, the variations of the milk components are very small and the cheeses we have obtained were perfectly normal to every evaluation of the study of commodities. (6)

Even today the separation of part of the fat from milk naturally coming to surface in a basin seems irreplaceable.

For cheese of quality, an abundant microbial charge is necessary, but it should be preferably reduced in a vat.

Now, without pasteurization or adding of chemical bacteriacides, and only with the upward movement of fat corpuscles, we obtain quantitative carry-over of part of microorganisms, the spores included, towards the surface with an agglutination which can reach 95% of the total microflora. (7) (8)

We obtain in this way a cream with very high microbial contents, but above all, a partially skimmed milk with a non-high microbial charge, without affecting natural enzymes or enzymes liberated from microorganisms during the pre-ripening stage.

This aspect is fundamental for cheese typicalness. The replacement of the proceeding in which milk comes to surface in a basin, with another proceeding such as centrifugation, which liberates it from bacteria, has not given the same results.

At this point, we can say that, when milk has the necessary chemical, enzymatic, bacteriological, rheological requirements, every phase of the following dairy processing loses its importance as far as typicalness is concerned. Today, for example, processing whose total time from the rennetting to the end of the processing is 48', 36', and 26', are employed without affecting the quality of the product.

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The lactic ferments present in the milk in the vat, in order to direct the fermentation process, consists of a natural high acidity degree - culture with numerous species and strains obtained through a spontaneous acidification at 45°C. of residual whey. The culture is ready after 24 hours, and has an acidity degree of 28 - 32° SH/50 ml. and a flora, which above all consists of homofermentating and heterofermentating thermophilous lactobacillilli, but also of streptococci and of microbial forms different from classical milk enzymes. (9)

Now, the cheese is the result of numerous simultaneous or consequent enzymatic actions on the curd components. (10)

The hydrolytic processes on proteins stop at various levels, swinging the liberation of polypeptides of different formula and molecular weight, and the deamination of decarboxylation of the amino-acids. Through lypolitic actions on fat and the following intervention of aminases or oxydasess, it is possible to come to fat acids and then to ketones and amino-acids. The lactic and acetic acids come from the lactose; the butyric or propionic acid comes from the acetic acid and the acetoin and the diacetyl and other side-compounds from the citric acid.

These processes, which lead to the formation of organoleptic characteristics of cheese, and above all their regular development are affected by the lactic (and non-microbial)species. During the processing of dairy products, some conditions, which direct flavour, are fixed and they favour the development of some microbial forms existing in the milk. The lactose biological activity, proteins, organic acids and fat constitute the first stage of the ripening process. Not only do the milk enzymes contribute to the two phases, but also those added during the dairy processing, and above all, certain types of microorganisms, which differ from the acidifying or flavouring ones of the first phase such as Str. faecalis, Str. durans, Pedicoccus cerevisiae, Proponibacterium shermanii, Micro-coccus caseoliticus.

In such long-aged cheeses such as grana, a rapid succession of these processes can be seen. The natural cultures consist of a microflora, which has a great variety of species and strains of the Lactobacillaceae family, but also of other families, which, with their presence in this harmonic development, favoured by the seasoning conditions, mould the characteristics of the ripe product.

From this point of view, the processing of dairy products with raw milk and the employment of natural cultures plays a fundamental role in the quality of the product.

It would be possible to discuss for a long time about this subject, but I just want to point out that the prefermentation of raw milk and the subsequent presence of enzymes also from very different microorganisms, the employment of natural cultures, where it is possible to find lacto-bacilli, streptococci, pediococci, micrococci, etc., are significant aspects, which characterises the grana-cheese processing in Italy. If we consider now some other types of Italian cheese, we think we can underline the same aspects.

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For example, the milk prefermentation is very useful also for soft cheeses, even if they are produced with pasteurized milk. It is more possible to obtain good quality crescenza or mozzarella from milk, whose contents are 3 - 5 million germs/ml than 100,000/ml. This microbial charge is various and consists of both pro-dairy and anti-dairy forms. For these types of cheeses, it is necessary to pasteurize milk in order to get the necessary hygienic conditions and to standardize the microbial characteristics of the processed milk.

This has probably to be attributed to the action carried on by the microbial enzymes on the milk components and, for their non-total denaturation with thermal treatment, also on cheese during the ripening process. We have also a production of important grow factors, which stimulate the development of the cultures added during the dairy processing.

The employment of natural cultures in milk or whey presents some advantages also in the production of cheeses such as provolone or mozzarella, soft cheeses such as italic cheese, taleggio, crescenza or traditional gorgonzola. (11)

These cultures are obtained with proceedings similar to the whey starters for grana cheese, such as, for example, the whey starter for provolone or with more specific techniques of cheeses such as crescenza or italic cheese. (12)

We just want to point out that the acidity degree and the kind of prevalent microflora can be regulated.

For example, the starter for grana and provolone are whey cultures with a high acidity degree and a high presence (1 - 2 billions/ml.) of lactobacilli; the ones for soft cheeses consist of selected milk and their microflora mainly consists of coccius and thermo-resisting forms, such as Str. therophilus and a significant presence of Str. faecalis, Str. faecium, micrococci, etc.

We have also to remember other types of Italian cheese, such as the Aosta Valley fontina, half-cooked cheese, whose processing starts 1 - 2 hours after the milking. This is a very delicate product, whose flavour and smell are characteristic and appreciated. Its organoleptic characteristics are very different from the similar industrial products.

In this case the typicalness has to be related not only to the milk characteristics of the production environment, but also to the number of microorganisms, that it contains and which are able to reproduce in ripening conditions. (10-12°C.)

The microbial contents are about 100-400 thousand/ml. during the dairy processing which is carried on with raw milk without starter or natural cultures.

The curd, at 6.5 - 6.6 pH during the production, does not go below 5.5 - 5.6 during the seasoning stage even if, during the ripening, the number of acidifying germs sharply increases. A high number of microorganisms, the enterococci, is also present.

The characteristic aroma (see picture n.1 and 1B) is to be attributed to these microorganisms. The flavour diagrams of these pictures refer to the volatile compounds with a low number of carbon atoms liberated from fontina cheese and from a stock of enterococci isolated from cheese itself. (14)
Under these processing conditions, waste is quite frequent. In particular, because of the low microbial charge, the absence of fermentation and the lack of starters, the processing becomes more difficult and the quality of the product can be conditioned; it is obvious that, under such conditions, an imbalance in the normal microflora can favour the development of fermentation harmful to the formation of an anti-dairy microflora. (15)

The curd obtained is sweet and the microbial multiplication very active within pressing condition, when temperature drops. Then, the reproduction process is reduced or it affects only the forms, which can develop at ripening temperatures. (10-12°C.) (16)

When a number of microorganisms is very low (below 100,000/ml.) in the vat, with a final serum at 0SH/50 ml., that is 1.7-1.8, it is possible to favour the development of anti-dairy forms and the following harmful fermentations. On the other hand, when the microbial contents are high, cheese gets too hard and acid, so that it cannot acquire the typical flavour, that it develops with certain pH and humidity values.

If it is not possible to find effective remedies in this last case, the only thing to do is to better the hygienic conditions of milk; when the microbial charge is too low, we can obtain significant advantages employing milk cultures, which consist of enterococci. Its contents must be 1-2°/ooo in order not to get into the opposite defect. (17)

From the experimentation carried on by our Institute, it seems it is possible to gain advantage from the direct addition of lyophilized cultures in the vat that slowly develop in the curd and in the ripening, holding in this way, the acidification.

I do not claim to have explained the typical factors of the types of Italian cheese. I only hope to have put out some processing characteristic aspects, which contribute to determine it.

Our goal, as researchers, is to preserve the positive factors of tradition, keeping them up to date, in order to maintain as far as possible the organoleptic characteristics and not to fall in the complete flavour standardization.
The following paper was presented by Dr. F. Bodini, General Manager, Latteria Soresinese, Soc. Coop. S.R.L., 26015 Soresina, Italy, especially for the 14th Annual Marschall Invitational Italian Cheese Seminar - "A Field Trip to Italy" held at the Congress Centre, Hotel Michelangelo, Via Scarlatti, 33, 20124 Milan, Italy, on May 16, 1977.

THE FUTURE OF THE DAIRY INDUSTRY IN RELATION WITH THE DEVELOPMENT OF THE EUROPEAN COMMUNITY

by Dr. F. Bodini

We are pleased to say "welcome to Italy" once more and we greatly appreciate the presence of an illustrious group of experts of a particular branch of the human activity, the conversion of milk into cheese, because this tradition, long since handed down, dates back to the origins of the American people.

I am glad, personally, to welcome you as Chairman of "Federlattae", which represents 1200 dairy factories aimed to produce typical Italian cheeses, that is to say, more than half the whole cheese-devoted milk in Italy. I will be pleased to receive your visit in two days at "Latteria Sorinese", the most important dairy factory directly in connection with the consumers in your country.

Needless to say, the production and the consumption of Italian cheeses in America is most important; this tendency is still rapidly growing in all the European countries, inside and outside the Common Market. Big European cities like London, Paris and Hamburg, up to 20-30 years ago, absolutely did not know "pizza", and now scores of Pizzerias, serving the tasty Italian specialty, are based there.

During the three decades after World War II there has been a great migratory movement towards the European countries from the part of Italian workers and this movement made many Italian communities be founded abroad. They were mainly of Southern origins and seemed to be inclined to keep their food traditions.

That is why it could be interesting to follow, today, the evolution of the Italian cheeses from this and the other side of the Atlantic.

Let us see the figures relating to this huge phenomenon reported by your organization; the USA produces a very large amount of Italian-type cheeses; 2,700,000 quintals (over 600 million pounds) equivalent to twice the amount of both Parmigiano-Reggiano and Grana Padano produced in Italy. This is a very high figure, even though we must take into account that the American market is about five times greater than the Italian one.

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Mozzarella, which is not the small cheese as the one sold in Italy, but the pizza-cheese, ranks first with 400 million pounds out of the 600 millions of 1974, thus 66% of the overall Italian cheeses produced in the USA.

It is followed by provolone and similar cheeses, with 56 million pounds, about 280 thousand quintals, equivalent to about 70% of the Italian production, and by grana with 50 million pounds (about 220 thousand quintals), 15-20% of the Italian production.

Also the growth of these productions from 1957 to 1974 is astonishing; the total of Italian-type cheeses manufactured in Wisconsin has increased from 55 to 217 million pounds, thus it has multiplied by four. Mozzarella instead, has increased by more than ten times.

The same happened in Europe, although it did not reach these proportions; the growth of these productions from 1957 to 1974 is astonishing; the total of Italian-type cheeses manufactured in Wisconsin has increased from 55 to 217 million pounds, thus it has multiplied by four. Mozzarella instead, has increased by more than ten times.

The pizza-cheese type has attracted various levels of consumers thanks to the success of pizza. This cheese is now produced locally, near the places of consumption, by people of Italian origins, or by those who have learned its technology.

Simultaneously, there has been a certain diffusion in Europe of the typical Italian grana cheeses (Parmigiano Reggiano and Grana Padano) and of Provolone, Gorgonzola, Taleggio and Pecorino.

Their consumption which has asserted mainly in the Italian communities founded after World War II, especially in Germany, Belgium, France and so on, became constant, because it represents a food tradition which links the Italian worker to his country, even after years and decades, as the Italian experience in the USA has shown.

This demonstrates that feeding, beyond the economic point of view, is also a matter of customs; the way of eating is an important part of the way of living and, therefore, is an evidence of civilization.

We must also take into account the consumption of Italian cheeses at a specialty level; some European consumers who tasted Italian cheese while staying in our country, or who knew their reputation in gastronomy, keep on eating them, demanding high quality. So we see that in the USA and in Europe the situations are alike, from the consumption point of view, as there are two levels of consumers; one more numerous and less demanding, which adjusts little-by-little to the local production, cheaper but poorer in quality, and the other numerous, but requiring the original typicality and which looks for top-quality despite high prices.

As far as production is concerned, in Europe a situation different from that of the USA has taken shape in the last few years. While in the USA there is a sharp distinction between "home" production and the imported product, in Europe there has been an increased production of Italian cheeses, manufactured by Italian factories employing foreign milk, which is much cheaper. Then the cheeses produced are sent to Italy for the seasoning, thus creating a fraudulent nationalization as a production made in Italy.

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This is the case with provolone, which is produced in all the countries of the European Community, but mainly in Germany; with Fontal produced especially in France, and with Incanestrato and Grana produced in France and Belgium.

These cheeses are soon transported to Italy for the seasoning; as they are not finished products, they get through customs without denomination, except that of "fresh cheese". This affects badly our statistics and makes useless any attempt to plan our production. It is the first serious damage to our dairy economy.

The second, much worse than the other, is that these goods come into Italy benefiting from the so-called "compensatory amount". These are economic measures adopted by the European Community to redress the balance of competence in case of variations in the value of national currencies. These can be understandable measures for certain sectors, like that of grain, but are unjust and very heavy in the milk sector. In fact, to set an example, Germany exports to Italy milk and dairy products and receives from the Community a reward (about 20%) so as to sell on the Italian Market, which is 20% higher than that of Germany. Thus, we have to face a compence beating us by 40%. When the community rules were made, probably these repercussions had not been foreseen, but now that they have occurred, they must be changed as soon as possible.

Moreover, these compensatory amounts are unfair because Italian farmers buy the means of production (fodder, fertilizer, implements and so on) with a devaluated currency and, consequently, their production costs are much higher as against those of their German or Dutch counterparts.

These reasons, together with those of natural causes, lead the Italian cattle to produce high-priced milk. Therefore, it is not easy to answer my question; "What is the future of Italian cheeses also in relation to the development of the European Community"? First, it will depend on the general conditions of our economy, which should reduce inflation in order to enable us to produce at competitive prices. But we have a strategic line which should not change; the line of quality. We want to keep the two levels of the market, in the USA as well as in Europe; one with prices which everybody can afford, where the consumer's choice is orientated towards the price, and the other at a "specialty" level, where the consumer orientates towards the gastronomic and organoleptic quality.

This is also the strategic line adopted by the Swiss Emmenthaler and, outside our sector, by renowned Italian and French wines, by cognac, by the Parma and S. Daniele ham and other gastronomic specialities. We could set other examples, outside the food industry, as in every sector there are consumers willing to spend, but requiring choice quality and the brand available, not the market.

Italy cannot do without this line because, as we have already said, the production costs of milk are higher than those of America and those of the member States of the European Community. Communitary rules help us because they allow us to enjoy some drawing of repayment, which is calculated according to the difference between the Italian market and the Italian market of cheeses. But this is not enough for the Italian product to compete with the price of the American "home"production.

(over, please)
So we try to orientate towards high quality. You should know that Italians in the USA have kept the "typical" taste in a better way than our fellow countrymen in Southern Italy. The same has happened to the Roman pecorino.

I am, therefore, glad to welcome you in Italy on behalf of all Italian dairy cooperatives, which produce cow's milk and ewe's milk cheese and of all Italian regions which are pleased to strengthen friendship and trade relationships between Italy and the American Nation with their every day work.
THE ITALIAN - AMERICAN RELATIONSHIP

by Joseph Sartori

This opportunity to address so many distinguished and learned native Italians is both a privilege and a challenge. I haven't used the Italian language except sporadically for some years now. Years ago I would visit with clients in Italian inasmuch as most of our buyers were themselves direct immigrants from Italy. However as time went by and we began to enlarge our business to include more second generation Italians as well as non-Italians, I reverted to the language which comes so much easier, my native English. For the practice that was occasioned by that early necessity, I am of course very grateful. The Italian language, despite my faulty grasp thereof, is certainly one of the most beautiful languages in the world. I trust that you will bear with my grammar and try to understand my meaning and sincerity at least.

We all of us owe a debt of gratitude to the Marschall Laboratory and all of its hard working management, particularly the Italian cheese sector, for the careful preparation and assiduous work that they have put on this particular seminar. Over a period of many months, perhaps a full year, their planning efforts for this 14th annual cheese seminar have put a terrific burden on them. I feel certain that their thoroughness and hard work will result in making this grand occasion worthwhile to all of us from America who literally "came across" to meet with our Italian "cousins".

Your presence here is of course very gratifying. Perhaps some of you are asking, actually why are we from America here today and what do we plan to do on our 15 day visit to your beautiful country? The answer is simple and sincere. As Italian American "cousins" of the traditional Italian cheese industry, we are anxious to study the foundations of the art and science and to humbly honor the origins and development of Italian cheese production. Our purpose is not basically tourism at all, though we will certainly enjoy this marvelous opportunity to explore a few of your wonderful cities and some of the lovely countryside. Through the well selected papers specially prepared for today's program, we have and we will learn more about your industry. We also expect to visit several of the large and interesting cheese operations in the areas which we will tour. We are not here on a one-way street, I assure you, neither as teachers or as students only. Instead, our attitude is to acknowledge all the tremendous tradition of the original Italian cheese industry and at the same time to lay an international foundation of goodwill and understanding regarding our industry in America.

(over, please)
It is important to acknowledge, both on our side and from the Italian viewpoint, that there are some obvious differences between the United States cheese production and the products of Italy. In many instances, for example, similar names are used to describe Romano, Parmesan, or Provolone and Mozzarella. These terms are used to refer more or less to the same basic types of cheese of the Italian varieties. Nevertheless there are notable differences that both you and we are aware of between our Romano and yours — between our Provolone and yours, and for that matter also Mozzarella and other types. Some of the factors involved in these differences might be explained briefly. First of all, we in the States are always looking for economies of mass production and centralization of our operations, which has brought about a rather significant mechanization to a high degree that perhaps is lacking in the original tradition. Palates and preferences vary also between the people of different countries, and we are of course always striving to follow the "vox populi". Even the milk backgrounds and derivation for Italian cheese are quite different in the United States as against those here. You all know that basically all cheeses produced in the United States with few exceptions are made from cow's milk, whereas in Italy there is a long and substantial history of sheep and also goat milk cheese. These are some of the important differences that must be recognized between our cheese production and yours, all of which fit under the so-called "Italian types of cheese" category.

Something about our history or background in the States. It is generally agreed that Italian cheese was first produced in America approximately at the beginning of the first World War, though in very small amounts. Production lagged for several decades, and got its early strong growth in the 1930's and 1940's. It is well to note that in the past 10 years, the growth of the Italian cheese industry in the United States has been phenomenal, ranking second now only to the production of so-called American or Cheddar cheese. Today, it is reliably estimated that total production of all types of Italian varieties in the United States approximates seven hundred million pounds or about three hundred and twenty thousand tons. Among the various types produced, Mozzarella constitutes well over one half of the total. The growth in Mozzarella alone runs approximately three to four times the figures of only ten years ago.

Those of us from Wisconsin, where the dairy business is so very important, are proud to claim that we play the major role in this growth, since Wisconsin Italian cheese represents approximately 45% of the total U.S. production of these types. Of course cheese is made in the States from coast to coast, California to New York, Louisiana to Minnesota, and from Maine to Florida, in varying types and amounts.

If I may be permitted a personal diversion, a few words about my background. I feel that I am one of you, since I am of 100% Italian blood, the son of a dynamic and resourceful father who emigrated to the United States from the Venetian area while still a very young man. In 1939 I was fortunate to help my father and another partner to establish the S & R Cheese Corporation in Plymouth, Wisconsin. Progress was very slow in the beginning, but there is no doubt in my mind that we entered a fertile field with great horizons. My father was dedicated to hard work, and made certain that his only son exercised the same ideal! He was by the way already 57 years of age when
he left his position as a sales manager for a large competing Italian cheese company to formulate the new enterprise. Long before my father passed away in 1957 I came to appreciate his sterling Italian-bred qualities. Of course he made me proud of his heritage, and to be an italo-American. After achieving success in the United States he revisited Italy several times, doing his best to extend to his native villagers some of the good fortune brought about through his dedication and hard work. In the very small village of San Pietro Val d' Astico he founded some 25 years ago a home for the recovery of the aged, later setting up a modern hospital facility through the establishment of a foundation. Some 30 years ago he received the Star of Solidarity from the Italian government in honor of his dedication to the Italian ideal. On my part, I must admit to being only a shadow of this remarkable man, but I have always felt a strong dedication and obligation to his memory and that of my mother.

This occasion marks my fifth visit to Italy, most of which have been in company with my wife, who by the way is not fortunate to have good red Italian blood in her veins. I shall always feel humble, grateful and excited when revisiting this beautiful homeland of my ancestors. In concluding, I make no pretense at being an Italian cheese expert, or an expert of any kind, for that matter. My one expertise perhaps lies in the area of fecundity. With the willing cooperation of my wife, we raised nine children, six girls and three boys. Perhaps in one other area I may qualify as an expert also, at least according to the American definition, which says that an expert is simply "anyone far from home." On behalf of the entire touring delegation, once more let me thank you for your cooperation and mutual respect. We look forward to the important papers on this afternoon's program and hope to see and meet with many of you personally. I appreciate your attention.
NEW TENDENCIES IN THE MECHANIZATION OF CHEESE MAKING IN ITALY

by Dr. Augusto Balducci

In Italy, the mechanization in the dairy industry had, in the last 15 years, a considerable growth.

Italian industries directed themselves toward the use of more equipments for curdling. In other words, there has been an attempt to mechanize traditional production processes with lines allowing the conversion of milk into cheese with traditional organoleptic characteristics.

The organization of these lines had to allow the production of various types of cheese since Italian plants are based on various kinds of production rather than on a single one.

In order to meet the Italian transformers' productive and industrial needs it has been necessary to provide them with some particularly flexible equipments which could release the making of cheese from the machine itself and leave to the technician the possibility of adapting the equipment for the making of different types of cheese.

The polyvalence was obtained by dividing the curdling process into two different phases, carried out with two different equipments:

- curdling boiler (dynamic phase).
- drainage basin (static phase).

As far as the process of curdling is concerned, it takes place in totally mechanized oval and round-shaped boilers provided with fixed or oildynamic scaffoldings.

Obviously, curdling a large amount of milk involves a rational placing of large amounts of clotted milk. In fact the clot placed in any curdling basin is constantly in movement in the whey and it is discharged from the basin together with the same whey.

We should examine the type of discharging adopted, mainly when we want to make soft cheese, in order to prevent the process from crumbling the clot and wasting, in this way, whey and casein powder.

(over, please)
As a rule, the curd and the whey are gathered in drainage basins. Two kinds of drainage basins can be used: the static ones, which are basins with holes in the bottom, or real machineries which allow the drainage of whey, the pressing of the rennet under they whey, its division into cube-shaped portions and the automatic filling up of moulds.

For some Italian cheese, cooked, half cooked or soft, the productive cycle ends when the curd is poured into the moulds; for others, like pasta filata, the deriving curd must undergo a phase of ripening to be subsequently stretched and shaped in the way desired. In this case, the deriving cheese must be hardened in cold water and salted in brine.

Also, the phases for the making of pasta filata have been totally mechanized with the usage of "in continuous" stretching, moulding, hardening and salting equipments.

These methods are already widespread among Italian manufacturers in the making of all kinds of cheese, except grana, for which traditional productive processes are still employed. However, even for this type of cheese, many technological phases have been settled and changed.

The research carried out, especially at the "Institute of Dairy Microbiology" of the Cattolica University in Piacenze, by Prof. Bottazzi and his team, enabled to realize new equipments, like those for the agglutination process in order to facilitate and quicken the stages of appearance of fat during their stay in vats.

What above said refers to lines widely tested and in full production, which have been completed in the last few years with complementary equipments that gave them a greater automation.

The present tendency in the process of mechanization in the making of cheese has a completely different origin from the former ones. As we have already pointed out, Italy was previously inclined to mechanize traditional production processes, whereas now, it has entered a new phase, adopting new technologies developed after a period of research and experiments.

Therefore, present and future mechanization will require considerable changes in the equipments used in order to apply new technologies. For instance, the process of continuous curdling, which in Italy is now going from the experimental to the productive phase, would not have been successful if Beeridge in 1945 and Radema in 1958 had not overcome the problem of clotting.

After the solution of the basic problem, it has been possible to develop equipments which, with various systems, allowed continuous curdling.

This subject has been tackled by our firm. A prototype is already working in an Italian Company for the production of pasta filata, Mozzarella type.

Even in the field of Mozzarella, processes of stretching are having an interesting evolution by means of electromagnetic energy and microwaves (See Bottazzi- Batti-stotti). Thanks to them, waste of fat and soluble material can be avoided.

(over, please)
Another continuous curdling group is being tested by our firm in order to obtain clots suitable for the making of cooked, half cooked and soft cheeses.

Among new technologies, ultrafiltration had a successful industrial application. Allowing the cold concentration of macromolecules of fat, milk and whey, it created new prospects both in the production of milk and the one of products obtained from whey.

Unlike other countries, in Italy the utilization of whey has been solved for a long time by the production of ricotta and by the utilization in the zootechnic sector.

We can say that 50% of the whey made in Italy is converted into ricotta. Up to now, this has been carried out following traditional schemes (heating the whey at a temperature of 80-85°C, appearance on surface of whey and manual extraction). Thanks to the employment of ultrafiltering systems, some continuous lines for the production of ricotta were set up. In the past, the mechanization of ricotta involved huge problems because of the little quantity of precipitated part in relation to the liquid part.

The same process is employed for the production of mascarpone-type cheese in which the milk preconcentration reduces the original volume at 1/4, eliminating or cutting down considerably the hard phases of traditional cleaning.

The process for the production of concentrated milk by ultrafiltering and adding of cream can be obtained by using equipments similar to those used for production of ricotta.

The results achieved with the preconcentration of milk for ultrafiltration in the production of cheeses are extremely interesting. In this case, the Italian approach is different from the French one, as it works on milk with lower concentration degrees (a 20% removal of the permeate), thus enriching the percentage ratio of milk components like fat and proteins.

In this case, ultrafiltration is considered as an equipment to be inserted at the receipt. This enables the achievement of milk with different characteristics in relation with the type of cheese we want to produce.

This process produces an economic advantage as well as a technological one; the easy utilization of refrigerated and pasteurized milk in the production of cheeses, including the more demanding ones such as grana (Resmini-Peri), the achievement of curd with structures more suitable for the production of cheeses, less amounts of rennet and so on.

Other technological aspects in developing future mechanization of cheese will undoubtedly be represented by improvements in the choice of ferments and their employment, by the utilization of fixed enzymes and by an acceleration in the processes of ripening. However, the development of this new theme has to be controlled in order to avoid production of cheeses with organoleptic characteristics too different from those of traditional cheeses. This will prevent us from destroying our national dairy inheritance which we are world-renowned for.

Therefore, the cheese making mechanization keeps up with the introduction of new technologies which should have to be taken from the experimentation to the transformation industry in well-defined economic and technological terms.
The following paper was presented by Prof. Cesare Corradini, Institute of Chemistry, Dairy Research Dept., Universita Cattolica del Sacro Cuore, Piacenze, Italy, especially for the 14th Annual Marschall Invitational Italian Cheese Seminar — "A Field Trip to Italy" held in the Congress Centre, Hotel Michelangelo, Via Scarlatti, 33, 20124 Milan, Italy, on May 16, 1977.

NON-TRADITIONAL CURDLING AGENTS IN THE PRODUCTION OF ITALIAN CHEESE

by Prof. Cesare Corradini

Strictly economic reasons caused non-traditional curdling agents to become interesting, linked with the cost of raw materials, the lack of reliability on the market supplying calf-stomachs, suckling kids and lambs; from the stomachs of those last animals, the rennet containing lipasi is prepared, to be used in the production process of provolone cheese, typically hot flavoured.

Now, anyway, we should confine ourselves to talk about proteolytic enzymes which catalyze the transformation of casein from the colloidal dispersion stage, as we can find in the milk to the gel stage; in other words, we will consider the enzymatic preparations, capable to curdle milk, different from those derived from suckling-calf rennet whose curdling property is mainly due to the rennin.

As for the Italian cheese, among animal, microbial and vegetal coagulants coming from superior plants — as found in bibliography (1,2,3), the following preparations made a certain interest arise:
- Bovine rennet with high pepsin content.
- 50/50 rennet pork pepsin and calf rennet mixture.
- Microbial coagulants from Mucor pussillus, Mucor Miehei, Endothia parasitica.

Using the above mentioned coagulants most researchers studied experimental cheesemaking systems in order to produce different types of cheese, whereas more and more frequently, many Italian dairy industries are using coagulants different from the traditional ones.

Now, leaving aside the results of the aforesaid tests, it is advisable to take into consideration the main principles on which we can start to evaluate the coagulants envisaged to replace the traditional rennet. In other words, we shall evaluate the differences along the evolution of the process for those cheeses in which the enzymes take a major role.

The first stage to be considered is obviously the curdling of milk and particularly the stages following the formation of coagulum hardening of the curd, synaeresis. These actions which together lead to the rheology of the curd, must develop in a way enabling to obtain from the cheese vat a curd having all the suitable properties for the conversion into the predetermined cheese, that is to say having a fixed consistency, elasticity and moisture.

(over, please)
The second stage in the production process where the coagulant is relevant, is the ripening of the curd. In fact, if not denatured or drained by cheese-making operations, the enzyme which remains in the curd takes part in the proteolytic process occurring during the ripening, and since each enzyme has its own activity and specificity, the speed and the type of proteolytic action, and subsequent effects on the structure of the cheese and on the flavour, are different according to the coagulant used.

When trying, therefore, to replace a traditional rennet with a new coagulant, the substitute must be chosen in such a way that serious alterations of the rheology of the curd are prevented and relevant changes of the organoleptic characteristics are avoided. Let us examine the guidelines for this choice.

Importance of the coagulants in relation to the curd

An instrument enabling to follow the milk curdling, the formation and the contraction of the gel is the thrombelastograph. This instrument (see figure 1) utilises a system of coaxial cylinders and the measuring vat is put into a slow alternating coaxial motion so as not to provoke disruption of the developing gel by shearing. Along with the gel formation, a torsion wire is increasingly stressed: its movements are recorded through an optical system. We obtain diagrams like Fig. 2 where "T" is the coagulating time and "Et" (in mm.) is, according to the width of the oscillation, the curd consistency at "t" minutes from coagulation start.

In the following tables we can find measurements made by thrombelastograph, showing the comparison between calf-rennet and microbial coagulant first, then the comparison with bovine rennet. When these tests were made it was taken into account the influence of the main factors affecting coagulation and syneresis, such as acidity of milk, curdling temperature, enzyme concentration.

In table 1 we have data related to thrombelastograph measurements performed on fresh skimmed milk, curdled with calf, rennet and microbial rennet from Mucor miehei; in these tests the quantities of rennets were selected in order to obtain in any case the same coagulation time, so that the tendency to increase of curd consistency could be related to the nature of the rennet, not to a different curdling activity.

From the data obtained we can easily conclude:

The curd hardens more slowly with microbial rennet; an increase in coagulation temperature and overall in acidity smooths the trend difference between the curd recorded in test A, whereas it accelerated the hardening in both cases. It is worth noting that the aforesaid tests have been made in Crescenza cheese-making where the aim was to evaluate the replacement with coagulant from Mucor miehei of traditional calf rennet. The technological observation * in the cheese vat mirrored exactly the thrombelastograph tests. We noticed, in fact, the need of a slightly longer hardening time for the microbial curds, having with just this precaution, a curd suitable for Crescenza cheese.

In table 2 we can instead see the comparison between powder calf rennet and bovine rennet with pepsin activity around 77%. The acidity and temperature condition of the test simulate the Grana production. In case of bovine rennet, two different concentrations were used in order to obtain, in the first case, the same coagulation time, and in the second case, a slightly shorter time than the coagulation with calf rennet.
In the above mentioned conditions and particularly when using a slightly higher quantity of bovine rennet, the rheologic pattern of the coagulation is the same, in line with the observation of a wide range of grana cheesemaking, both Padano and Parmigiano Reggiano.

In the considered cases, from the observation of the thrombelastograms, we had the confirmation of the possibility to replace the traditional rennet in milk coagulation process and useful indications about the most important factors on which we can act.

**Importance of the curdling agent in ripening proteolytic processes**

The most important factor for a new coagulant, in order to be suitable for replacing the traditional rennet in a given cheesemaking process, is certainly linked to maintaining the same structure, the same flavour and taste. As before mentioned, these features are strictly connected with the speed of the proteolytic action in which the enzyme takes part.

In this report we are not taking into consideration whether the peptides freed from the caseins by different enzymes are similar, whether they cause bitter taste, if they are liable to further lysis, but we are examining whether the vat conditions and the stages of the cheesemaking process perform on traditional rennet or its replacement, the same denaturant or impoverishment effects.

We can certainly state that "cooking" is an operation which affects the enzymes: this operation, in particular in hard cheeses with slow ripening, causes a marked syneresis of the curd. The "cooking" is a thermal treatment not higher than 55°C., but rather long since, besides the time required in the cheese vat to reach the scheduled temperature, we must take into consideration the slow heat-release properties of the curd, substance with very low thermic conducibility.

Data has been collected about the loss of curdling activity in relation to the temperature, for a bovine rennet with high pepsin content (nearly 77%), quickly brought to the temperature of 55°C. in whey, obtained from Grana production pasteurized and filtered and with the adjusted pH at different values by means of lactic acid, then left at this temperature for 5 minutes (table 3). For these values of pH, which certainly include the usual values of Grana production, the coagulant is denatured. Therefore, since bovine pepsin has a higher thermal resistance than rennin and pork pepsin (5,6) all the animal rennets considered can be used for Grana cheesemaking.

The data in table 4 confirms the foregoing (we can also see the affect of heat on the proteolytic activity on haemoglobin) and so do all the Grana productions - both Padano and Parmigiano Reggiano - we have observed, during the last few years (7,8) and under observation at present.

Another outstanding thermal treatment is, in pasta filata, the lay phase of curd under whey and the stretching. In table 5 we can see the way animal rennets are affected by thermal treatment at 60°C. when diluted in stretching water from Mozzarella cheese. Microbial rennets are admittedly more thermostable than animal ones, and consequently less liable to be affected by thermal treatment. In this connection we are reporting the data of Table 6, observed after a coagulant from Mucor pusillus underwent treatments, with conditions similar to those occurring in cooked cheeses.

(over, please)
The conclusion of the aforesaid observations are confirmed by experimental tests of Grana cheesemaking - we noticed, in fact, that using microbial coagulant from Endothia parasitica, cheese at the end of the ripening process was not as well balanced as the comparison cheese, and bitter and hot flavours were noticed, while the brown colour of the paste was definitely reddish-brown. Brown coloured paste and "seasoned" taste were also noticed at the end of ripening in Grana cheese produced with coagulant from Mucor miehei: in this case (table 7) the situation related to the extent and the type of proteolysis is remarkably different.

Other experts (10) on the other hand, have failed to notice relevant differences in the ripening process during the first four months, even in Grana cheese made using coagulants from Mucor miehei. Examining their observations together with our data, we can conclude that the proteolytic process adverse action, as far as the taste is concerned, - due to the enzymes of the microbial rennet - is not relevant during the first stage of ripening.

This statement is supported by some of our assays and by some other authors' too. For instance, we are reporting some data referred to experimental Crescenza cheesemaking using microbial rennet from Mucor miehei (see table 8). Compared to "comparison cheeses" (calf rennet) we notice a definite, higher proteolysis in microbial cheeses produced with rennet; however, a cheese tasting panel carried out by 15 tasters did not pick out any real faults, and the favourite cheese of each taster was merely the result of personal choice.

Furthermore, using microbial coagulants, both from Mucor pusillus (14) and from Mucor miehei, we obtained excellent Mozzarella cheese; in this case, as shown in Fig. 3, the cheese proteolysis occurring during its shelf life is just slightly stronger as compared with calf rennet cheese.

We must keep in mind that in pasta filata cheese, stretching along with a thermal effect - implies a washout of the curd, lowering consequently the coagulant content; in this connection we might also use safely microbial rennet in semi-aged sweet pasta filata cheeses. At present, however, no written contribution is available to support our opinion on the basis of experimental tests.

On the contrary, as for long ripening piccante Provolone cheese, a recent paper is available showing that microbial curdling agent from Mucor miehei leads to organoleptic characteristics similar to paste rennet. From this paper we learn that "all the observed ways of degradations of casein, typical of each proteolytic and coagulating system, do not seem to be likely to affect the organoleptic features of the cheese. In our view, we maintain - as shown previously (14) - that the organoleptic features and particularly the taste of strong provolone cheese - above all depend upon the action of the lipolytic enzymes of paste-rennet or added lipasi, like in the case observed.

Conclusions

We can here conclude this short assay summarizing some usefully guidelines for the choice of replacement for traditional rennet in our common cheesemaking practice.

As we learned from assays about curd rheology, usually the replacement of the traditional rennet is absolutely safe if the factors interesting the coagulation, the consistency of the curd, the syneresis, are not affected. These factors are: milk acidity, coagulation temperature, enzyme concentration;
in some countries we might as well add calcium chloride, which action varies according to the coagulant (8).

Working appropriately on these factors, even the small yield losses that some authors point out, can be controlled. On the other hand, we must take into account how an excessive enzyme concentration could adversely affect the process, should the enzyme not be denatured or separated with subsequent stages of the cheesemaking.

As for cheese with short ripening, there is quite a large choice of coagulating enzymes, either animal or microbial; this choice, conversely, for the long ripening cheese is to be made only among animal rennet. This principle is based on the consideration about the long-discussed thermo resistance of the enzymes.
Table 1 - Thrombelastographic observations on skim fresh milk, curdled using calf rennet and microbial rennet from Muco meihei (M) at different values of temperature of coagulation and pH.

<table>
<thead>
<tr>
<th>COAGULATION TEMP/ pH</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35°C.</td>
<td>38°C.</td>
<td>38°C.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>M</th>
<th>V</th>
<th>M</th>
<th>V</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (MIN.)</td>
<td>14</td>
<td>14</td>
<td>12</td>
<td>12</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>E₁₅ (mm)</td>
<td>48</td>
<td>44</td>
<td>51</td>
<td>49</td>
<td>66</td>
<td>64</td>
</tr>
<tr>
<td>E₃₀ (mm)</td>
<td>63</td>
<td>60</td>
<td>63</td>
<td>62</td>
<td>70</td>
<td>69</td>
</tr>
<tr>
<td>E₄₅ (mm)</td>
<td>67</td>
<td>66</td>
<td>67</td>
<td>66</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>E₆₀ (mm)</td>
<td>69</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>
Table 2 - Thrombelastographic observations on fresh milk partially skimmed, curdled in conditions simulating Grana cheesemaking, using calf rennet (V) and bovine rennet with high pepsin content (B).

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coagulation time</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (minutes)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>Curd consistency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E15</td>
<td>61</td>
<td>56</td>
</tr>
<tr>
<td>E30</td>
<td>74</td>
<td>72</td>
</tr>
<tr>
<td>E45</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>E60</td>
<td>79</td>
<td>79</td>
</tr>
</tbody>
</table>

Coagulation temperature: 30°C.
Milk acidity: 4.23 °SH
pH (adjusted with lactic acid): 6.47

(over, please)
Table 3 - Influence of the thermal treatment ($55^\circ C \times 5'$) on a bovine rennet with a high content in pepsin (activity due to pepsin $= 77\%$) diluted in distilled water or in whey derived from Grana cheese-making process (in this case the value of pH, after the whey being purified and pasteurized, has been adjusted using lactic acid).

<table>
<thead>
<tr>
<th>SOLUTION</th>
<th>pH SOLUTION</th>
<th>COAGULATING ACTIVITY SECOND</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BEFORE</td>
<td>AFTER</td>
</tr>
<tr>
<td>DISTILLED WATER</td>
<td>5.36</td>
<td>115</td>
</tr>
<tr>
<td>WHEY</td>
<td>6.15</td>
<td>116</td>
</tr>
<tr>
<td>WHEY</td>
<td>6.29</td>
<td>118</td>
</tr>
<tr>
<td>WHEY</td>
<td>6.35</td>
<td>120</td>
</tr>
</tbody>
</table>
TABLE 4 - The effect of the thermic treatment on the curdling and proteolytic power of different curdling agents, solved in pasteurized and filtered (pH 6.20) grana whey when curd is broken (7).

<table>
<thead>
<tr>
<th>Curdling agent</th>
<th>Concentration of the curdling agent in grana whey when curd is broken</th>
<th>CURDLING POWER (time in seconds for the curdling of 200 ml. milk reconstructed in CaCl₂ 0.01 M-pH 6.25 at 35°C, adding 1 ml. curdling solution)</th>
<th>PROTEOLYTIC POWER (tyrosine liberated by a 2.5% haemoglobin solution)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>before the thermic treatment</td>
<td>after an incubation period of the solution at 55°C. for:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15'</td>
<td>30'</td>
</tr>
<tr>
<td>Crystallin rennin</td>
<td>1 g/100 ml.</td>
<td>305</td>
<td>560</td>
</tr>
<tr>
<td>Swine pepsin 1:60,000</td>
<td>0.04 g/100 ml.</td>
<td>190</td>
<td>900</td>
</tr>
<tr>
<td>Calf liquid rennet</td>
<td>10 ml/100 ml.</td>
<td>295</td>
<td>635</td>
</tr>
<tr>
<td>Ox liquid rennet</td>
<td>10 ml/100 ml.</td>
<td>290</td>
<td>740</td>
</tr>
<tr>
<td>50/50 liquid rennet</td>
<td>10 ml/100 ml.</td>
<td>195</td>
<td>900</td>
</tr>
</tbody>
</table>

* The pepsin and the ox solutions, incubated at 55°C. for 45', have not formed any rennet either after 2 hours and 30', while the others, incubated at the same temperature for 30' and 45', have formed rennet in 2 hours and 30'.

(over, please)
TABLE 5 - The effect of the thermal treatment (60°C. x 5') on the curdling and proteolytic power of different curdling agents, solved in pasteurized and filtered (pH 6.30) mozzarella stretching water.

<table>
<thead>
<tr>
<th>Curdling Agent</th>
<th>Concentration of the curdling agent in the spinning liquid</th>
<th>Curdling Power</th>
<th>Proteolytic Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time in seconds for the curdling</td>
<td>Tyrosine liberated by a 10% solution of 5.5% haemoglobin solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of 200 ml. milk, 10% of which reconstructed in CaCl₂ 0.01 M - pH 6.25 adding 1 ml curdling solution</td>
<td>/ml.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>before the thermal treatment</td>
<td>after the thermal treatment</td>
</tr>
<tr>
<td>Crystallin rennin</td>
<td>1 g/100 ml.</td>
<td>5' 24&quot;</td>
<td>324</td>
</tr>
<tr>
<td>Swine pepsin 1:60,000</td>
<td>0.04 g/100 ml.</td>
<td>3' 33&quot;</td>
<td>213</td>
</tr>
<tr>
<td>Calf liquid rennet</td>
<td>10 ml/100 ml.</td>
<td>5' 10&quot;</td>
<td>310</td>
</tr>
<tr>
<td>Ox liquid rennet</td>
<td>10 ml/100 ml.</td>
<td>5' 8&quot;</td>
<td>308</td>
</tr>
<tr>
<td>50/50 liquid rennet</td>
<td>10 ml/100 ml.</td>
<td>3' 33&quot;</td>
<td>210</td>
</tr>
</tbody>
</table>
Table 6 - Stability when undergoing a thermal treatment (55°C. x 60') of a microbial curdling agent from *Mucor pusillus* in aqueous solutions at different pH values.

<table>
<thead>
<tr>
<th>pH RELATED TO THE SOLUTIONS</th>
<th>CURDLING ACTIVITY in seconds BEFORE THE THERMAL TREATMENT</th>
<th>CURDLING ACTIVITY in seconds AFTER THE THERMAL TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>390</td>
<td>392</td>
</tr>
<tr>
<td>6.0</td>
<td>395</td>
<td>405</td>
</tr>
<tr>
<td>6.5</td>
<td>401</td>
<td>508</td>
</tr>
</tbody>
</table>
Table 7 — Nitrogen fractions to be found in 13 month old Grana Padano cheese produced using calf rennet or microbial curdling agent from _Mucor miehei_.

<table>
<thead>
<tr>
<th></th>
<th>CALF RENNET</th>
<th>MICROBIAL CURDLING AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOISTURE g/100g CHEESE</td>
<td>43.30</td>
<td>43.25</td>
</tr>
<tr>
<td>DRY MATTER g/100g CHEESE</td>
<td>66.70</td>
<td>66.76</td>
</tr>
<tr>
<td>TOTAL NITROGEN g/100g DM</td>
<td>8.31</td>
<td>8.38</td>
</tr>
<tr>
<td>SOL. NITROGEN g/100g DM</td>
<td>2.62</td>
<td>3.45</td>
</tr>
<tr>
<td>SOL. NITROGEN TCA 2% g/100g M.S.</td>
<td>2.27</td>
<td>2.58</td>
</tr>
<tr>
<td>N SOL X 100 / N TOT</td>
<td>31.53</td>
<td>41.16</td>
</tr>
</tbody>
</table>
Table 8 – Nitrogenous fractions contained in 12 day old Crescenza cheese produced using calf rennet (V) or a curdling agent from *Mucor miehei* (M).

<table>
<thead>
<tr>
<th></th>
<th>SAMPLE A</th>
<th></th>
<th>SAMPLE B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V</td>
<td>M</td>
<td>V</td>
<td>M</td>
</tr>
<tr>
<td>MOISTURE g/100g CHEESE</td>
<td>59.21</td>
<td>60.61</td>
<td>59.82</td>
<td>60.24</td>
</tr>
<tr>
<td>DRY MATTER g/100g CHEESE</td>
<td>40.79</td>
<td>39.39</td>
<td>40.18</td>
<td>39.76</td>
</tr>
<tr>
<td>TOTAL NITROGEN g/100g D.M.</td>
<td>6.01</td>
<td>6.12</td>
<td>5.75</td>
<td>5.78</td>
</tr>
<tr>
<td>SOLUBLE NITROGEN g/100g D.M.</td>
<td>0.74</td>
<td>0.92</td>
<td>0.75</td>
<td>1.25</td>
</tr>
<tr>
<td>( \frac{N_{\text{SOL}}}{N_{\text{TOT}}} \times 100 )</td>
<td>12.29</td>
<td>15.01</td>
<td>13.04</td>
<td>21.62</td>
</tr>
<tr>
<td>N RESIDUAL CASEIN ORIGINATED NITROGEN %</td>
<td>87.60</td>
<td>84.86</td>
<td>86.20</td>
<td>78.01</td>
</tr>
</tbody>
</table>

(over, please)
FIGURE N.1 - SCHEME OF THE MEASURING PRINCIPLE OF THE HELLIGE THROMBELASTOGRAPH
Figure n. 2 - Thrombelastograph parameters adapted to evaluate the rheologic properties of the curdling agents.

\[ T = \text{Coagulation in minutes; is obtained dividing the millimeters of the corresponding thrombelastographic track by 2.} \]

\[ E_t = \text{Consistency of the curd at time from coagulation start. It is given in mm.} \]
Figure n. 3 - Curve of proteolysis, as a function of the residual casein-nitrogen content, in mozzarella cheese obtained from comparative processes using calf rennet (V) and microbial curdling agent from Mucor pusillus (M).
Rheological properties of curd using bovine rennet or calf rennet

(Measurements made with Hellige thrombelastograph).

by C. Corradini

Thrombelastograph parameters obtained with bovine rennet (SPRAY) and calf rennet (POWDER) (Hansen lab.) in coagulation of milk at conditions simulating Grana cheesemaking.

Coagulation temperature
- 33°C.

Acidity of milk
- 4.23 °SH

pH of milk (corrected with lactic acid) 6.47

<table>
<thead>
<tr>
<th></th>
<th>bovine rennet</th>
<th>calf rennet</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (coagulation time) in minutes</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Curd consistency (mm.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E_{15}$</td>
<td>56</td>
<td>61</td>
</tr>
<tr>
<td>$E_{30}$</td>
<td>72</td>
<td>74</td>
</tr>
<tr>
<td>$E_{45}$</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>$E_{60}$</td>
<td>79</td>
<td>79</td>
</tr>
</tbody>
</table>

Thrombelastograph parameters: $T = \text{coagulating time in minutes}$

$E_t = \text{curd consistency at } t \text{ minutes from coagulation start.}$

(in mm.)

(over, please)
Test n. 2 - Influence of thermal treatments on coagulating activity of bovine rennet (SPRAY) in water solution (pH 5.22).

<table>
<thead>
<tr>
<th>Time of thermal treatment (minutes)</th>
<th>Coagulating activity (seconds) after incubation at:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>55°C.</td>
</tr>
<tr>
<td>0</td>
<td>130</td>
</tr>
<tr>
<td>5</td>
<td>135</td>
</tr>
<tr>
<td>20</td>
<td>150</td>
</tr>
<tr>
<td>40</td>
<td>155</td>
</tr>
<tr>
<td>60</td>
<td>200</td>
</tr>
</tbody>
</table>

Test n. 3 - Influence of thermal treatment at 55°C. for 5 minutes on different solutions of bovine rennet.

<table>
<thead>
<tr>
<th>Rennet solution in</th>
<th>pH of solution</th>
<th>Coagulating activity (seconds) before thermal treatment</th>
<th>Coagulating activity (seconds) after thermal treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>5.36</td>
<td>115</td>
<td>120</td>
</tr>
<tr>
<td>Whey from grana cheesemaking</td>
<td>6.15</td>
<td>116</td>
<td>&gt;1200</td>
</tr>
<tr>
<td>Whey from grana cheesemaking</td>
<td>6.29</td>
<td>118</td>
<td>&gt;1200</td>
</tr>
<tr>
<td>Whey from grana cheesemaking</td>
<td>6.35</td>
<td>120</td>
<td>&gt;1200</td>
</tr>
</tbody>
</table>
## ANALYTICAL DATA OF GRANA CHEESES
(after 12-13 months of ripening)

**MADE WITH CALF OR MICROBIAL RENNET**

<table>
<thead>
<tr>
<th></th>
<th>Calf rennet cheese</th>
<th>Nucor miehei cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>g/100g cheese</td>
<td>43.30</td>
</tr>
<tr>
<td>Dry Matter</td>
<td>g/100g cheese</td>
<td>66.70</td>
</tr>
<tr>
<td>Ashes</td>
<td>g/100g dry matter</td>
<td>5.32</td>
</tr>
<tr>
<td>Total Protein (Nx6.38)</td>
<td>g/100g dry matter</td>
<td>53.03</td>
</tr>
<tr>
<td>Total N</td>
<td>g/100g dry matter</td>
<td>8.31</td>
</tr>
<tr>
<td>Soluble N</td>
<td>g/100g dry matter</td>
<td>2.62</td>
</tr>
<tr>
<td>TCA 2% Soluble N</td>
<td>g/100g dry matter</td>
<td>2.27</td>
</tr>
<tr>
<td>Sol. N (\times 100)</td>
<td>Total N</td>
<td>31.53</td>
</tr>
<tr>
<td>TCA 2% Sol. N (\times 100)</td>
<td>Total N</td>
<td>27.32</td>
</tr>
</tbody>
</table>

(over, please)
B.5 Penetrometry-Torsion measurements: The firmness of the paracaseinate gel or of the curd has always been estimated if not measured in the cheese industry since it determines to a large extent the organoleptic quality of the product. Recent measurements use penetrometry 41, 42, 63, 44, 46 or torsionmetry 47, 39, 49. The latter technique, unlike the penetrometry which gives punctuated measurements, is apt to describe continuously a part or the complete evolution of the coagulum.

In this regard, the thrombelastographic method which has originally been developed to study blood coagulation is interesting. It has already been discussed in detail elsewhere 50, 51. Torsimeter and thrombelastograph uti-

lize a system of coaxial cylinders. In the latter, the measuring vat is put into a slow alternating coaxial motion so as not to provoke disruption of the developing gel by shearing. The essential characteristic of the thrombelastographic technique is its ability to allow us to follow the gel formation and the contraction of the gel. However, it must be noted that the flocculation time as measured by the thrombelastograph corresponds to the beginning of the gel formation but not to the appearance of visible flocks. It will therefore necessarily be longer than the time measured with the technique of Sommer and Matsen 46.

Furthermore, the usage of small quantities of milk and rennin makes manipulations very delicate. Careful control of the temperature at which experiments are carried out is required. Fig. 4 and 5 show a thrombelastograph and a scheme of the measuring unit.

Fig. 3: Shape of casein micelles in cow milk after 14 minutes of rennin action; beginning of aggregation. Magnification × 8000 (Hostettler and Imhof 46).

Fig. 4: Thrombelastograph. From left to right: thermostated bath, actual thrombelastograph with the three measuring units. Top of system used in winding the photographic paper.

Fig. 5: Scheme of the principle of the measuring unit of a thrombelastograph.

3 Syneresis

A) Mechanism

The mechanism of the syneresis succeeding coagulation has not been clearly elucidated. The aggregation of casein micelles which causes flocculation continues with the establishment of different types of bonds which will lead to a contraction of the coagulum with expulsion of serum.

Rennin action itself, involving the hydrolysis of \(\kappa\)-casein, causes an initial dehydration due to the loss of the most hydrophilic part. Electrokinetic potential measurements confirm this release and the dehydration of the micelles. The protecting sheet of hydration water is thereby reduced thus facilitating the formation of different bonds. These may be due to the appearance of active groups.