Proceedings from the 25th Annual Italian Cheese Seminar

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Proceedings

25th ITALIAN CHEESE SEMINAR

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25TH ANNUAL MARSCHALL
ITALIAN CHEESE SEMINAR

September 14 & 15, 1988

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A NEW INSTRUMENTAL METHOD FOR MEASURING MOZZARELLA CHEESE CONSISTENCY

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Introduction

Mozzarella differs from most cheeses in that it is usually consumed in the melted state, e.g., on pizza and related foods. This means that Mozzarella quality and acceptability are determined in large part by its melting properties. Melted Mozzarella cheese is viscoelastic in nature, behaving like a liquid in some respects and a solid in others. This viscoelastic behavior has proven difficult to measure because it is extremely temperature dependent and subject to artifacts due to inhomogeneities that frequently occur in melted cheese such as oil separation (3,6).

Traditional methods for assessing Mozzarella melting properties typically involve subjecting a disk of cheese of specific dimensions to heating under defined conditions of time and temperature. The decrease in disk height or increase in disk area following heat treatment is measured and expressed as a percentage of original disk height or area (1,2).

While such methods have given useful information in the past, they are not without problems, particularly in the areas of sensitivity (ability of the test to distinguish between cheeses which "truly" differ in melting properties), repeatability (ability of the test to give the same results when a particular sample is analyzed repeatedly), and interpretation (ability of the researcher to translate analytical test results into meaningful information with practical application) (3).

Data in figure 1 illustrate the problem. In this example, core samples were obtained using a No. 10 cork borer from the middle of two different 5 lb. blocks of 2 day old low-moisture Mozzarella. Each core extended through the entire cheese and included the upper and lower surfaces. The entire core was sliced into 5 mm disks, placed on Whatman 40 filter paper, and heated in an oven at 110°C for 10 minutes. Areas of the melted cheese disks were determined by planimetry and meltability was calculated as increase in disk area expressed as a percentage of original disk area. Meltability values varied greatly, ranging from 0 to 20%, depending on location of the disk along the core. These data demonstrate the large disk-to-disk variation in meltability that is inherent to the test, and which becomes a limiting factor to test sensitivity, repeatability, and one's ability to interpret the test data.

The limitations of traditional meltability tests prompted a search by our research group for a more suitable objective method for assessing melted Mozzarella consistency. Our approach was to find an instrument that is capable of mixing and stretching melted cheese and recording cheese response. That is, we wanted an instrument that can perform under controlled conditions, and
provide a measurement of, something similar to what a person does when he or she consumes a slice of pizza. Two instruments, Brabender farinograph and helical viscometry, were identified as having potential.

Brabender Farinograph

The Brabender farinograph is used widely in industry to measure rheological properties of bread dough (4). The instrument consists of a temperature controlled mixing chamber containing a pair of rotating blades or paddles which are designed to mix or "knead" bread dough under defined conditions. The resistance to mixing of the dough is recorded directly on a mechanical line recorder, providing a graphical profile of dough resistance over mixing time. Because melted Mozzarella displays some of the same properties of consistency as bread dough, we felt that a useful application to Mozzarella was possible.

The following protocol was developed for evaluating Mozzarella cheese:

1. Adjust mixing chamber to 75°C.
2. Add 40 grams of grated Mozzarella to the chamber and mix at 63 RPM for 2 minutes.
3. Add an additional 40 grams of grated Mozzarella to the chamber and continue mixing at 63 RPM for a total of 20 minutes.

Graphical profiles for triplicate analyses of typical Mozzarella cheese (16 days old) are shown in figure 2. The X-axis indicates the 20 minute mixing period while the Y-axis represents the resistance of the cheese to mixing, expressed in farinograph units. The shape of the resistance curve is quite repeatable for an individual cheese but differs from one cheese to the next, thus permitting one to differentiate between cheeses according to resistance profile. Our work with the farinograph is ongoing and currently we are trying to relate the resistance profile to important rheological properties such as elasticity and stretchability. Although this method holds promise as a research tool, a major disadvantage is the cost of the farinograph, about $20,000.

Helical Viscometry

The Brookfield viscometer is used widely to measure viscosity of food and non-food materials (4). Two recent developments have made this instrument a potentially useful tool for measuring melted Mozzarella cheese functionality. The first is incorporation of microprocessing which permits the viscometer to be coupled with a strip-chart recorder or computer, providing a continuous permanent record of the data. The second is the helipath stand which raises the viscometer spindle through a sample at a constant rate, permitting greater test versatility. The following protocol takes advantage of these improvements for the measurement of melted Mozzarella consistency:

Apparatus

- Brookfield RVTDV-II digital viscometer mounted on helipath stand and coupled to a strip
chart recorder
- t-bar spindle “E”
- water bath at 60°C
- large diameter (58 mm) glass cylinder

Test Procedure

1. Cut entire cheese or portion of cheese into 1-2 cm cubes and grate completely in a blender. Mix grated sample completely.

2. Weigh 150 g of grated cheese into a large diameter glass cylinder.

3. Place cylinder containing cheese in a 60°C water bath and set timer for 60 minutes. The 60°C water level should extend well above the upper surface of the cheese.

4. Lower the viscometer fitted with t-bar spindle “E” into the column of grated cheese such that the spindle is positioned 2 cm from the bottom of the cylinder.

5. Cover the cylinder top snugly with plastic wrap to minimize moisture and heat loss and allow the cheese to remain undisturbed for 60 minutes. During this time cheese will melt and form a molten column above the spindle.

6. At the end of 60 minutes, zero the strip chart recorder and simultaneously activate the viscometer at 1 RPM and the helipath stand.

At this point the spindle begins to cut a helical path as it rotates and is lifted through the cheese column. Resistance of the melted cheese to spindle rotation is recorded continuously by the strip chart recorder on standard recorder paper (% yield scale of 0 to 100%). Eventually, the spindle is lifted out of the cheese column, at which point a strand of melted cheese may form between the spindle and cheese surface. Whether or not a particular cheese forms a strand depends on its melting properties. This strand is stretched by the rising spindle to a maximum of about 13 cm above the cheese surface, during which the resistance exerted by the strand on the spindle is recorded continuously. Figure 3 shows a schematic diagram of the test apparatus.

A graphical profile of a typical Mozzarella cheese is shown in figure 4. The X-axis represents time while the Y-axis indicates resistance, expressed in % yield units that we refer to as “apparent viscosity”. Resistance increases progressively as the spindle cuts a helical path through the cheese column, but then decreases sharply as it exits the cheese surface. Eventually, resistance stabilizes as the strand is stretched above the cheese surface. Thus, the profile of melted Mozzarella typically takes the form of a peak with an extended tail region. It should be noted that the profile shown in figure 4 is specific for the test conditions outlined above. If conditions such as sample temperature, t-bar spindle choice, or RPM setting are altered, the resulting profile will differ. We chose the conditions outlined above because most Mozzarella cheeses give a profile that is on-scale and easy to distinguish when analyzed by this procedure.
Test Interpretation

The question that must now be addressed is: what does this graph mean? How does one interpret the analytical data? One way to approach this question is to study cheeses that have very different melting properties and observe how those differences are reflected in the viscometer profile.

Consider first a highly viscous liquid. Figure 5A shows the profile of a liquid viscosity standard (64,960 cp at 25°C) supplied by Brookfield. Test conditions for the viscosity standard (t-bar spindle E, 1 RPM) were the same as those used to test cheese with one exception: the analysis was conducted at 25°C instead of 60°C because the viscosity standard was specifically formulated by Brookfield to give a true liquid of known viscosity at exactly 25°C. The profile of the viscosity standard was a flattened peak. That is, resistance on the spindle increased rapidly to a maximum, corresponding to the viscosity of the liquid, and then remained at the maximum until the spindle exited the liquid. Also, the graph showed no tail because the viscous liquid did not form a stretchable strand above its surface. Finally, the height of the profile was much lower than the Mozzarella cheese profile in figure 4. That is, this very viscous true liquid exerted much less resistance on the t-bar spindle than the melted Mozzarella sample.

The profile of a processed American cheese is shown in figure 5B. This cheese melted at 60°C to a uniform, pourable state that was similar in appearance to a viscous liquid. The viscometer profile resembled that of the viscosity standard in figure 5A, showing a flattened peak. Like the viscosity standard, the melted processed cheese did not form a stretchable strand above its surface.

Figures 7A-7C show profiles of 3 Mozzarella cheeses with very different melting properties. None of the cheeses melted at 60°C to a uniform, pourable state. The first cheese was not a typical Mozzarella. It was extraordinarily tough and fiberous upon melting, forming the thick, ropelike strand shown in figure 6A. The viscometer profile of this cheese (figure 7A) went completely off-scale, indicating extreme resistance exerted by the melted cheese on the spindle. The second cheese was very firm and elastic, typical of a “green” Mozzarella. This cheese gave the strand pictured in figure 6B. The viscometer profile for this cheese (figure 7B) went partially off-scale and gave a very high tail region. The third cheese was much more smooth and gelatinous than the previous two, giving the thin silky strand shown in figure 6C. This cheese exerted much less resistance on the t-bar spindle, resulting in the profile shown in figure 7C.

From these and other analyses we propose the following interpretation of the viscometer profile. Cheeses that are predominantly liquid in nature when melted at 60°C under test conditions give a flattened viscometer profile, the height of which is related to viscosity, or “liquid-like” properties, of the melted material. Thus, processed cheese, which melts to a uniform, pourable state that approaches a viscous liquid, gives a flattened viscometer profile. Mozzarella, on the other hand, does not melt to a uniform pourable state because its curd protein molecules interact strongly with one another. These interactions, largely absent in processed cheese due to addition of calcium-binding emulsifying salts during manufacture (5), are the basis for the properties of stretchability and elasticity that characterize Mozzarella. Stretchability can be thought of as the ability of curd protein molecules to interact in a unidirectional fiberous manner, while elasticity relates to the
strength of the fiberous interactions and their ability to resist deformation upon application of stress.

The viscometer profile of melted Mozzarella reflects a composite of 1.) the viscosity or liquid-like properties of the melted cheese; 2.) the ability of the melted cheese to form fiberous strands that progressively accumulate around the rotating spindle (related to stretchability); 3.) the capacity of the fiberous strands to resist deformation and thereby exert drag against the rotating spindle (related to elasticity). Cheese with a high degree of stretchability tends to accumulate more readily and exert greater resistance on the t-bar spindle, giving higher profile peak height, than one that is not stretchable. In addition, the fiberous strands of a highly elastic cheese exert greater resistance, giving higher profile peak height, than those of a cheese with little elasticity.

In short, the viscometer profile provides qualitative or descriptive information regarding melted cheese viscoelastic properties. It perhaps can be thought of as a “fingerprint” of cheese melting behavior. Figure 8 shows duplicate profiles of 6 different Mozzarella cheeses. Each cheese has its own unique repeatable “fingerprint” determined by its melting properties.

Quantitative Measurements

Our next concern was to reduce this qualitative graphical profile to quantitative terms; that is, to individual measurements that can be summarized, analyzed statistically, and interpreted. A profile measurement that has great intuitive appeal is the maximum peak height. Comparing viscometer profiles in figures 5B, 7B and 7C, one finds that the highly meltable, non-stretchable processed cheese, the firm elastic Mozzarella (figure 6B), and the soft gelatinous Mozzarella (figure 6C) can be differentiated clearly on the basis of maximum peak height.

Future Investigations

Helical viscometry as means to assess cheese melting properties shows exciting potential, but much additional work is needed to optimize the method. For example, cheese melting properties are extremely temperature sensitive. Our test system does not control temperature perfectly. Therefore, we will need to determine how small changes in melted cheese temperature and formation of temperature gradients within the melted cheese column affect the viscometer profile, how to minimize cooling and desiccation at the melted cheese surface, and ultimately how to devise a test system that affords perfect control over temperature. Also, more work is needed to account for and minimize the effect of oil separation on viscometer profile, and to better interpret the information contained within the profile.
Figure 1. Meltability values along core samples taken from two 5-lb blocks of Mozzarella cheese. Core samples were obtained using a No. 10 cork borer. Disks were cut at 5 mm intervals along each core.

Figure 2. Triplicate resistance profiles of a 16 day old Mozzarella cheese obtained by Farinograph method.
Figure 3. Schematic diagram of the helical viscometer apparatus.

Figure 4. Apparent viscosity profile of a typical Mozzarella cheese by helical viscometry method.

A. Spindle immersed in melted cheese begins helical rotation.
B. Spindle exits melted cheese column and forms strand above surface.
C. Cheese strand is stretched by spindle above surface.
Figure 5. Apparent viscosity profiles of (A) a liquid viscosity standard and (B) a processed American cheese by helical viscometry method.

Figure 6. Visual appearance of three different Mozzarella cheese strands by helical viscometry.

A. Tough, fiberous.  
B. Firm, elastic.  
C. Soft, gelatinous.

Figure 7. Apparent viscosity profiles of three different Mozzarella cheeses by helical viscometry.

Figure 8. Duplicate apparent viscosity profiles of six Mozzarella cheeses (A-F) by helical viscometry.
Acknowledgements

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References


PROCESS YIELD OPTIMIZATION MODELS FOR THE CHEESE INDUSTRY

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ABSTRACT

Research advances in the identification of cheese processing variables and their effect upon yields combined with the advances in microcomputer modeling power can be applied to significantly increase processing yields.

The author, using published research and personal research and observation, has developed a user-friendly computer modeling method using identifiable process variables to optimize processing yields. The model is based upon advanced statistical analysis methods of evolutionary processes.

The authors' studies indicate that increases in processing yields of 10-20 percent may be possible with careful identification and control of processing variables.

Process Yield Optimization Models for the Cheese Industry is, I hope, a reasonable title for this paper. However, if I were more marketing oriented, I would rather have titled the paper "How to improve your net profit by 10 percent in the next year", or "How to add $400,000+ to your bottom line" as one of our clients has been able to do using a structured or modeled approach to process yield optimization. These latter titles may in fact also be more accurate titles for this paper because we will be talking about the profit improvements that can be made from the use of models.

Process improvement studies are not something new for the cheese industry. We all have some kind of effort under way, usually within our quality control groups, to control and improve yields. Despite all the investment and commitment we have made to process improvement, we are not always satisfied with the results. With all of the "arts" of cheesemaking we do not seem to be able to make really significant improvements in our process yields. Are our methods and techniques inadequate or are they being misused? Perhaps both.

Some time ago we conducted a process improvement study for an Italian cheese producer. One of the many process variables that we included within the study was the effect that the individual cheesemaker himself had upon the yield of the process. At the conclusion of our study we determined, among other things, that the cheesemaker had a significant impact upon the yield of the batch processed. Indeed, the master cheesemaker consistently out-produced those cheesemakers with less experience, and frequently by as much as 3 to 5 percent.
You are not surprised. After all, the master cheesemaker is by definition experienced, a master, a craftsman, an artist. However, further study showed that as batch sizes increased to more than 10,000 pounds, the higher yield of the master cheesemaker began to diminish. At batches approaching 30,000 pounds, there was no significant difference between the master and the young cheesemaker.

For this company, and perhaps for your own, what this study began to tell us was that as production increases, the "art" of cheesemaking begins to become less important than the "science" of cheesemaking.

For example, preliminary results of microbiological studies at Cornell University indicate a strong correlation between somatic cell count and processing yields. In excellent papers presented at the seminar last year by Barbano and Bringe, the effect of somatic cell count on process yield was clearly demonstrated. Other studies also indicate yield increases of 2-3 percent and possibly higher when somatic cell count is reduced from above 1,000,000 to 100,000 and lower. It is generally known in Wisconsin that at least one cheese producer is paying a 5 percent premium for milk with a somatic cell count under 100,000. Do they know something we do not?

Let's look at another example. A study of one of our client's plants showed that the acidity of their incoming milk was reported to be $16 \pm 0$. For a period of 2 years! Inasmuch as the standard laboratory variance for this test is 15-17...what do you think of the reliability of their laboratory or their ability to use this information to improve process yields? Does your milk show a normal variation for acidity? Do you use blind testing for independent certification of your laboratories?

In the last several years, tremendous advances have taken place in the sciences of microbiology, qualitative and quantitative chemistry, mathematics and statistics, and computers. And these areas alone can provide the basis for the identification and control of the science of cheesemaking.

The world of applied mathematics and statistics has made quantum leaps in just the last several years due principally to the advances in the power of the personal computer. (Newer PCs are capable of operating at speeds of up to 1,000,000 instructions per second faster than many mainframes.)

The personal computer has made practical the uses of matrix algebra, linear programming, mixed integer processing, systems of equations, and evolutionary processes algorithms. And these tools have led to the development of simulation and optimization models for processes, systems, and logistics networks that are revolutionizing some businesses.

(Using these new applications of mathematics and statistics with "Total Quality Control" concepts such as HACCP (Hazard analysis and critical control point) should be priority for this industry, that is another topic, however.)

But, there is another more important result from all of these advances. For the first time in this industry it is possible to take the best "art" and the best "science" of cheesemaking and combine them with reliable measurement, advanced mathematics and statistics, and the computer to
develop models that will optimize the yield of cheese processing.

Many of you may have already conducted studies of your processing operations using control charting techniques to determine the effects that process variables have upon yield. In most cases these studies, while being interesting, rarely pointed to any areas of the process that significantly affected yield because:

1) The input data contains errors similar to those which I discussed earlier.

2) Significant variables were not included in the study (somatic cell count, starter pH, etc.).

3) It is difficult to implement the results of the study in real-time processing because the input data are usually available only "after the fact."

The challenge then is to develop a model (a mathematical representation of the process) that:

1) Automatically determines, statistically, if the input data are accurate and reliable.

2) Automatically determines if all significant variables are included within the model (a minimum regression coefficient of .7 is recommended).

3) Automatically recommends (adjusts) process variables to optimize yield for any "fixed" or any combination of "fixed" input variables.

4) Automatically prints a "batch process order" for each variable of the process based upon the input "fixed" variables such as batch size, somanic cell count, milk pH, etc.

5) Automatically (using evolutionary processes techniques) determines if the batch just processed represents the optimum yield possible and readjusts the regression analysis and coefficient of determination for the next batch.

There are some rather sophisticated mathematics included in this model. You may ask if it is practical for your operation and the answer is simply, yes. The model exists (we like to think that we have already done most of the hard work) and we are prepared to give you a demonstration copy of the software for your review and or use.

The demonstration model (software) works in the following manner using user friendly menus and prompts:

1) Identify all of the significant variables of the process. (You will be limited to 10 variables for this demonstration software.)
2) Input historical data for each variable in the process model for at least the last ten batches produced.

3) Input all known variable data for the batch to be processed. The model will then tell you:
   a) If there are any variables that appear "out of control".
   b) If the variables you have included in the model represent the "significant" variables for optimization of the process yield.
   c) What adjustments or limits to the process should be made to optimize the yield of the batch.
   d) Information within the model database is available for plotting process yield improvement versus history.

The mathematics that take place within the model when you enter data for a processing batch are outlined as follows:

1) The historical data of the process are analyzed using multiple linear regression analysis. Partial regressions and coefficient of determination are calculated for each variable. This analysis includes up to the last 30 batches. (After 30 batches, the oldest batch is dropped leaving us with a 30-batch moving average analysis. The number 30 is chosen as a reasonable compromise between statistical reliability and mathematical complexity.)

2) The known data for the batch to be optimized are checked against the results of the partial regression analysis to determine if there is a significant difference (at the .95 confidence level) between the known variables.

3) Using the known data for the batch to be optimized the historical data are recalculated using "stepwise" multiple regression analysis to determine inter-variable relationships.

4) Using algebraic transformations, predictive statistics are calculated for each unknown or controllable variable in the process. These calculations are based upon the "stepwise" regression analysis.

5) Evolutionary processes calculations are completed using all of the above data to improve the yield by one percent over historical data. This limitation ensures that the process is not radically changed and that yield optimization is steady and gradual, affording maximum process control.

These calculations are automatically completed each time new data are entered for a batch. This
creates a self-correcting analysis that is capable of redirecting the process as more accurate data become available for any process variable.

Concluding this paper, I should restate that the purpose of the model is to help improve processing yields and therefore improve your profitability, perhaps significantly. The model is relatively easy to use and most of your quality control people will have no problems with it.

Our use of the techniques that I outlined has resulted in the following observations about cheese processing in general. You may or may not have similar results for your products and processes.

1) As somanic cell count increases, yield decreases.
2) As batch size increases, yield decreases.
3) As milk pH decreases, yield decreases.
4) As starter pH decreases, yield increases.
5) As mill time increases, yield decreases.

Again, these are not hard and fast rules for every product or process as there may be many interrelationships between variables.

Process optimization modeling exists for the specialty cheese industry and may be an important tool for your company to improve profitability. It is certainly worth a try.
References


ECONOMICS OF CHEESE PRODUCTION COSTS

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The objective of this research was to estimate production costs of Cheddar cheese manufacturing and to assess the cost impacts of different plant sizes, various production schedules, and several current manufacturing technologies. From the perspective of the major factors influencing cheese manufacturing costs, there are many similarities between Mozzarella and Cheddar cheese. This study characterized the relative magnitudes of the impact of a range of plant sizes, production schedules, capacity utilizations, and different conventional technologies for cheese production. The largest influence on cheese manufacturing cost was plant size. Differences in utilization of capacity at utilization levels above 70% had a relatively small influence on cost compared to the economies of plant size. A comparison of various types of conventional technologies and equipment to make Cheddar cheese again revealed relatively small differences in the manufacturing cost per pound of cheese in light of the large economies of plant size.

Introduction

The in-plant cost of manufacturing cheese is of great interest to cheese manufacturers because it is one of the few things in the dairy business that is directly under their control. This study was conducted using Cheddar cheese plants as a model, however most of the relative production cost relationships and some of the actual production costs will be identical for Mozzarella cheese.

Production costs were budgeted for 783 different basic plant designs using the economic-engineering approach. Six plant sizes, nine different production schedules, five conventional cheesemaking technologies and three hooping/packaging systems were used to form the plant combinations needed for the cost estimation (2). Data from a survey of plants done in an earlier phase of the study (1), and engineering consulting firm, equipment manufacturers, product suppliers, plant managers and others were used in the plant design and cost estimation procedures.

The average costs calculated in this manner indicate what could be expected with a new plant, engineered according to the specifications of the design and operated according to the assumed achievable standards based on observations of existing cheese plants (1). For any given plant design or operating schedule, cost that would be achieved in an actual plant would vary with the
quality of the management and labor, actual prices paid for fixed and variable inputs, and milk composition and quality factors which affect cheese yield (3,4,5). The estimated costs included only the costs associated with plant production, that is from the raw milk receiving room through the cheese chilling room. The production costs did not include the cost of raw milk, milk assembly, whey handling, cheese aging, cheese marketing, or any management or administration except direct plant management. Likewise, no credit or charge was considered for the whey cream sold and the liquid whey processed at the plants. The effect on average cost of any of these real-life factors could be very significant; nevertheless, this study demonstrates the importance of scale economies and operating schedules when differences in management, milk quality, and so on are neutralized.

Results

Production Costs. Production costs per pound of Cheddar cheese ranged between 11.0 and 27.4 cents for the model plants with different sizes, production schedules and manufacturing technologies. Production costs for labor, capital costs, utilities, materials, repair and maintenance, property tax and insurance, production inventory, and other costs are itemized in Table 1. Also the range of cost for each category is given for the smallest plant at the lowest utilization level to the largest plant at the highest utilization level.

Economies of Size. Large economies of size were observed in Cheddar cheese production regardless of technology or operating schedule (figure 1). Plant size, by all means, was the most important factor affecting unit costs of production in the model plants. Plant sizes ranging from 480,000 lbs to 2,400,000 lbs of milk per day were modeled. For example, as plant size increased from 480,000 pounds to 960,000 pounds of daily milk capacity, average production costs per pound of cheese decreased by about 30 percent. If the plant size were to increase to about 2,400,000 pounds, the reduction in unit cost would be approximately 50 percent over the 480,000 pound plant.

Production Schedules. Production schedules also had an important impact on the average cost of production. As the number of operating days per week or the number of production hours per day increased, the average production costs per pound of cheese decreased. In other words, the higher the utilization of plant capacity the lower the average costs of production.

Changes in the daily schedules of production had a relatively larger impact on production costs than similar changes in the weekly schedules. For example, model plants were designed to have the same level of plant utilization (71%) with two different production schedules: 5 days per week and 24 hours per day or 6 days per week and 21 hours per day. But the 5-day, 24-hour production organization had a lower cost than the 6-day, 21-hour production organization. Increasing the number of hours of production per day at the plant from 18 to 24 hours caused a reduction in the average costs of about 15 percent (Table 2). On the other hand, increasing the number of operating days from 5 to 7 days per week reduced the costs by about 6 percent (Table 3).

Capacity Utilization. The plant size effects observed in Cheddar cheese manufacturing were so large that they more than offset many increases in cost resulting from operating larger plants at lower levels of plant capacity utilization. This is particularly evident with smaller plants. For
example, a 480,000 pound plant operating 5 days per week and 24 hours per day produces as much cheese per (12.5 million pounds) as a 720,000 pound plant operating 5 days per week 18 hours per day (see figure 1). However, the average costs for that 480,000 pound system were approximately 10 percent higher than the costs for the 720,000 pound plant. Likewise, a 960,000 pound plant operating 5 days and 24 hours manufactures approximately the same volume of cheese per year (25 million pounds) as a 1,440,000 pound plant operating 5 days and 18 hours. However, the larger plant had a 4 percent lower cost than the smaller plant. It appears that the relative cost savings are smaller as the size of the plants increase (see figure 1).

The observation that a given volume of production could be produced at a lower cost per pound of cheese in a larger operation than in a smaller one, generates many horizons for the industry. It suggests that firms that can market only limited volumes of Cheddar cheese perhaps should build a larger plant and operate it at less than capacity instead of building a smaller plant and operating it at capacity. An additional possibility that comes from this situation is that the larger plant might also use the Cheddar down days to manufacture other cheese types. Doing this, the cheese operation would be taking advantage of both the economies of size and the economies of operating a plant at a higher capacity producing relatively smaller volumes of various cheeses.

Technologies. In general, differences in cheesemaking or hooping/packaging technologies had a relatively small impact on the costs of production. The standard cheddaring technology and the regular 40-pound hooping/packaging technology were the highest cost production technologies studied (Table 4). The other four cheesemaking technologies, the automatic cheddaring, the advanced cheddaring, the standard stirred curd, the advanced stirred curd, resulted in similar costs. As the size of the plants increase, the cost difference among these last four technologies became much smaller or nonexistent. Moreover, the block former and the 640/40-pound hooping/packaging technologies also resulted in similar costs for most plant sizes (Table 5).

Labor was the most important component of the production costs and more important in smaller plants than in larger ones. Labor represented between 42 and 58 percent of the total production costs for the smaller size plants while labor accounted for between 24 and 36 percent of the production costs in the larger size plants. Annual capital costs were lower than labor although they are still significant in Cheddar cheese manufacturing. Capital costs represented between 9 and 23 percent of the production costs for all model plants of all sizes. On the other hand, costs of materials represented between 18 and 27 percent in the smaller size plants and as high as 40 percent in the larger operations. Labor, capital and materials accounted for about 83 to 93 percent of the production costs.

For the most part, the relative differences observed between systems and sizes in the original models did not undergo important changes when different cheese yields, interest rates, labor wages and income taxes within normal ranges were considered even though these factors will influence the actual manufacturing cost per pound of cheese.

Conclusion

The primary function factors (equipment, building size, labor, utilities, etc.) that influence cost of
production of Mozzarella cheese will be very similar to Cheddar cheese up to the milling step in cheese manufacture. From this point on there are differences between the two processes that would probably impact greatest on the utilities and labor cost categories. The cooker/stretcher in a Mozzarella cheese plant will use more utilities than are required for Cheddar. Typically, Mozzarella is packaged in smaller sizes and thus would likely have a higher cost of packaging material per pound of cheese. Despite these and other minor differences, we feel that the same trends that characterize the influence of plant size, production schedules, different conventional technologies, etc. on manufacturing cost per pound of cheese in Cheddar will also hold true for Mozzarella cheese.
### Table 1. Average Production Costs for a Selected Group of Five Model Cheddar Cheese Plants\(^a\).

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Cost per Pound of Cheese(^b) (Cents)</th>
<th>Percentage of Total Costs (%)</th>
<th>Cost Range for Different Plant Systems(^c) (Cents/Pound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervisory</td>
<td>0.5</td>
<td>3.0</td>
<td>(0.2 - 1.3)</td>
</tr>
<tr>
<td>Direct Fixed</td>
<td>0.6</td>
<td>3.6</td>
<td>(0.3 - 1.4)</td>
</tr>
<tr>
<td>Direct Variable</td>
<td>5.8</td>
<td>34.7</td>
<td>(3.0 - 9.7)</td>
</tr>
<tr>
<td><strong>Total labor</strong></td>
<td><strong>6.9</strong></td>
<td><strong>41.3</strong></td>
<td><strong>(3.5 - 12.4)</strong></td>
</tr>
<tr>
<td>Capital Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation &amp; Int.</td>
<td>2.3</td>
<td>13.8</td>
<td>(1.2 - 5.2)</td>
</tr>
<tr>
<td>Utilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>0.2</td>
<td>1.2</td>
<td>(0.1 - 0.3)</td>
</tr>
<tr>
<td>Fuel</td>
<td>1.2</td>
<td>7.2</td>
<td>(1.0 - 1.6)</td>
</tr>
<tr>
<td>Water &amp; Sewage</td>
<td>0.1</td>
<td>0.6</td>
<td>(0.1 - 0.2)</td>
</tr>
<tr>
<td><strong>Total Utilities</strong></td>
<td><strong>1.5</strong></td>
<td><strong>9.0</strong></td>
<td><strong>(1.2 - 2.1)</strong></td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>0.1</td>
<td>0.6</td>
<td>(0.1 - 0.1)</td>
</tr>
<tr>
<td>Production</td>
<td>2.9</td>
<td>17.3</td>
<td>(2.9 - 2.9)</td>
</tr>
<tr>
<td>Packaging</td>
<td>1.2</td>
<td>7.2</td>
<td>(1.2 - 1.2)</td>
</tr>
<tr>
<td>Cleaning</td>
<td>0.5</td>
<td>3.0</td>
<td>(0.2 - 1.0)</td>
</tr>
<tr>
<td><strong>Total Materials</strong></td>
<td><strong>4.7</strong></td>
<td><strong>28.1</strong></td>
<td><strong>(4.4 - 5.2)</strong></td>
</tr>
<tr>
<td>Repair &amp; Maintenance</td>
<td>0.2</td>
<td>1.2</td>
<td>(0.1 - 0.3)</td>
</tr>
<tr>
<td>Property Tax &amp; Insurance</td>
<td>0.7</td>
<td>4.2</td>
<td>(0.3 - 1.6)</td>
</tr>
<tr>
<td>Production Inventory</td>
<td>0.2</td>
<td>1.2</td>
<td>(0.2 - 0.2)</td>
</tr>
<tr>
<td>Other Expenses</td>
<td>0.2</td>
<td>1.2</td>
<td>(0.1 - 0.4)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16.7</strong></td>
<td><strong>100.0</strong></td>
<td><strong>(11.0 - 27.4)</strong></td>
</tr>
</tbody>
</table>

Lbs of Cheese per Year 25.0 Million  

\(^a\) The five model plants selected had the following technological systems: standard cheddaring with regular 40-pound hooping; standard stirred curd with block former; automatic cheddaring with 640/40-pound & cutting line; advanced stirred curd with block former; and advanced cheddaring with block former.

\(^b\) The average cost per pound corresponds to plants with a capacity of 960,000 pounds of milk per day, operating 21 hours per day, and 6 days per week.

\(^c\) The upper and lower range ends of the cost correspond to the average costs of the same five systems with a capacity of 480,000 pounds of milk per day, operating 18 hours per day, and 5 days per week and 2,400,000 pounds of milk per day, operating 24 hours per day, and 7 days per week, respectively. The average for the upper cost range excludes the advanced stirred curd system not modeled for that size plant.
Table 2. Production Costs for Four Technological Systems Operating 6-Days per week and Different Daily Production Schedules.

<table>
<thead>
<tr>
<th>Technological System</th>
<th>Plant Size\textsuperscript{a}</th>
<th>Daily Production Schedule (Cents per Pound of Cheese)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18-hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Automatic Cheddaring &amp;</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>640/40-Pound Cutting:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td>26.6</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td>13.9</td>
</tr>
<tr>
<td><strong>Advanced Cheddaring &amp;</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Block Former:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td>25.8</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td>13.7</td>
</tr>
<tr>
<td><strong>Standard Stirred Curd &amp;</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Block Former:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td>24.9</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td>13.5</td>
</tr>
<tr>
<td><strong>Advanced Stirred Curd &amp;</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Block Former:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td>24.5</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td>13.6</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Plant size given in pounds of milk per day.
Table 3. Production Costs for Four Technological Systems Operating 21-Hours per Day and Different Weekly Production Schedules.

<table>
<thead>
<tr>
<th>Technological System</th>
<th>Plant Size</th>
<th>Weekly Production Schedule</th>
<th>5-days</th>
<th>6-days</th>
<th>7-days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Cents per Pound of Cheese)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic Cheddaring &amp; 640/40-Pound Cutting:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td></td>
<td>25.5</td>
<td>24.5</td>
<td>23.7</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td></td>
<td>13.4</td>
<td>12.9</td>
<td>12.5</td>
</tr>
<tr>
<td>Advanced Cheddaring &amp; Block Former:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td></td>
<td>24.6</td>
<td>23.7</td>
<td>23.0</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td></td>
<td>13.2</td>
<td>12.7</td>
<td>12.4</td>
</tr>
<tr>
<td>Standard Stirred Curd &amp; Block Former:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td></td>
<td>23.8</td>
<td>23.0</td>
<td>22.4</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td></td>
<td>13.0</td>
<td>12.6</td>
<td>12.3</td>
</tr>
<tr>
<td>Advanced Stirred Curd &amp; Block Former:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 480,000 Pounds</td>
<td></td>
<td></td>
<td>23.5</td>
<td>22.6</td>
<td>22.0</td>
</tr>
<tr>
<td>b) 1,800,000 Pounds</td>
<td></td>
<td></td>
<td>13.1</td>
<td>12.6</td>
<td>12.3</td>
</tr>
</tbody>
</table>

a Plant size given in pounds of milk per day.
Table 4. Costs for Various Cheesemaking Technologies, Different Size Model Cheddar Cheese Plants Operating at 100 Percent Capacity with Regular 40-pound Hooping.

<table>
<thead>
<tr>
<th>Plant Size</th>
<th>Cheesemaking Technology</th>
<th>(Cents per Pound of Cheese)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard Cheddaring</td>
<td>Automatic Cheddaring</td>
</tr>
<tr>
<td>480,000</td>
<td>25.5</td>
<td>24.3</td>
</tr>
<tr>
<td>720,000</td>
<td>19.8</td>
<td>18.7</td>
</tr>
<tr>
<td>960,000</td>
<td>17.3</td>
<td>16.2</td>
</tr>
<tr>
<td>1,440,000</td>
<td>14.7</td>
<td>13.6</td>
</tr>
<tr>
<td>1,800,000</td>
<td>13.2</td>
<td>12.4</td>
</tr>
<tr>
<td>2,400,000</td>
<td>11.8</td>
<td>11.1</td>
</tr>
</tbody>
</table>

* Plant size in lbs of milk per day.
NA - not available at the time of the study.

Table 5. Costs for Various Hooping/Packaging Technologies, Different Size Model Cheddar Cheese Plants Operating at 100 Percent Capacity and Using Standard Cheddaring Technology.

<table>
<thead>
<tr>
<th>Plant Size</th>
<th>Hooping/Packaging Technology</th>
<th>(Cents per Pound of Cheese)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regular 40-Pound</td>
<td>Block Former</td>
</tr>
<tr>
<td>480,000</td>
<td>25.5</td>
<td>23.1</td>
</tr>
<tr>
<td>720,000</td>
<td>19.8</td>
<td>18.6</td>
</tr>
<tr>
<td>960,000</td>
<td>17.3</td>
<td>16.5</td>
</tr>
<tr>
<td>1,440,000</td>
<td>14.7</td>
<td>14.1</td>
</tr>
<tr>
<td>1,800,000</td>
<td>13.2</td>
<td>12.7</td>
</tr>
<tr>
<td>2,400,000</td>
<td>11.8</td>
<td>11.5</td>
</tr>
</tbody>
</table>

* Plant size in pounds of milk per day.
Figure 1. Long-Run Cost Curve for Cheddar Cheese Production.
References


Acknowledgements

Financial support for this research was provided by two sources: Agricultural Marketing Service of the United States Department of Agriculture and the Agricultural Research and Development Grants Program of the New York State Department of Agriculture and Markets. Mead & Hunt, Inc., an engineering consulting firm in Madison, WI, in cooperation with many equipment manufacturers and cheesemakers provided information on costs and engineering data for the model cheese plants. We thank the many industry and university personnel that acted as a critical review panel for this project.
AUTOMATIC MULTI-COMPONENT STANDARDIZATION FOR DAIRY PRODUCTS

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Leeuwarden, The Netherlands 8901 BD

The paper which I am about to present, intends to provide you with an impression of the Automatic Multi-Component Standardization System, in short AMS.

Introduction

First I should like to give you an overall view of the dairy industry in Holland, to give you an idea of the developments that have stimulated us to develop an in-line standardization system.

Holland is a small, densely populated country. Its territory covers one quarter of the area of Wisconsin, but it has a population of 14 million.

Milk production is about the same as in Wisconsin. The most important dairy product is cheese. Holland specializes in hard cheese like cream, Cheddar, Edam and Gouda cheese.

There are about 60 cheese factories. The largest cheese factory processes 690 million pounds of milk per year. The average cheese factory processes 410 million pounds of milk per year.

Until 1984 there was an upward trend in milk production. In April 1984 the European Community introduced quota regulations. Farmers who produce more than their quorum are fined. This has caused a downward trend in milk production since 1984. Since 1984 milk production has decreased by approximately 20%.

Statistical Figures

In 1987 25 billion pounds of milk were produced in Holland.

Cheese production amounted to 1,225,000 pounds.

Production of whole milk powder was 370,000 pounds.

Skimmed milk powder production was 205,000 pounds.

Production of condensed milk amounted to 1 million pounds.

Production of butter was 430,000 pounds.

Standardization Trends

Before 1960 the dairy industry developed gradually, at a moderate pace. There was a continuous
decrease in the number of dairy plants. The average size of a plant increased gradually.

Between 1960 and 1980 developments went very fast. There was a strong tendency to rationalization and automation. There also was a rapid decrease in the number of dairy plants. The average size of a dairy plant increased very fast.

Since 1980 there has been a trend to more flexibility. Much effort went into product diversification. A lot of money has been invested in more flexible equipment.

Before 1960 the cheese vat was subject to standardization. Standardization in the cheese vat has the advantage of minimum investment costs and maximum flexibility.

The disadvantages of cheese vat standardization are high labor costs and low accuracy of the standardization.

Between 1960 and 1980 most cheese factories have introduced standardization tanks. Advantages of standardization tanks are high accuracy and lower labor cost than standardization in the cheese vat.

Disadvantages of standardization tanks are low flexibility and high investment costs.

After 1980 some dairy plants changed over to in-line standardization. Advantages of in-line standardization are:

- maximum flexibility
- minimum labor costs
- investment costs independent of the number of cheese types which have to be produced per day
- short storage time of the milk
- very compact equipment
- more data available (This makes it possible to improve quality control and to make more reliable plannings.)

Disadvantages of in-line standardization are:

- expensive for small cheese factories with few cheese types
- necessary to train operators

**Standardization For Different Products**

One can distinguish two kinds of standardization: standardization on fat and multi-component standardization. In the case of standardization on fat the aim is to get a certain percentage of fat in the milk. In the case of multi-component standardization, the aim is to get a certain ratio between fat and another milk component.
Standardization on fat is suitable for market milk. Multi-component standardization is necessary for cheese, whole milk powder, evaporated milk and sweetened condensed milk.

**Automatic Multi-Component Standardization System (AMS)**

The AMS system was developed in 1985 at the request of one of our customers, a cheese factory with a serious lack of space.

The factory did not have room for standardization tanks and was therefore interested in an in-line system. At the time there were only in-line systems which were capable of standardization on fat. This was not acceptable for the factory concerned.

They demanded an in-line system that could offer the same or a better accuracy than standardization tanks. In order to obtain such accuracy, one has to use multi-component standardization.

I shall now explain with respect to the standardization of cheese milk why multi-component standardization offers a better accuracy than standardization on fat.

The objective of cheese milk standardization is to obtain a desired percentage of fat in the dry matter of the cheese.

The fat content in the dry matter is dependent on 2 factors:

1. The amount of fat which passes from cheese milk into cheese.
2. The amount of fat free dry matter which passes from cheese milk into cheese.

The percentage of fat in the cheese milk is a good indication for 1. The percentage of casein in the cheese milk is a good indication for 2. Unfortunately, there is no equipment available for the in-line measurement of casein.

Instead, one has to measure either fat or protein. From these two, protein gives a better indication than fat. The casein - protein ratio is more constant than the casein - fat ratio.

The following formula can be used for standardization when the percentage of protein in cheese milk is used as an indicator for the casein content.

\[
\frac{F_{cm}}{P_{cm}} = \frac{F_{D}}{100 - F_{D}} \times \frac{C_{R}}{C_{F}}
\]

- \( F_{cm} \) - Fat content cheese milk
- \( P_{cm} \) - Protein content cheese milk
- \( C_{R} \) - Conversion factor fat free dry matter
- \( C_{F} \) - Conversion factor fat
- \( F_{D} \) - Fat content in dry matter in cheese

\[
\frac{F_{cm}}{P_{cm}} = \text{Ratio}
\]
Fat in cheese milk divided by protein in cheese milk equals
Fat in dry matter of cheese divided by hundred minus the percentage of fat in the dry matter times
Conversion factor fat free dry matter divided by conversion factor fat
* The conversion factor fat free dry matter fluctuates a little with the season.
* The conversion factor of fat is nearly constant.

So the right part of the formula can be considered as a constant which has to be adjusted a few times during the year.

Therefore there is a linear relation between the ratio of fat in cheese milk to protein in cheese milk and fat in dry matter divided by hundred minus the percentage of fat in the dry matter.

The percentage of fat in dry matter is dependent of the type of cheese. Therefore the fat : protein ratio you want to have in the cheese milk depends on the type of cheese you want to make.

You can see some ratios which are used for different types of cheese.

Gouda - 1.000  Maasdam - 0.870  Edam - 0.745  20+Cheese - 0.300

For cheese with high dry matter fat contents you have to opt for a higher ratio than for cheeses with a low content of fat in the dry matter.

The percentage of fat in the dry matter of Gouda cheese must be higher than 48% and lower than 52%.

20+ Cheese must contain more than 20% fat in the dry matter of the cheese.

I shall now discuss the technical aspects of the AMS system. You can see in figure 1 that the technical principle is simple.

Whole milk from tank no. 1 and skimmed milk from tank no. 2 are pumped into the main pipeline. If the length of the pipeline between the storage tanks and the cheese vats is very short, a static mixer is used to achieve a correct mixing of these liquids. In most factories a static mixer is not necessary, because mixing takes place in the pipeline.

The fat and the protein contents of the standardized milk are measured in-line by infrared analysis equipment. A microprocessor calculates what the required percentage of fat in the cheese milk is, taking into account the protein content.

The microprocessor uses the calculated value for the fat content of the cheese milk as a setpoint. When the measured fat content is lower than the calculated value, the whole milk flow is adjusted upwards. When the measured fat content is higher than the calculated value, the whole milk flow is adjusted downwards.

The microprocessor controls the number of revolutions of pump 1 by means of a frequency
regulator. The capacity of the total liquid flow is kept constant with a capacity controller, operated from the microprocessor.

Pump 1 can be a centrifugal or a positive pump. If pump 2 is a centrifugal pump, the skim milk supply will be adjusted downwards or upwards automatically whenever the whole milk supply is adjusted owing to the constant total capacity.

In a version with two positive pumps there is no need for a total capacity control valve. In that case the number of revolutions of both pumps is controlled by the microprocessor.

The AMS system can control up to 3 lines simultaneously.

In figure 2, you can see how the AMS system can be used for the standardization of cheese milk.

Whole milk, skimmed milk, and in some cases buttermilk and whey cream are fed by pumps from storage tanks to the manifold, which injects the four supply flows into the main pipeline. A small part of the flow is routed to the analysis equipment.

The analysis equipment continuously samples the cheese milk, analyzing in terms of fat and protein content. The sampling line should be as short as possible to keep the lag time short.

The total flow is preset by the operator. The total flow is measured continuously by a flow meter. Capacity control takes place by means of a control valve.

The whey cream and buttermilk capacity are set at a fixed percentage of the total quantity of cheese milk.

The microprocessor decides the quantity of whole milk needed to get cheese milk with desired fat content.

The supplied quantity of skim milk is determined by the preset total flow.

In figure 4, you can see the measurement and control unit of the AMS system.

Infrared analysis equipment is used for the measurement of fat and protein in the cheese milk. Therefore equipment of Foss Electric has been selected. A MMS 305 is used when there are two or three cheese lines. A milcoscan 133 is used when there is only one cheese line.

The master of the in-line unit is an μ mac 5000 or 6000, an industrial computer. The μ mac samples data from Foss and PLC and follows instructions of the operator. With the collected data the μ mac exercises flow control. After each produced cheese vat the μ mac generates a report.

The PLC follows the orders of the μ mac. When a flow has to be increased, the action is executed by the PLC. It is the μ mac however which decides that the flow has to be increased at a given time.
The program of the μmac is menu driven. The most important menu is the one which is used to enter the desired production schedule.

First, the operator can choose the cheese line. The maximum number of cheese lines is three. Then the operator must enter the sequence of vats. For instance from vat number 1 to vat number 4 he wants to make Gouda cheese. From vat number 4 to vat number 10 he wants to make Edam cheese.

For a maximum of 16 cheese types the computer can store standards. These standards are for instance the fat - protein ratio of the cheese milk, the quantity of cheese milk in a cheese vat etc.

When set on automatic the AMS executes the production schedule automatically. The cheese vats are filled in the right sequence with cheese milk. After a cheese vat has been filled, a vat report is printed.

The vat report contains:

- the number of the cheese line
- the sequence number of the cheese vat
- the type of cheese which has been made in the cheese vat
- the number of samples that has been taken by the infrared analysis equipment
- the weight of fat in kg in the vat
- the weight of protein in kg in the vat
- fat - protein ratio
- charge of liters of cheese milk
- liters of whole milk
- liters of whey cream
- liters of buttermilk

As you can see the exact composition of the cheese milk is registered for each cheese vat. At any time it is possible to have the computer make a report containing the cumulated results of all the vats that have been produced that day. As you can see in-line standardization offers the possibility to provide the management with a lot of information automatically, which otherwise has to be compiled by hand.
Figure 1.

Figure 2.
AMS-system
AUTOMATIC
MULTICOMPONENT
STANDARDIZATION

Figure 3.

Figure 4.
DAIRY CENTER RESEARCH AND PROJECTS AFFECTING ITALIAN CHEESE

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Prior to the Dairy and Tobacco Adjustment Act of 1983, U.S. food and agricultural research funding was divided among private, state and federal sources as follows:

**U.S. AGRICULTURAL RESEARCH**
Funding Sources in 1983

<table>
<thead>
<tr>
<th>% Total Funding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>Private</td>
</tr>
<tr>
<td>18</td>
<td>State</td>
</tr>
<tr>
<td>31</td>
<td>Federal</td>
</tr>
</tbody>
</table>

About thirty-one percent (31%) of the agricultural research came under Federal funding programs (1,2).

USDA has many of the postharvest programs, but others involve the Food and Drug Administration, the National Science Foundation and other federal agencies (3). In 1987, approximately twelve percent (12%) of the total agricultural research dollars was spent for postharvest and marketing research. The 1983 Office of Technology Assessment report indicated a reduction of seventeen percent (17%) in USDA support of postharvest research over the previous ten to fifteen (10-15) years (4). Although state and industry funding increased during that time, much of this research is of an applied nature and plays a supporting role to production agriculture.
As a result of dairy research funding priorities, the amount of research in dairy production, measured by the number of papers presented (or published) at the ADSA annual meetings, has been ever increasing.

This year, 451 dairy production papers were presented (5).

In contrast, it was not until 1980 that the general decline in dairy food research papers stabilized, and a significant increase has been evident since 1981.
This year 166 dairy foods research papers were presented. As a percent of total research papers, dairy foods research is nearly constant.

This year dairy foods research papers represented about twenty-seven percent (27%) of the total papers presented.

It was recognized that something needed to be done to increase support for Dairy Foods research. In 1983 the Dairy and Tobacco Adjustment Act established the National Dairy Promotion and Research Board (NDPRB), funded by the dairy farmer checkoff program with USDA oversight review (6). The Board seeks to increase the utilization of milk and dairy products by humans through advertising, nutrition education, and nutrition and product research (7).

The Product Research Program included Competitive Research, Dairy Centers, Scholarships and Focused Research. It is the Dairy Foods Research Centers (DFRC) that will be the focus of this presentation.

Six DFRC’s have been selected after review and screening of twelve proposals involving thirty-two institutions.
All six Centers have signed contracts and received funding. Annual Plans for the first year operation have been approved leading to the funding of seventy projects now underway at Center locations with twenty-nine more pending approval by local Advisory Boards.

Support for the Centers comes from the universities, local dairy industry and NDPRB. University support is in the form of facilities and staff, measured in full time equivalents (FTE).

<table>
<thead>
<tr>
<th>Center</th>
<th>FTE's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast</td>
<td>6.0</td>
</tr>
<tr>
<td>Northeast</td>
<td>9.6</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>7.5</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>6.2</td>
</tr>
<tr>
<td>Western</td>
<td>6.6</td>
</tr>
<tr>
<td>California</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>41.6</strong></td>
</tr>
</tbody>
</table>

There is a real need to increase the research manpower at these Centers. The total number of people, 41.6, committed to dairy research is rather small considering that the Dairy Centers are a national effort. Project funding addresses the need to support young researchers at the graduate level. The newly established Scholarship Program seeks to attract undergraduates to a career in the dairy industry by providing twenty scholarships, One Thousand Dollars ($1,000) each, to juniors and seniors seeking a career based on dairy food science.

Local industry support comes from financial contributions of participating local sponsors.

<table>
<thead>
<tr>
<th>Center</th>
<th>Annual Local Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast</td>
<td>$388,413</td>
</tr>
<tr>
<td>Northeast</td>
<td>939,175</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>721,311</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>400,000</td>
</tr>
<tr>
<td>Western</td>
<td>500,500</td>
</tr>
<tr>
<td>California</td>
<td>458,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,407,399</strong></td>
</tr>
</tbody>
</table>
Based on selection criteria and other financial support, NDPRB has allocated its annual funding, totaling $13,500,000 over a five-year period, as follows:

<table>
<thead>
<tr>
<th>Center</th>
<th>Annual Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast</td>
<td>$400,000</td>
</tr>
<tr>
<td>Northeast</td>
<td>600,000</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>500,000</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>400,000</td>
</tr>
<tr>
<td>Western</td>
<td>400,000</td>
</tr>
<tr>
<td>California</td>
<td>400,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,700,000</strong></td>
</tr>
</tbody>
</table>

The objectives for the Dairy Foods Research Centers are:

- Conduct research that would increase the utilization of milk for human consumption.
- Develop, coordinate and seek funding for multi-disciplinary research programs.
- Develop, maintain and disseminate information on dairy research.
- Attract visiting scholars from universities, governmental agencies and industry.
- Coordinate activities with other Dairy Centers.

In the Annual Plans for the six Dairy Centers, there are six general research categories:

**DFRC Research Categories**

- Dairy Food Processing
- Dairy Food Development
- Dairy Biotechnology
- Dairy Food Quality
- Dairy Food Safety
- Basic Studies

First year Budgets indicate a good mix of funding percentage over these six areas.

At this writing, five of the six Dairy Foods Research Centers have approved projects for funding. Twenty-seven projects have a direct relationship to cheese and several more would indirectly apply to cheese. It is expected that more cheese research projects will be added when the Northeast Center’s Advisory Committee meets to approve projects and when projects are periodically reviewed at all Centers for future years.
The following projects would lead to results that could be applied to Italian cheeses.

<table>
<thead>
<tr>
<th>Center</th>
<th>Investigator</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>S. Schwartz</td>
<td>Supercritical Fluid Technology-Application to the Dairy Industry</td>
</tr>
<tr>
<td>WI</td>
<td>R. Bremmel</td>
<td>Incorporation and Expression of Bovine Casein in Transgenic Animals</td>
</tr>
<tr>
<td>WI</td>
<td>E. Johnson</td>
<td>Generation and Roles of Proline in Providing Flavor and Pathogen Protection in Cheese</td>
</tr>
<tr>
<td>WI</td>
<td>E. Johnson</td>
<td>Prevention of Survival and Growth of Pathogens in Milk and Cheese by Enhancement of the Activity of Lactoferrin and Lysozyme</td>
</tr>
<tr>
<td>WI</td>
<td>R. Hartel</td>
<td>Enzymatic Modification of Butterfat in Supercritical Carbon Dioxide</td>
</tr>
<tr>
<td>WI</td>
<td>C. Hill</td>
<td>Use of Immobilized Enzymes in the Treatment of Milkfat</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>L. McKay</td>
<td>Plasmid Biology and Analysis of Gene Transfer Systems of Dairy Streptococci in Order to Construct Strains for Improved Dairy Fermentation Processes</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>S. Harlander</td>
<td>Genetics of Lactobacilli of Interest in Dairy Fermentations</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>S. Harlander</td>
<td>DNA Fingerprinting for Identification of Microorganisms of Interest to the Dairy Industry</td>
</tr>
<tr>
<td>MN/SDS</td>
<td>S. Tatini</td>
<td>Use of Specific Lactic Acid Bacteria to Control Pathogens in Cheese</td>
</tr>
</tbody>
</table>
The major themes of these projects can be identified as follows:

- Genetic improvement of milk proteins to optimize cheese characteristics
- Control of pathogens in cheese
- Application of biotechnology to improve quality and functionality of cheese
- Process development and improvement of cheese
- Modification of milkfat to improve its functional and nutritional quality
Much of this work will lead to increased utilization of milk satisfying the funding mandate of the National Dairy Board. Some work will not fit this guideline but will fit the needs of local industry sponsors. The Dairy Center concept is large enough to include both interests.

Perhaps the key to the impact the DFRC program will have on the Italian cheese industry is communication of industry needs and research results. Now that the majority of research projects are underway, there will be more emphasis on gathering information relating to industry needs and on commercializing research results. Innovative strategies will be needed to make this communication successful. Participation of industry sponsors in the research programs of the individual Dairy Centers is encouraged to help identify needs and pave the way for implementation of new technology.

In summary, the NDPRB Dairy Foods Research Centers Program is designed to contribute to the Cheese Industry by:

- Participating in funding of multidisciplinary dairy research programs that would increase the utilization of milk and dairy products by humans.
- Supporting the development of dairy careers at the graduate and undergraduate levels and provide for exchange of dairy research professionals.
- Coordinating the research activities and results among the six Dairy Centers.
- Develop promising technologies and communicate research information to industry.
References


A SURVEY OF CHEESEMAKING TECHNOLOGY AND CHEESE PRODUCTION IN ITALY

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Cheesemaking Technology

Although cheesemaking survived for 6000 to 7000 years as an "Art," the advance of scientific knowledge (while still incomplete) has enabled cheesemakers to advance from the small-scale farm operation to the large-scale factory production of consistently sound cheese. Today, cheesemaking is known as a fermentation process within which time, temperature, acidity, concentration of reactants (or metabolites in relation to bacteria), water activity in the curds and concentration of inhibitors (salt) play significant roles. Apart from the growth of microorganisms, the cheesemaker has the physical control of some of these parameters.

Figure 1 shows the outline of cheesemaking procedures used in Italy, as follows:

- raw milk-supplies collected from a large number of farms are stored at the cheese plant into silo tanks at a temperature of 3° to 5°C (for 1-3 days), until required for transformation into cheese. During this storage, the biological, biochemical and physical changes of milk supplies are often controlled using rapid and specific tests of routine. Before the milk is passed over to cheesemaking, the standardization is usually carried out as part of a total cheese process, involving a) the use of a standardizing centrifuge to take sufficient cream off the milk so that the remaining cream and milk together are of the correct fat standard; b) heat treatment at 72°C for 15 seconds in order to destroy unwanted bacteria;
- the milk already heat treated is cooled at a temperature of 28 to 30°C, pumped into cheese vat and then starter culture and rennet are added according to the cheese to be produced. The cheese coagulum formed is cut and, for some cheese types, scalded or cooked under stirring;
- after draining of the whey, the cheese coagulum (curd) is ready for further manipulation, i.e. molding of curd, salting of untextured cheese, pressing of cheese to expel any free whey, ripening of cheese at temperatures dependent on the type of cheese, packaging of ripened cheese on retail markets for consumer sale.

These cheesemaking procedures deeply change according to the various types of cheese. In this paper, it is advisable to consider only the Italian cheese types best known in Italy as well as in other countries, emphasizing some technical characteristics of their own. This choice is due to the fact that in Italy there is a great variety of cheeses.

The Pasta Filata Cheese Types. MOZZARELLA and SCAMORZA cheeses, normally eaten fresh, and PROVOLONE cheese, a type of ripened cheese, belong to this group of cheese. Mozzarella cheese, originally made from buffalo milk in southern Italy, is now produced from whole
or partly skimmed buffalo milk or cow's milk, or mixed. It is a rennet curd cheese rather than an acid precipitated curd cheese. Acidity is allowed to develop in the curd mass (pH 5.2 down to 4.9). The acidified mass is then reduced to a plastic mass in hot water (80-85°C) by hand or machine. Finally, the plastic curd is formed into bands and cord strips which are rolled into spiral shape or rounded into smaller shapes and then cooled in 15-20% salt brine at 5-10°C for the time required. Artificial flavor or flavor-producing enzymes are never added to Mozzarella cheese. Standards of identity for this cheese have been proposed by various Regions of Italy, but with no success; there is only an Act (Act of September 28, 1979) which prescribes, for Mozzarella cheese produced from buffalo milk, the legal water and fat contents, 65 percent (maximum value) and 50 percent (minimum value on dry basis), respectively (1). Apart from this Act, manufacturing methods of Mozzarella cheese change according to the market to which the cheese is destined. In fact, the cheese exists in a large number of shapes and sizes with different fat and water contents.

Scamorza cheese is a low moisture cheese made in similar manner to Mozzarella, but shaped only into balls with top protruding lobes.

The Provolone cheese is a ripened cheese best typifying the Pasta Filata cheese. In actual practice, the manufacture of this cheese is simply a continuation of Mozzarella cheese manufacturing since the plastic curd, after being shaped into definitive forms, is ripened for several months at temperatures ranging from 12° to 14°C. It is made in a number of different sizes and shapes, i.e. bottle shaped, cylindrical, square, oblong, etc. The flavor is typically sweet, but when fully ripened, sharp and piquant. Sometimes, Provolone cheese may be smoked after salting by suspending the cheese in the smoke from burning maple, hickory or oak logs until the soot covers the cheese. Provolone cheese is consumed as a dessert.

Today, these Italian types of cheese are produced and consumed in other European countries as well as Canada and the United States, wherein the Mozzarella cheese, for example, is consumed in the measure of 1.6 Kg per capita yearly (2). The Italian influence in countries outside Italy is also shown by the significant presence, in these countries, of Ricotta and Ricottone (Whey cheese) cheeses, originally made in southern Italy from Mozzarella cheese whey with or without added milk.

Hard Italian Cheeses. Although many cheese types, belonging to this group, are produced in Italy, the most important, especially for export, are PARMIGIANO-REGGIANO, GRANA PADANO and PECORINO ROMANO. These cheeses need a long period of ripening and, when fully ripened, are used for grating.

Parmigiano-Reggiano and Grana Padano are also known as Parmesan cheese and Grana cheese, respectively. These two cheeses are similar with respect to cheesemaking technique, but different with respect to area and year's period of their productions. Parmigiano-Reggiano cheese is manufactured between April and November in the typical area, which includes the provinces of Parma, Reggio Emilia and Modena in their entirety and some towns in the provinces of Mantua and Bologna. Grana Padano cheese is produced all year round in the provinces of Pavia, Milano, Cremona and Brescia. These two cheeses have a distinct granular structure and hard rinds. They are cylindrical cheeses, 35-45 cm diameter x 18-25 cm, weighing 24 to 40 Kg. Milk from two successive milkings is used in each batch of cheese: the evening milk and the morning one. Before
use, the evening milk is poured into the trays to rest throughout the night, while the morning milk is used after resting for approximately one hour. A portion of the cream, naturally accumulated on the surface during the night, is taken off the evening milk. This milk, partially skimmed, and the morning one are then poured together into a copper cauldron shaped like an inverted church bell. At this stage, whey starters (instead of milk starters) are added to the milk which is held under a light stirring at 32°-34°C for 10-15 minutes. After this period of time, the heat is taken off and the rennet (a natural extract from the stomachs of suckling calves) is added to the milk. Coagulation occurs within 12-15 minutes. The resulting coagulum is cut up to 3 mm size, then the temperature raises slowly up to 52°-55°C and the mass is stirred for 30 minutes. After this time, the heat is switched off, and the cheese granules are precipitated towards the bottom of the cauldron, where they again form a solid mass. After about half an hour, this mass is raised with a wooden paddle, collected in a sieve-cloth and then taken out. While wrapped in its cheese-cloth, the “cooked” curd-mass is placed inside a circular wooden mold or “fascera” and lightly pressed down to put out the remaining whey. After a few hours, the cloth is removed and a special stencil is inserted between the cheese and the inside part of the mold. The stencil impresses over the entire lateral side of the new cheese the words “Parmigiano-Reggiano”, repeated at close intervals. The cheese is then turned at frequent times, to rest on each of its flat sides alternately, and is left in the mold for a few days until its final shape is set without a danger from subsequent distortions. The cheese is then removed from the mold and salted by immersion in coarse-salt brine at 7°-10°C for a period of 20-25 days. Successive ripening of cheese in the curing room at 5°-10°C for 2-3 years ends the manufacturing process of this cheese.

Pecorino Romano cheese is the oldest cheese manufactured in Italy; it takes its name from Rome since it was made for many years in the region of Lazio. Today, it is produced in other areas of Italy, especially in Sardegna, where there are sheep-breedings. The Pecorino Romano is a cheese from sheep’s milk, but there are also little productions of Caprino Romano, goat’s milk cheese, and of Vaccino Romano, cow’s milk cheese, both produced with the same technology of Pecorino Romano cheese. This is a cylindrical cheese, size 20-25 cm diameter x 14-24 cm, weighing 8-20 Kg. The Pecorino Romano cheese is grating cheese with a piquant flavor. The milk is usually treated at temperatures ranging between 60° and 65°C for 30 minutes and then cooled at 38°-40°C. At these temperatures, lamb past rennet is normally added to obtain firm curd within 15-20 minutes. The curd is cut up to size of wheat grains, scalded at 44°-46°C for 15-20 minutes and then slowly stirred for further 20 minutes. After draining whey, the curd is placed in wooden hoops and then pricked thoroughly (frugatura) with long metal prongs (anciently with fingers) to consolidate the curd in the hoops and take off the remaining whey. The cheese is then removed from the hoops, rolled in fine dry salt and placed again into hoops. This operation is repeated more and more during a period of 3 months. After this period, the cheese is washed with 10% brine and held in the curing room at 15°-18°C. The cheese is ripe in approximately 8 months. It has a high salt content (5-8%) and is salty to taste.

Table 1 shows a typical analysis of Mozzarella, Scamorza, Provolone, Parmigiano-Reggiano, Grana Padano and Pecorino Romano cheeses.

**Cheese Production.** The annual production of cheese in Italy depends not only on the availability of milk but also on the ability to sell the cheese. The Italian cheese market is somewhat complex
since it depends on a variety of factors such as prevailing economic conditions, market changes due to eating habits, and changes in tariff barriers to trade. This last observation recalls to mind the milk production quotas, imposed recently by the European Economic Community (EEC) by means of EEC Regulations No. 1335 and No. 1336 of May 6, 1986 and No. 726 of March 16, 1987. As a consequence of these Regulations, at present, only an aliquot part (about 85%) of the milk utilized by dairy and cheese industry is produced in Italy, member of the EEC, and sixty percent of the milk received by plants is processed into cheese (3).

Italy is exporter of cheese, in spite of the high consumption (about 15 kg) per capita of cheese a year (4). Also the other EEC countries produce more cheese than they need, as it can be seen from the self-sufficiency ratios issued in 1981 (Table 2) for each EEC member (5).

It Italy, cheese is still produced both by home industries and by highly mechanized ones. Furthermore the demand of cheese from consumers has recently modified. In general, we can state that: a) there has been an increasing demand for varieties of soft cheese, especially for Mozzarella and Scamorza cheeses; b) the production of hard cheeses has maintained unchanged; c) the number of cheese plants (especially plants of hard cheese types) has decreased, while the average production per plant has increased as a consequence of the new technological improvements adopted in the cheese plants.

Most of the highly mechanized cheese plants are in the North of Italy, where there are not only the biggest milk productions but also the most qualified cheesemakers. As a consequence, the cheese production still differs among the regions of Italy; the Center and the North produce altogether over 85% of cheese per year. A survey of the data, shown in Table 3, reveals a production of Parmigiano-Reggiano, Grana Padano, Pecorino Romano and Provolone cheeses almost constant during the years from 1984 to 1986, while in the same period of time the production of Mozzarella and Scamorza cheeses has registered yearly increases, which show more than a mere trend. These very soft cheeses (Mozzarella and Scamorza) seem to replace more conveniently the hard cheeses, whose production is unchanged in spite of the technological transformation occurred in plants of hard cheeses. This results also from the data of Table 4 referring to the production of Parmigiano-Reggiano cheese in the typical area of production during the years from 1984 to 1986.

In short, it is difficult to determine, today, the trends which will arise in the Italian Cheese Industry, because of the changing economic situation both in Italy and in the European Economic Community. Nevertheless, while the cheesemaker alone has little control over the economic realities, it will still be necessary that the cheesemaker is capable to supply those types of cheese (including eventual new types) which the market demands. For this reason a greater number of cheese types and more investigation on cheesemaking technology would be helpful to the Italian Cheese Industry.
Figure 1. Outline of cheesemaking procedures used in Italy.

Raw Milk
↓
Storage
↓
Standardization
↓
Basic cheese milk operations in cheese vat
↓
Draining of whey
↓
Moulding of curd
↓
Salting of cheese
↓
Pressing of cheese
↓
Ripening of cheese
↓
Cheese

(at 3°-5° C)

(at the required ratio of fat to protein)

(starter and rennet additions, cutting the coagulum)
Table 1. Typical analysis of some Italian cheeses.

<table>
<thead>
<tr>
<th>Cheese types</th>
<th>Moisture %</th>
<th>Fat %</th>
<th>Total Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Pasta Filata Cheeses:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mozzarella from buffalo milk</td>
<td>58</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Mozzarella from cow's milk</td>
<td>60</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Scamorza</td>
<td>47</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Provolone</td>
<td>35</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Hard Cheeses:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parmigiano-Reggiano</td>
<td>32</td>
<td>27</td>
<td>35</td>
</tr>
<tr>
<td>Grana Padano</td>
<td>33</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Pecorino Romano</td>
<td>30</td>
<td>30</td>
<td>28</td>
</tr>
</tbody>
</table>

Table 2. Self-sufficiency ratio and cheese production of the European Economic Community (EEC) countries in 1981a.

<table>
<thead>
<tr>
<th>EEC countries</th>
<th>Self-sufficiency ratiob</th>
<th>Cheese production (in thousand tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRG</td>
<td>100</td>
<td>815</td>
</tr>
<tr>
<td>France</td>
<td>119</td>
<td>1,163</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>236</td>
<td>468</td>
</tr>
<tr>
<td>Irish Republic</td>
<td>418</td>
<td>57</td>
</tr>
<tr>
<td>Denmark</td>
<td>540</td>
<td>243</td>
</tr>
<tr>
<td>Italy</td>
<td>76</td>
<td>609</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>70</td>
<td>242</td>
</tr>
<tr>
<td>Belgium and Luxemburg</td>
<td>43</td>
<td>50</td>
</tr>
</tbody>
</table>

*aSource: FAO Production Yearbook, 1982.
*bValue: production vs. home consumption
Table 3. Production of the main types of cheese in the years from 1984 to 1986*.

<table>
<thead>
<tr>
<th>Cheese types</th>
<th>Production (in thousand tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984</td>
</tr>
<tr>
<td>Parmigiano-Reggiano</td>
<td>90</td>
</tr>
<tr>
<td>Grana Padano</td>
<td>81</td>
</tr>
<tr>
<td>Pecorino Romano</td>
<td>48</td>
</tr>
<tr>
<td>Provolone</td>
<td>41</td>
</tr>
<tr>
<td>Asiago</td>
<td>12</td>
</tr>
<tr>
<td>Montasio</td>
<td>12</td>
</tr>
<tr>
<td>Gorgonzola</td>
<td>36</td>
</tr>
<tr>
<td>Italico</td>
<td>100</td>
</tr>
<tr>
<td>Taleggio</td>
<td>15</td>
</tr>
<tr>
<td>Mozzarella and Scamorza</td>
<td>199</td>
</tr>
<tr>
<td>Total production</td>
<td>634</td>
</tr>
</tbody>
</table>


Table 4. Production of Parmigiano-Reggiano cheese in the typical area of production in the years from 1984 to 1986*.

<table>
<thead>
<tr>
<th>Provinces</th>
<th>Production (in thousand tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984</td>
</tr>
<tr>
<td>Bologna</td>
<td>2</td>
</tr>
<tr>
<td>Mantua</td>
<td>11</td>
</tr>
<tr>
<td>Modena</td>
<td>18</td>
</tr>
<tr>
<td>Parma</td>
<td>29</td>
</tr>
<tr>
<td>Reggio Emilia</td>
<td>30</td>
</tr>
<tr>
<td>Total production</td>
<td>90</td>
</tr>
</tbody>
</table>

References

"What product will you give me today?"
"What product will you give me today and how much of it will you give me?"
Your reply to me would probably be "I won't give you any product, but I will sell you my product at a fair price!"

That is a reasonable reply, and, is the proper reply. However, if your facility does not maintain a rigid weight control program, you could effectively be giving away an unreasonable amount of overweight product; product that costs you money to produce and process, but due to lack of weight control was not paid for and therefore does not provide the earned profit. It is this problem that makes consistent weight controls so important.

According to the "Dairy Products Annual Summary 1987" nearly 1.4 billion pounds of Mozzarella and similar varieties of cheese were produced in the United States in 1987 (figure 1).

1.4 billion pounds of cheese! It sounds like a lot, indeed it is a lot, but difficult to visualize. Let's try to put it into a more understandable perspective. A leading pizza chain in the United States uses 10 oz. of shredded cheese on each of its 16 inch pizzas. If we were to lay out those pizzas, they would cover approximately 70,000 square acres. Now if that doesn't clarify the picture, another way to visualize this amount of cheese is to take our same 16 inch pizzas and circle the earth at the equator—23 times.

There are many ways to look at numbers and statistics. For cheese manufacturers and processors, statistics and numbers are much more important than the way I have presented them.

For cheese manufacturers to show a profitable yield, weight control needs to be an important part of their business strategy. In the manufacturing of cheese, the industry has been able to produce excellent and consistent weight control in terms of the individual ingredients that are used in the manufacturing process. However, the further processing of cheese introduces potential problems in terms of product weight vs. yield.

Let's look at shredded cheese for example. Our pizza manufacturer is concerned about costs of ingredients, giveaway and tight weigh control of the ingredients he uses. You might say that this does not affect the cheese manufacturer, but actually every package that goes out the door has a cost of producing. For the cheese manufacturer, profit is affected by the amount of "giveaway" that is allowed per package. "Giveaway" is a dreaded word, for while a manufacturer may be very cautious that underweight packaging never leaves his facility; if he is not cautious about the amount his product is overweight, he is reducing his earned profit margin.
Let's assume a 10 pound bag of shredded cheese has an average weight of 10.2 pounds, not 10 pounds, but 10.2 pounds. That means that out of the 1.4 billions pounds of cheese produced in 1987, nearly 95,000 pounds of product was given away. Even a small amount like 2/10 of a pound equates to big dollars. How can we overcome the product giveaway problem?

The answer—weight control in packaging! The label weight that goes onto your package should do more than reassure your customer that he has received all the product for which he paid. It should also be the target weight that you, through weight control seek to achieve. That 95,000 pounds of giveaway cheese equals 152,000 pizzas or 40 miles of 16 inch pizzas laid end to end! All with free cheese topping.

By using proper statistical data collection and associated process, you gain the assurance that control equipment giveaway is averaged and reduced. Random weight sampling has been proven ineffective as a method of weight control. By using a 100% inspection of each package produced, you may realize all the benefits of total process control with ensuing gains in profitability.

The system should provide the capability to have a complete statistical printout on both a periodic and on-demand situation. This information should also be long term and short term data to allow accurate decisions to be made based on the data gathered. The system should have the ability to provide a histogram printout, which gives individual weights of each package over the entire production run. This information is valuable in determining package weight distributions and the relation those distributions have with the target weight. (figure 2).

Let's use a 10 pound package of shredded cheese as an example. We begin with our control reference or target weight - 10 pounds. The product is metered in the packaging process by net weights scales which are calibrated to weigh to 10 pounds. The accuracy of these scales is governed by many factors:

1. Proper Calibrations
2. Product Density Change
3. Product Configuration i.e., Clumping or stringing together of product
4. Scale Wear and Maintenance
5. Quality (Capability of the Scaling System)

Even though these scaling systems are accurate most of the time, at the end of the day the volume processed should equal the amount of product that has been packaged. Even so, 2/10 of a pound more per package than ordered by the customer has been shipped, but not sold.

How can the statistical data be gathered and more importantly, once the information is gathered, how can we control the packaging process to reduce our giveaway?

The most effective method of doing this is by using a checkweigher. A checkweigher provides in motion dynamics weighing of 100% of the finished product—not only to reject underweight and overweight product, but to gather the statistical data needed to control the packaging process.
A microprocessor based checkweigher system for dynamic weighing of every package ensures process control which leads to a prediction of the outcome by providing statistical data accumulation and display. This is a continuous process that helps to pinpoint ways to improve and refine the packaging process.

This process control can be either manual, i.e., alerting an operator that a shredder or scaling mechanism needs adjustment, or automatic. Automatic adjustments would be accomplished by using checkweigher data to operate servomotors which would then adjust the scaling or shredding mechanism as needed. The objective here is to gain and maintain a state of control over the process.

If we examine figure 3, we can see our packaging process being controlled graphically. The top graph demonstrates how a checkweigher can effectively manage the process. We have already determined that we will average a specific number of packages to achieve a consistent level of data. For example let's average every ten packages and then perform a correction.

Beginning at the left side of the top graph in figure 4, our packaging process begins with a high rate of deviation. After the first ten packages of product are weighed, the data is used to make a correction in the process which lowers our deviation point. Because the checkweigher is performing continuous weighing of product, another ten packages are averaged very quickly and allows another correction to be made which again allows the deviation to be lowered. This function is done until the deviation level is as close to our target weight as possible, and allows the producer to maintain that level.

Contrast this to the lower graph in figure 3. This graph demonstrates random weight checks of a production line and the problems that this type of check causes.

Again we begin with our packaging process after a certain number of packages an operator may randomly select a package for a weight check. This is shown on the graph at the threshold of the first line. Based on the operator's assessment of the package, a correction will be made in the process. However, he is forced to make a critical decision based on only the weight of one package, not a continuous average of an entire production run. To carry this point a bit further, studying the second data gathering threshold reveals that the operator allowed a larger number of packages to be produced before obtaining another weigh sample. If the original correction was not enough and a new correction is needed, a potentially large number of excessive overweight packages can be shipped resulting in profit loss.

The idea is to provide a constant process of weight control to lower weight deviations to their lowest possible level. If the existing system does not lend itself to control an alternative should be considered. You cannot change your weight specification, but the process can be controlled to provide the required weight average, which will yield your earned profit.

Histograms of package weights in a non-controlled and controlled processes are shown in figure 4.
The base line shows our weight deviations, the center vertical line is the target weight and the additional vertical lines to the left and right of the target weight are the upper and lower limits of tolerable deviation.

Studying the production curve in the top graph, we observe a very flat curve. This represents random (non-controlled) weighing. The curve shows that much of the product falls across the entire tolerable limits of package weight with a large amount also in unacceptable under and over weight ranges.

Contrast this with the lower graph which depicts a controlled weight process using a checkweigher. We observe a very sharp, tight curve that maintains a close approximation with the target weight line and has very little production approaching even the lower and upper tolerable weight limits.

To explain the cause of the package weight variations, we need to understand the spread of weight variations before a reason for the cause can be obtained. With the random weight gathering method this is unexplainable. However in a checkweigher controlled weighing process, causes of variation can be explained and acted upon in a quick and concise manner.

Counter to previous beliefs, the modern cheese producer needs to focus on the process, not the product (figure 5). This means to continuously weigh the product while in production and based upon the data gathered, to control that process. By doing this, the manufacturer can predict the outcome in an accurate manner and to continue to study the process for continued improvements.

Accurate package weight control can only be accomplished through continuous monitoring of 100% of the entire packaging process and once this weight control is acheived, it will result in substantial savings for packages by reducing product giveaway.
THE USE OF WHEY PROTEIN AND/OR CASEIN IN MILK FORTIFICATION

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The title of my presentation, is "The Use of Whey Protein and/or Casein in Milk Fortification" - I think we all understand that what we are talking about here is cheese milk, as differentiated from beverage milk. Beverage milks are the foods described by standards of identity for milk (21 CFR 131.110), lowfat milk (21 CFR 131.123), and skim milk (21 CFR 131.143).

Recently - in the last 2 to 3 years - there has been a lot of interest in so called "fortification" of milk used for cheesemaking with milk-derived ingredients such as casein, caseinates and whey concentrate. Industry has approached us about use of these ingredients from several different directions. Today, I'd like to discuss four approaches and our reaction to them.

The first approach is taken from the standpoint that the standard of identity for skim milk which allows fortification with milk-derived ingredients. In light of this, some in the cheese industry may feel it is reasonable to fortify skim milk used in cheesemaking. The standard, in fact, permits the addition of milk-derived ingredients to enhance the mouthfeel of the skim milk and mask the blue color - that is, simulate the organoleptic qualities of higher fat milks. Neither of these functions is needed in skim milk for cheesemaking.

A second approach is through the use of nonfat dry milk made from protein-fortified skim milk meeting the requirements of the standard of identity for skim milk. While the original product, protein-fortified skim milk may meet the requirements of the standard, the dried version would not meet the standard for nonfat dry milk. That standard provides that the food is made by removing water from pasteurized skim milk, not protein-fortified skim milk. I emphasized the word "may" earlier in stating that protein-fortified skim milk may meet the requirements of the standard for skim milk because the question of whether it does or not rests on the level of fortification and whether the guidelines in the standard have been met. The guidelines I'm talking about limit fortification such that the ratio of protein to total nonfat solids of the food and the protein efficiency ratio (PER) of all protein present are not decreased as the result of adding milk-derived ingredients. Both parameters must be met, not just one. As I'm certain you realize, increasing the casein content of the milk without adjusting the whey protein levels will reduce the overall PER of the protein in the milk. Likewise, increasing the total nonfat solids with casein will reduce the level of other nutrients in the food.

A third approach; the starter stimulator. This product could be composed of several ingredients including non-milk ingredients such as protein hydrolysates of undefined sources. Starter stimulators are added to the vat prior to the addition of the starter culture or to the bulk starter. The purpose is to stimulate the growth of traditional bacteria by providing a source of "predigested nutrients" which the bacteria will use in preference to the milk solids. Yield, as the result of sparing
milk solids, is increased. Lactic acid production is purportedly faster and the times, both in the vat and in ripening, are shortened. The starter stimulator is added at the level of 0.5 - 1% by weight of the milk, to the cheese vat. There are variations on this scenario. This type of product contains ingredients, such as protein hydrolysates, which are not permitted for use in cheeses by the standards of identity. Moreover, claims made for these products raise questions about their actual effectiveness as a starter stimulator. Before these types of products can be considered appropriate for use in cheesemaking, the technical effects must be substantiated by data documenting the effects on starter growth and cheese yield. The ingredients in the stimulator are also important—are they permitted in cheese? And, of course, the level of use is important.

The fourth and last approach I'm going to discuss, is the use of whey concentrate. This ingredient is apparently added directly to the milk in the vat where it acts as a starter stimulator, but does not become incorporated into the cheese curd. Once again, use of this type of ingredient must be substantiated by data showing the effectiveness of the technique and that the whey concentrate indeed does not become part of the cheese.

The bottom line is that these types of ingredients are not appropriate for use in cheesemilk. The standards of identity do not provide for their use and we have no data or information on which to base an opinion that they are suitable ingredients. In addition to the questions raised above, addition of milk-derived ingredients and other ingredients may have an adverse effect on the nutrient content of cheeses, i.e., the levels of some nutrients may be diluted as the result of increasing the solids content. Section 402(b) (4) of the Federal Food, Drug, and Cosmetic Act deems a food adulterated if "any substance has been added thereto or mixed or packed therewith so as to increase its bulk or weight, or reduce its quality or strength, or make it appear better or of greater value than it is."

USDA's position on the use of these types of ingredients is in concert with FDA's. According to USDA, addition of excessive quantities of active starter culture, i.e. levels of 3% or more of the weight of the cheesemilk, is not appropriate. Levels of 1-2% are normal. Addition of dry starter media directly to cheesemilk is also not appropriate. FDA agrees with these guidelines.

We understand that increased cheese yield is increased income. If the starter stimulator concept is a technological advance toward increasing yield, then the effort should be made to gather the required data and petition for a change to the standards.
VARIATION IN COMMERCIAL MOZZARELLA CHEESE FUNCTIONALITY: EXTENT OF THE PROBLEM AND CAUSATIVE FACTORS

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Introduction

Mozzarella differs from most cheeses in that it is usually consumed in the melted state, e.g., on pizza and related foods. Consequently, buyers of Mozzarella, particularly large institutional buyers, incorporate strict standards for functional properties such as meltability, stretchability and elasticity into their quality specifications (7). As a result, Mozzarella cheesemakers often are under extreme pressure from buyers to produce cheese with consistent functionality.

Very little information is available in the published literature regarding commercial Mozzarella functionality. One reason no doubt is the lack of suitable testing methods for measuring melted cheese properties. Despite this, it is well known in industry that cheese plants sometimes experience problems with product functionality. In a market as competitive as Mozzarella cheese, an extended bout with poor functionality can be catastrophic for the commercial cheesemaker.

Earlier in these meetings we described a new instrumental method (helical viscometry) for measuring melted Mozzarella consistency (6). By providing sensitive and repeatable measurements of cheese melting properties, helical viscometry has opened up new opportunities for research. One of our first goals with this new research tool was to monitor and quantify variation in functionality that occurs during "normal" industrial cheesemaking. Our reasoning was that, functionality-wise, we know very little about what is "normal" or typical in industrial practice, let alone what happens when a plant experiences problems.

Our primary objective in this work, therefore, was to evaluate cheeses from two primary industrial plants (A and B) for an extended period of time to document typical vat-to-vat and week-to-week variation in cheese functionality. By chance, during much of the study plant A experienced extreme bacteriophage problems and poor starter culture performance. Therefore, data presented below represent a contrast between an industrial plant operating "normally" (plant B) and one under extreme duress (plant A).

Experimental Design - Cheese Plant Survey

Two industrial cheese plants, A and B, were chosen for study. Plant A produced low-moisture, part-skim Mozzarella, plant B low-moisture Mozzarella. Five 5-lb. blocks of cheese originating from different vats staggered throughout one production day were collected from each plant once every-
other-week for ten weeks. Cheeses were vacuum packaged at the plant immediately after brining and transported on the same day in an insulated container to the University. Cheeses were then held at 4°C for 12 days to simulate short term aging used in industrial practice (7).

On day 12, cheeses were analyzed for melting properties by helical viscometry (6). Cheeses also were analyzed for fat (Babcock), total solids (100°C, 24 hr), calcium (4) and salt (5).

Results - Cheese Plant Survey

Figure 1 shows average FDB for the five vats of cheese sampled at each plant during the five biweekly sampling periods (weeks 1,3,5,7,9). Plant A produced a low-moisture, part-skim Mozzarella with average FDB of about 33%. Plant B manufactured a low-moisture Mozzarella with average FDB slightly below the legal minimum of 45%.

Cheese Functionality

Melted cheese functionality was evaluated by helical viscometry. An example of a typical Mozzarella apparent viscosity profile is shown in Figure 2. As discussed in the earlier paper (6), this profile offers a “fingerprint” of cheese melting properties. The maximum height of the profile (point B in figure 2) is a particularly useful measurement because it reflects in part the stretchable, elastic nature of melted cheese (6). Therefore, we chose maximum profile height as a quantitative measure of melted cheese functionality; the apparent viscosity (AV) data presented below correspond to maximum profile height.

Figure 3A shows average AV values for the two plants over the sampling period. Average AV was consistently lower at plant B than plant A. This probably was due in part to higher FDB at plant B, which would tend to give a softer cheese and lower viscometer profile. More importantly, average AV at plant B was extremely consistent from one week to the next. In contrast, plant A experienced wild fluctuations from week to week, indicating large variation in cheese functionality.

AV standard deviations for the five vats sampled at each plant are graphed in figure 3B. Standard deviation is a statistical measure of variation, therefore, figure 3B represents a comparison of vat-to-vat variation in cheese AV at the two plants. Vat-to-vat variation at plant B was very low and highly consistent from one week to the next. In contrast, plant A showed much higher vat-to-vat variation throughout the sampling period and the magnitude of variation fluctuated widely from one week to the next. In short, plant B produced a highly uniform product while plant A showed enormous variability, both within a production day and from one week to the next. Recall that plant A experienced severe problems with bacteriophage during this time.

Cheese Composition

Average cheese moisture content is shown in figure 4A. Moisture levels at plant B tended to be highly consistent from one week to the next, a minor exception being week 3. In contrast, levels at plant A fluctuated greatly from week to week.
Vat-to-vat moisture variation, as reflected by standard deviations, are graphed in figure 4B. Plant B showed consistent low vat-to-vat variation while plant A experienced much greater variation.

Poor moisture control at plant A was no doubt related to the bacteriophage attack that plagued this plant during the sampling period. Phage outbreak caused significant changes in starter culture performance which necessitated adjustments in manufacturing schedules. Typically, some of the vats during a production day experienced very slow acid development. To compensate, make times were increased by as much as an hour or more over normal practice. Thus, it is not surprising that cheese moisture content was erratic.

Average calcium content and calcium standard deviations are shown in figures 5A and 5B, respectively. Standard deviations for plant A were erratic, varying greatly from one week to the next. In contrast, plant B showed consistent low standard deviations. Cheese calcium content is strongly influenced by acid production during manufacture, therefore, erratic vat-to-vat variation at plant A probably was caused by problems with phage and starter performance.

Cheese salt content (means and standard deviations) are compared in figures 6A and 6B, respectively. Although not all cheeses were analyzed, it is evident that plant B produced a higher salt cheese than plant A.

**Composition and Functionality**

Can this data set be used to gain insight into the relationship between cheese composition and functionality? One way to approach this question is through stepwise regression, a statistical technique that can be used to sort out the individual effects of composition on AV, provided that the data conform to a series of complicated assumptions necessary for statistical validity. Our data set did not meet these assumptions perfectly, therefore, regression analysis did not offer clearcut revelations. It did, however, support the view that moisture content was a dominant factor associated with cheese AV (functionality).

Figure 7 shows the relationship between moisture content, expressed on a nonfat substance basis (MNFS), and AV for all individual cheeses included in the study. As moisture decreased, AV increased; that is, cheeses tended to be tougher and more fiberous with decreasing moisture. Cheeses from plant A showed much greater variation in both moisture and AV than plant B. Thus, starter culture performance, by way of its effect on moisture content, is a very important factor in the development of Mozzarella functionality.

**Functionality and Aging**

It is well known in industry that a brief "aging" period improves Mozzarella melting properties (7). Cheeses in our study were aged for 12 days at refrigeration temperature to permit these desirable changes to take place. What causes Mozzarella functionality to change during short term aging? For many cheese types such as Cheddar, proteolysis during aging is the principle agent in body and texture development (1), and the rate at which proteolysis proceeds is strongly dependent on moisture content. It seems possible, therefore, that the strong relationship between moisture and
functionality seen in figure 7 may be due in part to differences in proteolysis experienced by cheeses during the 12-day holding period. In light of this, we next conducted an aging study to better document changes in Mozzarella functionality over time.

**Experimental Design - Aging Study**

Four 5-lb blocks of low-moisture Mozzarella (two from plant A and two from plant B), were obtained immediately after brining. Each block was cut into seven equal pieces and the two end pieces from each block were discarded. The remaining five pieces were vacuum packaged at the plant and then transported on the same day in an insulated container to the University. Samples were then held at 4°C for up to 36 days.

On days 2, 7, 14, 22 and 28 from manufacture, one piece from each of the four blocks was randomly chosen and analyzed for melting properties by helical viscometry. Cheese also were analyzed for fat, total solids, calcium, and salt as above, and for alpha and beta casein by polyacrylamide gel electrophoresis (2).

**Results - Aging Study**

Figure 8 shows the appearance of one of the cheeses at 2, 7 and 36 days of refrigerated storage. During aging, cheese consistency was transformed from tough fiberous to silky smooth. Similar transformations to varying degrees were observed for all cheeses.

Figure 9 shows the AV values of the four cheeses throughout the 28-day refrigerated storage period (one of the cheeses was held for 36 days - see figure). Two things should be noted. First, the four cheeses had widely different AV values on day 2. This means that these cheeses had very different functional properties right out of the brine, i.e. before any changes due to aging had taken place. Second, all of the cheese showed a steady decrease in AV value over time, indicating that large changes in functionality occurred during aging. Interestingly, the ranking of cheeses on an AV basis remained constant throughout aging, suggesting that the AV of "green" Mozzarella may provide a predictive index of cheese aging properties and refrigerated shelf life.

Why did 2-day old Mozzarella cheeses show such large differences in functionality (AV)? Cheese composition did not provide any clear answers but an interesting observation can be made. One of the cheeses from plant A was manufactured from a very slow vat caused by bacteriophage. This cheese is labeled "off-scale" on day 2 in figure 9 because it was so tough that the viscometer went completely off-scale. Compositionaliy, this cheese was reasonably "normal" with respect to fat (23.25%), salt (1.06%) and moisture (45.70%). However, it contained an extremely high level of calcium (.880%). Thus, the abnormally tough nature of this cheese on day 2 may have been associated with excessive mineral content. This is consistent with earlier work that showed that mineral content is a key factor governing curd suitability for hot water stretching (3).

Figures 10A and 10B show the breakdown of alpha and beta casein during refrigerated storage. In these graphs, the amount of intact casein remaining at each time interval is expressed as a percentage of intact casein found on day 2. All of the cheeses showed breakdown of about 20%
to 40% of alpha and beta casein over time, but a clear relationship between rate of casein breakdown and changes in AV was not evident. It is very likely that casein breakdown is responsible in part for changes in Mozzarella functionality during refrigerated storage, but more work is needed to elucidate this relationship.

Conclusion

Industrial Mozzarella cheesemakers sometimes suffer severe extended problems with product functionality, as was evidenced at plant A during the 10-week sampling period. The source of this plant's problems was poor starter culture performance due to bacteriophage. Uniform starter culture performance, therefore, is critical to uniform product functionality. Starter culture performance appears to influence cheese functionality through its impact on at least two different aspects of cheese composition. First, it governs curd mineral content which appears to be important to functionality of the young cheese. It also affects curd moisture content which in turn influences functionality changes (probably proteolysis related) that occur during short-term refrigerated aging.
Figure 1. Week-to-week variation in FDB: average FDB for five vats of Mozzarella sampled at each plant A and B during five biweekly sampling periods.

Figure 2. Apparent viscosity profile of a typical Mozzarella cheese by helical viscometry method.

A. Spindle immersed in melted cheese begins helical rotation.
B. Spindle exits melted cheese column and forms strand above surface.
C. Cheese strand is stretched by spindle above surface.
Figure 3. Week-to-week (A) and vat-to-vat (B) variation in apparent viscosity (a measure of functionality): average (X) and standard deviation (SD) of apparent viscosity for five vats of Mozzarella from each of two commercial cheese plants during biweekly sampling periods.
Figure 4. Week-to-week (A) and vat-to-vat (B) variation in moisture: average (X) and standard deviation (SD) of moisture for five vats of Mozzarella from each of two commercial cheese plants during sampling periods.
Figure 5. Week-to-week (A) and vat-to-vat (B) variation in calcium: average ($\bar{X}$) and standard deviation (SD) of calcium for five vats of Mozzarella from each of two commercial cheese plants during biweekly sampling periods.
Figure 6. Week-to-week (A) and vat-to-vat (B) variation in salt: average $\bar{X}$ and standard deviation (SD) of salt for five vats of Mozzarella from each of two commercial cheese plants during biweekly sampling periods.
Figure 7. Relationship between moisture content (nonfat substance basis - MNFS) and apparent viscosity for Mozzarella cheese obtained from two commercial cheese plants. (Plant A ■; Plant B □)

Figure 8. Visual appearance of a melted Mozzarella cheese after 2, 7 and 36 days of storage at 4° C.
Figure 9. Change in apparent viscosity (a measure of functionality) during storage at 4°C of four Mozzarella cheeses from two commercial cheese plants: plant A (■,●) and plant B (○,△).
Figure 10. Change in $\alpha_\text{s}$,1 (A) and $\beta$ (B) casein during storage at 4°C in each of four Mozzarella cheeses from two commercial cheese plants: plant A (■, ♦) and plant B (O, Δ).
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References


MAKING A CRISIS WORK FOR YOU

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ABSTRACT

Crisis situations can and probably will happen and when they do, your organization may be at the mercy of the media, your customers, the regulators and the public. You can turn a disaster crisis into opportunity and an opportunity crisis into super-success. It can be done by planning, acting with confidence, controlling with a plan and communicating for results. This paper outlines the potential for crisis and suggests how you can prepare for the unexpected that can "break" or "make" your organization.

We have all heard friends or business acquaintances say that—if it wasn't for the bad luck, I'd have no luck at all...or...I seem to go from crisis to crisis...or...bad things always happen when everyone is looking, good things happen when no one is paying attention...or...it's the fault of the "press".

Of course, both bad things and good things do happen to individuals and to businesses. It's hard to prevent the bad ones or cause the good ones, but we can be prepared for each.

A company will face many critical and very serious situations during the normal course of business...like...borrowing money, meeting tight schedules, catching a plane or losing a key employee. Normally, these are resolved in a routine manner because of planning, management and luck...and business goes on without a ripple.

A company may also face a situation that falls outside the normal experience...it could be bad—a disaster, natural or man-made, or good—an award for excellence, a new product announcement or a promotion. In either case regular business routine is disrupted. Call it a crisis.

Moment of Truth! Zero hour! Emergency!

CRISIS...an unstable or crucial time whose outcome will make a decisive difference for better or worse.

It can happen...after all, most of you are directly involved with perishable food product, governed by regulations and work with people. Try as hard as you can to meet all the rules, regulations and common sense...your heart and Murphy's law says a crisis can and will happen.

And when it does—there will be confusion, stress and potential financial and personal damage...or OPPORTUNITY!
Crisis management is recognizing the potential, planning for the possibility, understanding the situation, controlling the action and communicating for results.

How you and your organization react to a crisis situation may well determine the future of each.

**Two Kinds of Crisis...Both Demand Action**

**Case #1 - Disaster potential.** Several children are in the hospital. Medical experts think your product purchased at a local supermarket may be the cause of their illness. It's too early to tell but there may be serious illness even deaths, accusations and lawsuits.

A terrible feeling! And your secretary is holding calls from TV, radio and print reporters demanding statements. YOU and YOUR ORGANIZATION are about to be the lead story in the newspaper and on TV.

**Case #2 - An Exciting Opportunity!** Your new product was selected by a national organization as the "outstanding product of the year". This is the culmination of years of research, thousands of hours of effort and can mean super-success for your company. It's the big break. Your organization is a SUCCESS. It means a building addition...sales gains...glory.

A great feeling! But your secretary is juggling calls from TV, radio and print reporters who want interviews. YOU and YOUR ORGANIZATION are going to be the lead story in the newspapers and on TV.

Both are crisis situations. Your organization must face reporters, employees and the public. How do you do it? Can you do it? No problem...if you have the facts, know the answers and have a crisis management plan.

Much trouble when facts are lacking, there is no time to think, you have no crisis control plan, you are uneasy with reporters and you know that a "no comment" won't do...and your top management team is on a plane to a convention.

**Can it happen?** It has happened within our industry...too many times. Look at the Hill Farms/Jewel situation several years ago. The Jalisco case soon after. The many product recalls attributed to Lysteria. Also think of the good situations...company promotions, awards, new plant additions and awards.

**Be Ready...Before It Happens.**

Start now...before the crisis. The positive approach can prevent crisis damage. PLANNING puts you in a control position. Let your PEOPLE help plan. Have a written plan for reference and use.

**Think about it.**

What's the worst that can happen in your business? Estimate the probabilities, consider the
seriousness, know the potential impact and look at the possible results in terms of dollars, reputation, operations and the future.

Just sitting down with key managers in your company to talk about disaster possibilities is hard to do. There is never enough time or never enough reason. But—when disaster strikes—it's too late.

Your people.

During a crisis period, your employees will carry on the business, undergo stress, be subject to questions and want to help. Crisis teams selected for their expertise and ability to operate under stress are a must. Who does what and how?

The plan.

The written plan is the roadmap. It assigns responsibilities, sets the strategy, and shows the direction. Spur-of-the-moment decisions must be made during a crisis, but the basics must be done earlier.

Employee names and phone numbers, designated speakers, backup systems, media listings, outside experts, product inventories...all are in the plan.

Action.

A crisis brings confusion but the emergency must be met. There will not be time to pause and think because you will be expected by your employees, the public, government officials and the press to know. Your planning and management will make the difference by UNDERSTANDING, CONTROLLING, COMMUNICATING and ACTING.

Understanding.

What has happened? What is happening? What is the real crisis? Knowing what can be done and how to do it are not easy when lightning is cracking around you.

Controlling.

Solving the crisis is the first priority. The who's, what's, where's, when's and how's facts must be determined. Up-to-date facts gathered, a course of action determined and information communicated...it takes teamwork and skill.

Communicating.

Crisis brings immediate pressures for information. Employees need to know. Owners and directors must know. Government officials will be on the scene. Reporters want to know. What you say and how you say it will have immediate impact.
What Do You Say When The Reporters Call?

An interview request from reporters-TV, radio or print strikes fear in the heart of managers. And, a "no comment" or a "punch in the nose" are not the answer. It's even more difficult if the chief executive is on vacation, traveling or ill. Who speaks for the company then?

Knowing how to relate to media can get the right story to the right people in the right way...to prevent crisis damage.

Communicating under pressure is not easy, yet can offer real opportunity for your organization. Ideally your representative will communicate with skill and honesty. Credibility and confidence will be maintained and increased.

Talking to the "press" takes practice and training. Know how to do it before you are forced to talk when under pressure. A few dollars spent in training will reflect in the future success of your company.

Action According to Plan

Crisis management is...recognizing the potential, planning for the possibility, understanding the situation, controlling the action and communicating for results. It is not...putting the problem into the hands of your attorneys and hoping the court will decide in your favor. Meanwhile your customers are gone.

A crisis will be confusing, stressful and potentially damaging. It can be controlled by having a plan, understanding the potential, initiating positive action and communicating for results.

How your organization plans for a crisis and reacts under pressure will determine the future of the employees, management and owners.

Dos and Don'ts of Successful Crisis Planning and Management

Do

✔ Recognize that a crisis can/will happen
✔ Know potential problems
✔ Make a written crisis plan
✔ Determine who is in charge
✔ Have employees know and assist
✔ Select crisis teams
✔ Designate spokespersons
✔ List backup people
✔ Know the media
✔ Speak with one voice
✔ Control the message
Dos (continued)

✓ Be honest and seem honest
✓ Plan ahead
✓ Control the situation
✓ Train your spokesperson in facing reporters

Don't

✓ Plan with half a heart
✓ Expect your employees to be interested if you aren't
✓ Say it can't happen to us
✓ Try to do it all yourself
✓ Delay planning
✓ Ignore the possibility of a crisis
✓ Issue a no comment
✓ Select a spokesperson strictly by seniority or position
✓ Underestimate the potential of turning disaster into opportunity
✓ Make a plan and "file it"
✓ Let the newest and lowest paid employee be the spokesperson by default
✓ Withhold news
✓ Ignore using outside experts
✓ Blame the press for your failings
✓ Try to be a "media star" without training

Crisis situations do happen and when they do it is too late to begin planning. You can turn a disaster crisis into opportunity and you can turn an opportunity crisis into super-success.

It can be done by...PLANNING FOR THE POSSIBILITY, ACTING WITH CONFIDENCE, CONTROLLING WITH A PLAN and COMMUNICATING FOR RESULTS.