

# Technology to Produce Ragusano Cheese: A Survey

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## ABSTRACT

A survey was carried out to characterize the composition of milk on 70 farms in the Hyblean region in the Province of Ragusa in Sicily, the processing methods used on the 20 of those farms producing the highest quality Ragusano cheese, and the average composition of the cheese at 4 to 6 mo of age. The milk used for cheese making is predominantly from the Modicana and Brown Swiss breeds, but some farms used Holstein cows. Characterization of the traditional Ragusano cheese manufacturing process (including times, temperatures, and pH) is needed. A flow chart of the average cheese-making conditions necessary for production of Ragusano cheese, has been created as an example of the first step that must be taken to document and preserve traditional cheese varieties that are part of the history and culture in various regions of the world. Ragusano is an aged pasta filata cheese. The process of Ragusano cheese making has some characteristics of cultured Mozzarella and some characteristics of Provolone manufacture. However, differences in the manufacturing and aging processes among the three cheeses produce different flavors and texture. The critical steps in the cheese-making process were identified, and recommendations were provided to cheese makers for practical approaches to improve the consistency of cheese quality. The results from the present study form the basis of future research designed to characterize cheese composition, chemical changes during aging, microbiology, yield, and flavor chemistry of Ragusano cheese.

**(Key words:** Ragusano, Sicily, cheese making, pastures)

## INTRODUCTION

Many cheese varieties that may not be well known outside of a specific geographic region are produced and consumed locally within various countries. As the economic and environmental conditions change within a region, the art of making some cheeses can be lost, particularly when the cheeses are farmhouse-type, or artisanal, cheeses for which manufacturing procedures are not well described in the literature. Ragusano cheese is an example of a pasta filata cheese that has been produced on farms for centuries in the Hyblean region of Sicily but that have little formalized description of the manufacturing procedure.

Ragusano cheese was officially recognized (3) as a typical cheese of Sicily in 1955 and is part of the cultural tradition of the people of that region of Italy. The Italian National Committee for the Control of Trade Names (origin and type) decided that the requirements have been met for Ragusano cheese to become a trade-named cheese. This recognition was supported by the fact that Ragusano cheese is a product with unique organoleptic characteristics that are derived from the environmental conditions and manufacturing practices already existing in the production area (4). In 1996, the European Economic Community gave Ragusano cheese the designation of Protected Denomination of Origin (5) within the European Union.

Even though Ragusano cheese currently is a commercially viable and popular hard cheese in Sicily, it was also exported to the US 50 yr ago when large numbers of Sicilians emigrated to the US. The production of Ragusano cheese on many small farms causes inconsistent product quality. The different uses of the cheeses, the way local farms are managed, and the unstandardized processing methods used by the farmers need to be documented and analyzed. Generally, farmers milk the cows and make cheese every day, in addition to growing crops to feed the cows. Traditionally, almost all Ragusano cheese has been made from milk produced by cows of the Modicana breed; however, currently about 42% of the

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Received March 13, 1998.

Accepted August 20, 1998.

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cheese is produced from milk of Modicana cows, 33% from Brown Swiss, 18% from Holstein, and the remainder from mixed breed herds (9). In addition to making Ragusano cheese each day, these farms also produce ricotta cheese daily from a combination of about 5 to 10% milk plus the whey from the Ragusano cheese production. The ricotta cheese is sold fresh each day by the farmer as a cash product.

The younger generation of children of farm families may not be willing to continue this very difficult tradition. In the past 10 yr, the number of farms producing Ragusano cheese has declined rapidly from about 600 in 1987 to 250 in 1997 (9). At some point, Ragusano cheese production may need to be centralized into small cooperative farmhouse cheese-making facilities to prevent the cheese variety from being lost. To accomplish this transition, it will be necessary to have a well-documented manufacturing procedure for Ragusano cheese and some understanding of the chemistry and microbiology of the product. Our objective was to conduct a survey of milk composition and the Ragusano cheese-making procedures used at various farms and to develop a consensus description of the traditional procedures as the foundation for further scientific research on this cheese variety.

## MATERIALS AND METHODS

This survey was carried out during the 1992 to 1993 cheese-making season and involved the collection of milk samples and a characterization of the processing methods used on farms producing Ragusano cheese (9). The 70 farms included in the milk composition survey and the 20 farms included in the survey of cheese-making procedures were situated in the province of Ragusa, which encompasses the Hyblean highlands and its coastline.

Milk from 25 Holstein, 25 Brown Swiss, and 20 Modicana herds were analyzed once each month from September to July (i.e., the cheese-making period of the year) because of the seasonal pattern of milk production. All farms used pasture feeding, but the farms with Holstein cows tended to use more supplementation of the diet with concentrates and stored forages. A sample of bulk tank milk from each farm was collected once each month, cooled to 4°C, and transported to the laboratory for analysis that day. The milk analyses were as follows: oven-drying for total solids [(1): AOAC method number 33.2.44, 990.20], total N by Kjeldahl [(1): AOAC method number 33.2.11, 991.20], true protein [(1): AOAC method number 33.2.13, 991.22], noncasein N (6), urea (13), fat [(1): AOAC method number 33.2.26, 989.05], and

electrophoresis (12). All values of N fractions are reported in protein equivalents ( $N \times 6.38$ ).

A two-page survey form for collection of cheese-making data was developed based on preliminary field visits. This survey form was used by the two staff members who observed, made measurements, and recorded the cheese-making procedures used on the farms. The cheese-making process at each farm was documented approximately once each month; pH, liquid and curd temperatures, ingredients, and times were measured and recorded during the entire cheese-making process.

Four blocks of cheese were identified and marked at each farm prior to their shipment to the cheese aging center for brining and aging. At 4 to 6 mo of age, these blocks were sampled with a cheese trier. Three cores were taken from three different locations in the block. The 1-cm portion of the core that came from the surface of the block was broken off and reinserted into the hole in the block. Three cores of cheese were comminuted in a blender and then analyzed for moisture using a forced-air oven method at 100°C for 24 h (11); the cheese was analyzed for other components as well: fat by Gerber (11), protein by Kjeldahl (1; AOAC method 33.2.11, 991.20), and salt by the Volhard titration method (11).

## RESULTS

### Milk Composition

The mean composition of milk produced by the three different breeds is shown in Table 1. There was no significant ( $P > 0.05$ ) difference in the mean total solids content of the milk for the cheese-making season between the Modicana and Brown Swiss cows, but the total solids content of the milk from Holstein cows was lower ( $P < 0.05$ ). The mean fat content of the milks did not differ significantly among breeds. The percentages of total protein and true protein content of milk differed ( $P < 0.05$ ) among the breeds; Modicana had the highest content, followed by Brown Swiss, and then Holstein. In general, protein content was the highest for all three breeds from December to May when the availability and quality of green forage were high. Milk urea content did not differ ( $P > 0.05$ ) among breeds, but the average NPN content (crude protein-true protein) for the milk produced by the Modicana breed was higher ( $P < 0.05$ ) than that produced by the other two breeds. The casein content is of interest for cheese making because casein is one of the most important components in theoretical formulas for cheese yield for the prediction of cheese yield. Milk casein content was different ( $P < 0.05$ )

TABLE 1. Mean<sup>1</sup> concentration of milk components for the Brown Swiss, Holstein, and Modicana breeds for the cheese-making season from September 1992 to July 1993 in the Hyblean region of Sicily.

Milk components	Brown Swiss		Holstein		Modicana	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Total solids, %	12.5 <sup>a</sup>	0.48	12.1 <sup>b</sup>	0.27	12.7 <sup>a</sup>	0.26
Fat, %	3.64 <sup>a</sup>	0.3	3.62 <sup>a</sup>	0.24	3.58 <sup>a</sup>	0.27
Crude protein, %	3.40 <sup>b</sup>	0.08	3.12 <sup>c</sup>	0.05	3.59 <sup>a</sup>	0.14
True protein, %	3.12 <sup>b</sup>	0.12	2.88 <sup>c</sup>	0.06	3.23 <sup>a</sup>	0.22
Casein, %	2.61 <sup>b</sup>	0.08	2.41 <sup>c</sup>	0.05	2.78 <sup>a</sup>	0.15
Urea, g/L	0.304	0.03	0.317	0.03	0.291	0.05
CN, % of CP <sup>2</sup>	77.0	2.05	77.3	1.82	77.3	1.88
CN, % of TP <sup>3</sup>	83.9	3.39	83.7	2.33	86.11	3.17

<sup>a,b,c</sup>Means within the same row not sharing a common superscript are significantly different ( $P < 0.05$ ). Lack of superscripts in row indicate no differences ( $P > 0.05$ ).

<sup>1</sup>Mean of monthly tests of bulk tank milk. Number of herds for Brown Swiss, Holstein, and Modicana were 25, 25, and 20, respectively.

<sup>2</sup>Casein as a percentage of CP.

<sup>3</sup>Casein as percentage of true protein.

among all breeds with Modicana having the highest content followed by Brown Swiss and then Holstein. There was a tendency ( $P = 0.089$ ) for the average amount of casein as a percentage of true protein to be higher for the Modicana breed than for the Brown Swiss or Holstein breed. From electrophoretic analysis (data not shown), it was found that the milk produced by Modicana cows was homozygous for the genotype  $\kappa$ -CN BB, and the Holstein and Brown Swiss breeds had a higher proportion of  $\kappa$ -CN AA or heterozygotic genotype AB. In a review by Lawrence (8),  $\kappa$ -CN BB was considered to have a positive impact on cheese yield.

The significantly higher casein concentration, higher casein as a proportion of true protein, and the high frequency of the  $\kappa$ -CN BB genotype in the milk produced by Modicana cows should have resulted in superior cheese-making characteristics for milk from Modicana cows compared with that from the two other breeds.

### Description of the Cheese-Making Process

In addition to looking after the animals in the barn and cultivating the forage, the farmer traditionally has made Ragusano cheese and ricotta daily from the milk produced on the farm. Cheese making almost always took place in a room adjacent to the barn where the raw milk, normally taken from only one milking, was filtered from the milking bucket into the cheese vat. Milk was coagulated with rennet without the addition of starter culture. The traditional cheese-making vats, the *tina*, were made from wood, but some farms used a plastic or stainless steel vat. The

average capacity of the traditional wooden Ragusano cheese vat was approximately 200 L. The native microflora present in the raw milk and in the wooden cheese-making equipment provided the bacteria that produced acid during the cheese-making process.

The mean pH (6.7) and temperature (34.6°C) at rennet addition to the milks used for cheese making are shown in Table 2, which represents the data for the months of the cheese-making season. The milk temperature was higher, and pH was lower, in the warmer months (i.e., September and October). Data are not included for June, July, or August because green forage was normally not available, ambient temperature was too high for good cheese making, and, therefore, very little Ragusano cheese was made during this period. Typically, the best quality cheese was made during February, March, and April, which corresponds to the time of the year when the green forage quality in the pastures was the best. The cheese makers on the farm took advantage of native pastures as much as possible by using a seasonal calving pattern. Also, the native pastures (10) contain many common Mediterranean plants (e.g., *Anthemis arvensis*, *Calendula arvensis*, *Medicago hispida*, *Scorpiurus subvillosus*, and *Trifolium subterraneum*), which may contribute desirable flavors to the milk and cheese.

Commercial rennet paste (made from lamb and young goat) was used by most farmers. Other farmers used the stomach of a young lamb or goat soaked in salt brine. About 1 kg of goat stomach was used for every 8 L of brine to prepare the rennet solution. About  $170.3 \pm 69.9$  ml of the rennet solution were used in 100 L of milk. When a commercial rennet

paste was used, coagulation was achieved by following the instructions of the manufacturer. In both cases, a firm coagulum was produced in about  $65.0 \pm 1.8$  min (Table 1).

A wooden staff, the *rotula*, with a wooden ball at one end, was used to break (i.e., cut) the curd. The best curd strength was obtained when the *rotula*, immersed in the coagulated milk, was able to stand by itself in an upright position. Once the proper curd strength was reached, the curd was broken with the *rotula* using a circular stirring motion. The cutting (breaking) time averaged 1.3 min. Immediately following cutting, hot water was added to increase the temperature of the curd plus whey to  $39.1 \pm 1.6^\circ\text{C}$  (Table 2). The quantity of water used by the farmers who took part in this study and the temperature of the water were variable ( $78.9 \pm 3.5^\circ\text{C}$ ) and were inversely correlated. The relationship was such as to permit a mean temperature increase of the curd plus whey of  $5.5 \pm 0.7^\circ\text{C}$  (Table 2). When the curd cutting step was completed, the curds (approximately 4 mm in size) were allowed to settle to the bottom of the vat for an initial cooking time of about 11.6 min (Table 2). The curd was taken from the vat and was left to drain in a plastic container, the *vascedda*, on an open-topped table (*mastredda*). The mean temperature of the whey at the end of the first cooking was  $33.5 \pm 1.4^\circ\text{C}$  (Table 2). This whey was used to make ricotta; then, the whey from the ricotta (*scotta*) was used as a source of heat for the second cooking of the Ragusano cheese curd.

The curd was removed from the whey after the first cooking and was drained for approximately 33.6 min (Table 2) while ricotta was made. After draining, the mass of curd was cut into slabs about 3 cm thick, placed back into the cheese vat, and cooked again (i.e., second cooking) by adding hot ricotta whey (liquid left over from the manufacture of ricotta) or, less commonly, hot water. The mean pH of the curd immediately prior to the second cooking was  $6.54 \pm 0.13$ , and the curd temperature just prior to the second cooking was  $36.1 \pm 1.8^\circ\text{C}$  (Table 2). After addition of the hot ricotta whey, the vat was covered to avoid a rapid decrease in temperature. The mean temperature and amount of the ricotta whey added were  $84.4 \pm 1.5^\circ\text{C}$  and  $25.0 \pm 4.5$  L, respectively. When water was used, the mean water temperature and amount of water added were  $80.9 \pm 5.7^\circ\text{C}$  and  $16.0 \pm 2.8$  L, respectively (Table 2). The curd remained in this liquid during the second cooking for an average of 85 min, but this time varied greatly from farm to farm.

Once the second cooking was completed, the curd was separated from the whey (or water) and left to

ripen (i.e., develop acid) in an open-topped wooden table for about 24 h at ambient temperature. The ambient temperature varies with the season of the year, but the range during the period of the year when the cheese quality is the best is from 20 to  $28^\circ\text{C}$ . The total time for proper acid development in the curd depended on the rate of pH decrease in the curd and averaged about 27.9 h for the cheese-making season. The time for acid development was longer in months (e.g., January, February, and March) when the ambient temperature in the cheese-making room was lower. The average value for pH of the curd prior to stretching was  $5.27 \pm 0.13$  (Table 2). During winter, when the temperature of cheese-making room was much lower, the natural acid development process was much slower and took as long as 78 h on some individual farms. Generally, longer times to achieve the desired pH were related to a higher frequency of gas defects in the cheese during aging. The months with the longest times to develop acid also had higher average pH at the time of stretching (e.g., January, February, and March). Once the optimum pH was reached, the curd was cut into slices (ca. 1 cm thick) and then placed in the *staccio*, a copper or wooden container, and covered with about  $12.1 \pm 2.6$

TABLE 2. Mean values<sup>1</sup> for pH, times, and temperatures used in Ragusano cheese making for the September 1992 to July 1993 cheese making season.

Cheese-making parameters	$\bar{X}$	SD
Milk pH	6.70	0.06
Coagulation temperature, $^\circ\text{C}$	34.6	1.2
Quantity of rennet, ml/100 L	170.3	69.9
Coagulation time, min	65.0	1.8
Cutting time, min	1.3	0.1
First cooking temperature, $^\circ\text{C}$	39.1	1.6
Added water temperature, $^\circ\text{C}$	78.9	3.5
Temperature increase, $^\circ\text{C}$	5.5	0.7
Whey temperature, end of first cooking, $^\circ\text{C}$	33.5	1.41
Time at first cooking, min	11.5	5.1
Remove curd from the whey, min	33.6	10.6
Curd pH before second cooking	6.54	0.13
Curd temperature before second cooking, $^\circ\text{C}$	36.1	1.8
Ricotta whey temperature used for second cooking, $^\circ\text{C}$	84.4	1.5
Quantity of whey added, L	25.0	4.5
Water temperature for second cooking, $^\circ\text{C}$	80.9	5.7
Quantity of added water, L	16.0	2.8
Time of curd ripening, min	27.9	4.4
Curd pH at end of ripening	5.27	0.13
Quantity of stretching water, L	12.1	2.6
Temperature of stretching water, $^\circ\text{C}$	85.0	3.9
Curd pH at end of stretching	5.25	0.15
Curd temperature during stretching, $^\circ\text{C}$	49.0	0.9

<sup>1</sup>Mean calculated for each of the 20 farms, and then the mean for the 20 farms was calculated.

L of water at a temperature of  $85.0 \pm 3.8^\circ\text{C}$  (Table 2) for about 8 min.

Batches of about 14 to 15 kg of curd were stretched slowly with a flat wooden stick, a *manuveda*, until one spherical mass of cheese was formed that had a smooth outer surface. The mean curd pH at the end of stretching was  $5.27 \pm 0.15$ , and the temperature of the curd was  $49.0 \pm 0.9^\circ\text{C}$  (Table 2). This temperature was relatively consistent among farms and across months and provided consistent thermal inactivation of bacteria and enzymes. The stretched mass of curd was formed into the characteristic shape of a squared rectangle (50 cm  $\times$  16 cm  $\times$  16 cm) by turning it several times in a squared off section of the open-topped table (*mastredda*). The cheese was kept on this table for about 12 to 18 h. During this time, the cheeses cooled to room temperature (20 to  $28^\circ\text{C}$ ) while the surface dried and took on a straw-yellow color that was typical of fresh cheese. Next, the blocks of cheese were immersed in a small basin of saturated brine at room temperature at the farm.

Except in rare cases, the complete salting and aging processes were not done at the farm. Once per week the cheeses were removed from the brine basins at the farm when the farmers sold their cheeses to an aging center. At the aging center, each block of cheese was registered with the identification number of the producer and placed in brine at 14 to  $16^\circ\text{C}$  (brine tanks were big enough to contain up to 400 blocks of cheese each). The owner of the aging center paid the farmer for the fresh cheese and took most of the risk of product defect development during aging. Therefore, the farmer received a relatively low price for the fresh Ragusano cheese. The brine in the tanks at the aging centers was rarely if ever replaced; it was usually regenerated by adding water and salt to maintain saturation. In general, owners of aging centers left the cheese in brine longer than seemed necessary to achieve a higher salt content in the cheese and reduce the risk of undesirable fermentation during aging (i.e., gas production). The oldest cheese aging centers utilized a cave in the mountain for the brine and aging rooms where a consistent environment (i.e., ca. 14 to  $16^\circ\text{C}$  and 80 to 90% relative humidity) contributed to the best aging process for Ragusano cheese.

Generally, the cheeses were kept in the brine for an average of 2 d/kg of cheese weight. Once the brine salting stage was completed, the cheese was removed from the brine and aged in a ventilated room at 14 to  $16^\circ\text{C}$  with a relative humidity of about 80 to 90%. Two blocks of cheese were tied together on opposite ends of a rope and then hung in pairs over a beam to

TABLE 3. Mean Ragusano cheese composition for cheeses made at 20 farms for the September 1992 to July 1993 cheese-making season after 4 to 6 mo of aging.

Cheese component	$\bar{X}$	SD
Moisture, %	36.77	3.42
Fat, %	28.60	1.88
Fat on a dry basis, %	45.24	4.06
Protein, %	27.69	1.71
Sat, %	3.74	1.03
pH	5.22	0.18

allow air circulation during 6 to 12 mo of aging. Those cheeses that needed to be aged longer were periodically covered with olive oil on their surface. The olive oil gave the surface of the block of cheese a characteristic color and shine that was considered to be part of the quality image of the traditionally aged Ragusano cheese.

### Cheese Composition

The cheese produced by this manufacturing process is typically consumed as a table cheese from about 3 to 9 mo of age. Generally, cheese that is going to be sold at 3 mo of age (as a mild cheese) is kept in the brine tank for a shorter time, and, as a result, the salt content is lower (e.g., 2.0 to 2.5%). Ragusano cheese that is aged longer than 9 mo is usually used for grating and is added as an ingredient in freshly prepared foods at home or in restaurants. Ragusano cheese is aged without packaging and develops a rind. In general, the average moisture content of each block of cheese decreases during salting and aging. The mean composition of Ragusano cheese at 4 to 6 mo of aging is shown in Table 3. A more detailed study of the changes in composition of Ragusano cheese during aging is being conducted.

## DISCUSSION

### Milk Composition

The fat content of the bulk tank milk from the Modicana breed was lower than expected (based on the high protein content) because it was the local farm management custom (on farms with Modicana cows only) to let the calves consume part of the milk directly from the cow at the end of milking. The milk at the beginning of milking typically has a lower fat content than the milk at the end of milking individual cows (7). Thus, in contrast to the composition of Holstein and Brown Swiss milk reported in the present study, the milk in the bulk tank on farms

with Modicana cows did not represent all of the milk produced by the Modicana cows, and the true value for the fat content of milk from the Modicana breed is probably higher than that measured in the present study. However, the milk composition for each breed

(Table 1) does correctly represent the composition of milk used on average for cheese making.

### Processing Methods

The entire cheese production process for the Protected Denomination of Origin Ragusano cheese is of the farmhouse type. Each stage in the cheese making is executed personally by the farmer, by hand, using experience and traditional customs. Often the same family makes Ragusano cheese on the same farm for many generations. Ragusano cheese making is a subjectively controlled process and has not been standardized.

The wooden vat serves as a reservoir for the growth of desirable bacterial flora, and rennet derived from a young goat or lamb provides proteases and lipases that contribute to flavor development during aging. The organoleptic and qualitative characteristics of Ragusano cheese might be tied to the characteristics of the milk that are derived from species of plants in native pastures and, consequently, to the land and soil conditions of the territory. Other researchers (14) have found desirable flavor compounds in cheese that originated from compounds present in feeds and forages. Because no starter cultures are used, the rate of acidification of the curd often is slow during times of low ambient temperature, which results in a higher frequency of undesirable fermentations, and the curd may not reach the best pH for stretching. Typically, the owners of the cheese aging centers leave these cheeses in the brine for an additional time to reduce the risk of excessive gas development.

Documentation of the average conditions for the cheese-making process in the present study provides a knowledge base on which a more standardized Ragusano cheese-making process can be developed for the future. A flow chart of average conditions for the manufacture of Ragusano cheese is presented in Figure 1. In the future, further refinements of the Ragusano cheese-making process can be made, and critical control points in the process can be identified to help the farmers produce cheese of more consistent quality. As a local traditional cheese variety, Ragusano is not unique. There are many artisanal cheeses throughout Europe and other parts of the world that have unique characteristics. These cheeses as foods are part of the culture and identity of various people. The approach used in the present study can be used by others as an example of a first step that must be taken to ensure preservation of the technology for production of specific traditional cheese varieties for future generations.

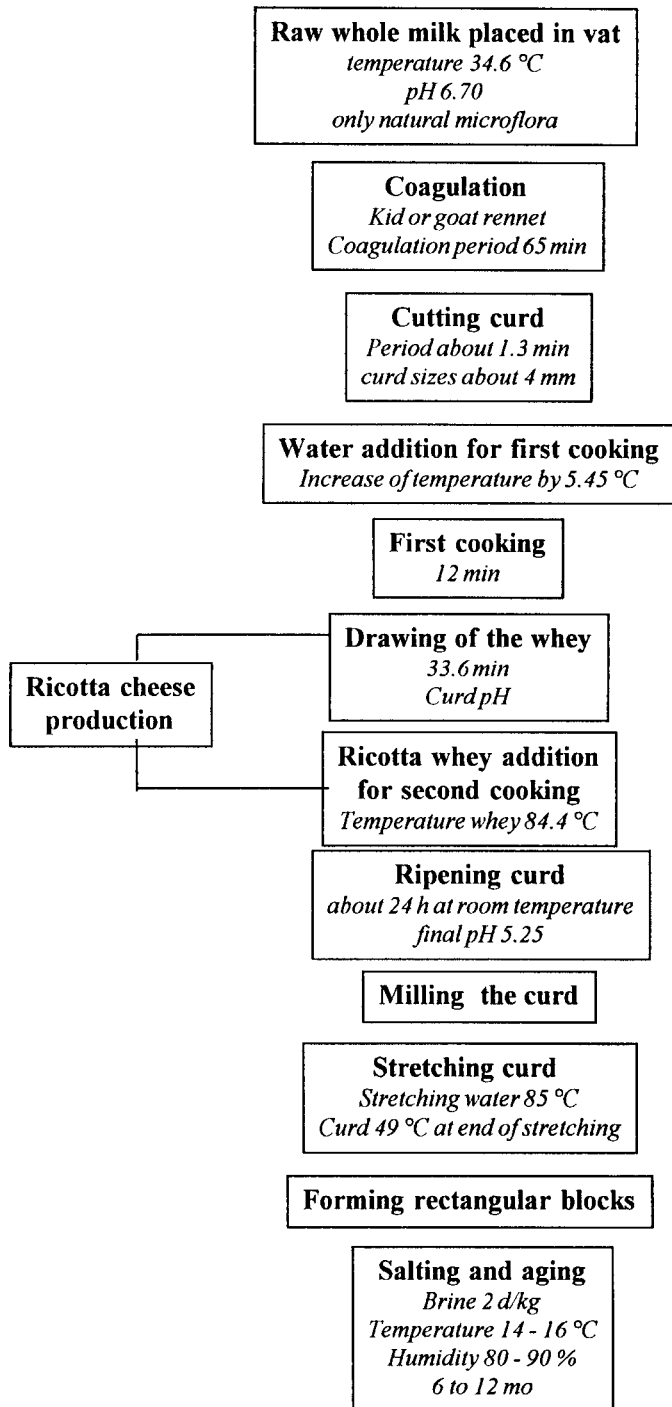


Figure 1. A flow chart of the Ragusano cheese-making process.

## Cheese Composition

The mean composition of Ragusano cheese is different from the composition of the two other common pasta filata cheeses (i.e., Mozzarella and Provolone). In general, Ragusano has a much lower moisture content and a higher percentage of salt than does Mozzarella, because Ragusano is an aged cheese. As an aged cheese, Ragusano is more similar to Provolone. However, Italian Provolone would typically contain about 39% moisture and 2.5% salt (2). The manufacturing process for Provolone has some key differences in temperatures from those used to manufacture Ragusano cheese. The higher temperatures that are used in the production of Italian Provolone may cause the level of proteolysis during aging to be lower for Provolone than for Ragusano cheese.

## CONCLUSIONS

This study has provided a detailed characterization of the traditional process for manufacturing Ragusano cheese, a flow chart of the average cheese-making conditions for production of Ragusano cheese, and an example of the first step that must be taken to document and preserve traditional cheese varieties that are part of the history and culture in various regions of the world. For a cheese produced from raw milk, it is essential that the milk be fresh and of the highest quality. The use of commercial rennet, the addition of a starter culture, and the improved control of time and temperature after the second cooking would contribute to a more consistent rate of acid development and more consistent Ragusano cheese quality. These controls would reduce the quantity of cheeses that have to be discarded because of their inferior quality, which would enhance revenues to dairy farmers.

Future research on Ragusano cheese should characterize the normal composition, chemical changes during aging, microbiology, yield, and flavor chemistry. It is also important to note the impact that the production of ricotta cheese has on the profitability of the farm to justify further study on the ricotta yield and the efficiency of recovery of the protein and fat in the whey from Ragusano cheese.

## ACKNOWLEDGMENTS

The authors thank Rosanna Bocchieri, Francesca Dipasquale, Mirella Migliore, Lucia Corallo, Rosabrina Gelsomino, Anna Maria LoPiccolo, and Salvatore Scuderi for their technical assistance in milk sample analysis and statistical evaluation. Financial support was provided by the Agricultural Department of the Sicilian Regional Government from the European Union Project POP '90/93.

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