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Making cheese with caprifig sap in Apulia, Italy: possible rebirth of an ancient tradition

Michele Faccia[1*], Daniele Apruzzese[2] and Pierluigi Passaro[3]

Abstract

Background and objectives: Making cheese by coagulating milk with extracts or parts of plants is a tradition of many countries facing the Mediterranean basin. Such cheeses were historically produced from sheep and goat milk and represent an important cultural heritage. In the European Union (EU), nowadays, their production is allowed only after legal validation of the manufacturing process under the hygienic point of view. Unfortunately, validation has been possible only for a few Protected Designation of Origin cheeses, but other dairy products exist for which it has not been carried out. It is the case of the caprifig sap cheeses produced in the "Murgia" highplain, Apulia region, Southern Italy. In this rural marginal area, three cheeses have been historically made by this coagulant: milk sap ricotta, Pampanella, and Cacioricotta. Due to the above legal concerns, they have become very rare and, if no action is taken, they will disappear very soon. The main purpose of the present work was to make a survey about the status of preservation of their processing methods and to document them before it is too late. A second aim was to perform a first summary investigation about their safety and compositional and sensory characteristics.

Methods: A series of face-to-face interviews was conducted to owners and cheesemakers of sheep and goat farms laying in the Murgia Hills territory. Cheese samples were prepared at three different rural dairies and subjected to chemical, microbiological, and sensory analyses.

Results and conclusions: The survey confirmed that caprifig sap cheeses are still occasionally produced for family consumption, mainly from goat milk in the southern part of the highplain. They have the common characteristic of deriving from milk subjected to strong heat treatment and containing both casein and whey proteins. The manufacturing procedures were observed, and two different methods of preparing and using caprifig sap were documented. The cheesemaking process was analyzed and discussed under a technological point of view, and geo-sociological connections were hypothesized. The three cheeses presented significant sensory differences and proved to potentially match the EU hygienic standards if the post-vat operations are performed under correct conditions. Overall, the study gave a contribution for the hygienic validation of the manufacturing process in view of a possible rebirth.

Keywords: Caprifig sap, Cheese, Composition, Safety, Technology

Introduction

Southern Italy is the "real Mediterranean" part of this country, both under a climatic and cultural point of view. In this geographical area, many traditional foods and gastronomic preparations have points of contact with other territories facing the Mediterranean basin. An example of this is the use of spontaneous plants for making cheese as an alternative to animal rennet. Spain and Portugal have a large variety of cheeses made with extracts from flowers of *Cynara* spp. [1]; fig tree latex is the milk coagulation agent of Teleme cheese in Turkey [2] and Djeben cheese in Algery, where artichocke and cardoon flowers and pumpkin seeds are also used [3]; finally, extracts from *Calotropis procera* (Sodom apple) are used in several African countries [4]. In Italy, two plants have been historically used in cheesemaking: marian thistle (*Silybum marianum*) and caprifig (*Ficus carica* var. *sylvestris*). This latter is a spontaneous xerophilous tree that plays an important role in agriculture since it hosts a Hymenopter (*Blastophaga psenes*) that pollinated cultivated fig [5]. The use of caprifig sap in cheesemaking is lost in the mists of time, and it was first

* Correspondence: michele.faccia@uniba.it
[1]Department of Soil, Plant and Food Sciences, University of Bari, Via Amendola 165/A, 70126 Bari, Italy
Full list of author information is available at the end of the article

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mentioned by ancient Greece authors Homer, in *Iliad* and *Odyssey*, and Aristotle, in *History of Animals* [6–8]. Of sure, the coagulant properties of fig latex were known in ancient Rome, since Columella, Plinio the Elder, and Varro clearly described it [9]. Continuation of the dairy use of caprifig in Italy in successive periods is reflected in several books, such as in *Del Compendio dei Secreti Rationali*, dated 1566, by the physical Leonardo Fioravanti Bolognese.

Apulia is probably the Italian region in which cheesemaking with caprifig sap has the oldest tradition [10]. It is located in the South-East part and is one of the most important agricultural areas of the country. The particular zone in which caprifig sap cheeses are known to be manufactured since ancient times corresponds to the "Murgia" hills (Fig. 1). Murgia is a calcareous highplain presenting a typical Mediterranean agro-pastoral landscape with rocky grassland and steppic vegetation. Here cheesemaking is historically linked to sheep and goat rearing, and rural dairies were very common in the past [11]. Three cheeses were traditionally produced by this vegetable coagulant: "Cacioricotta," "Pampanella," and "milk sap ricotta." They were made from ovine and caprine milk at the farm level until the introduction of the EU safety regulation in 1992. This regulation imposed stringent hygienic requirements, and from that time on, application for special permission is required for producing and selling these cheeses [12]. Basically, special permission is a sort of hygienic validation of the manufacturing process, but it is difficult to obtain for rural dairies, since it must be based on scientific studies. As a consequence, these cheeses have become very rare, and if nothing changes, they might cease to exist very soon.

The present investigation started from the consideration that the increasing interest towards traditional and ethnic/ethic foods could offer new chances for preserving this ancient dairy tradition. Besides representing a cultural heritage of Apulian agriculture, these unique cheeses can potentially intercept, for instance, the promising demand of vegetarian or kosher foods [13, 14]. These cultural contents could be suitably driven by tourism and food operators, giving a contribution to the survival of the small dairy farms in this fragile, marginal territory. In this perspective, the hygienic validation of the manufacturing procedure could become technically possible and economically sustainable. Unfortunately, scientific information on these cheeses is very rare: except for a research carried out on Cacioricotta [15], they are totally unexplored. The aim of the present paper was to investigate the current situation of caprifig sap cheeses on the Murgia Hills territory by (i) making a survey about the processing methods; (ii) documenting and describing them, before they disappear; (iii) taking cheese samples for assessing safety and the compositional and sensory characteristics.

Fig. 1 Geographical location of Murgia Hills within the European geographical context. Murgia is a calcareous highplain in Southern Italy that extends along about 4000 km^2. It is included in the territory of two regions: Apulia and Basilicata. It presents a typical Mediterranean agro-pastoral landscape with rocky grassland and steppic vegetation. In this area, sheep and goat rearing has an ancient tradition, and rural dairies were very common in the past

History of caprifig sap cheeses in Italy

Historical knowledge about caprifig sap cheeses is very poor. According to old shepherds, Pampanella and fig sap ricotta were only prepared in late spring and summer, when animal lactation was about to end and the amount of milk produced was too scarce for making hard cheeses. It is also probable that cheesemakers preferred to prepare fresh cheeses in that season since the very warm climate was not compatible with successful manufacturing of cheeses to be ripened (due to uncontrolled fermentations). According to an old Italian "domestic vocabulary" [16], Pampanella was a particular type of "Giuncata" (clotted milk obtained by the addition of animal rennet). In a successive edition of the book, the same author better defined Pampanella as "clotted milk put into vegetable leaves and eaten after addition of some sugar". Differently, we were not able to find any historical citation of milk sap ricotta in the literature, and neither discussion with old farmers helped us in getting more information. Since these two cheeses were too soft and delicate to be marketed outside the farm, it is probable that they were produced only for self-consumption. From the end of the 1950s and until the end of the 1980s, some local marketing started, and the product begun to be sold by itinerant sale. Very interestingly, Pampanella was known to be sold in summer on the Apulian beaches, until the implementation of the modern hygienic rules made it illegal. Differently from the above cheeses, Cacioricotta is cited in several old books, such as *Le spezzate durezze. Comedia nuoua del sig. Ottauio Gloritio dottor di leggi*, dated 1606. Furthermore, the association of this cheese with the name Apulia can be found in a book dated 1811 written by G.B. Gagliardo [17]. Nowadays, this semi-hard cheese is included in the traditional dairy knowledge of several regions of Southern Italy, where it is manufactured by using animal rennet. It is widely used for seasoning traditional pasta dishes such as "Orecchiette with tomato sauce and basil." Unfortunately, we did not find any ancient detailed description about the use of fig sap: a description about the manufacturing of Cacioricotta with vegetable rennet is dated 1823, but the type of plant used is not specified in the text [18].

Materials and methods

Survey

A series of face-to-face interviews, with replies to a questioner, was conducted to owners and cheesemakers of sheep and goat farms of the Murgia Hills territory, included in the provinces of Bari, Barletta-Andria-Trani (BAT), and Taranto (Apulia, Southern Italy). We asked them if they ever had manufactured cheese by using caprifig and classified the answers into three categories: never, in the past, or currently manufactured. In the case of positive response, we asked to provide a brief description of the method known. In total, 91 interviews were collected, and the answers were elaborated by the Microsoft Excel 2013 program.

Cheesemaking and cheese analyses

During the interviews, three producers were chosen for preparing cheese samples for the study. One was located in the province of Bari, the other two in the province of Taranto. The former manufactured milk sap ricotta from sheep's milk, and the latter two prepared Pampanella and Cacioricotta from goat's milk. In order to standardize the manufacturing conditions, they used the same amount of milk and produced cheeses of the same weight (about 400 g). Cheesemaking was done according to the "personal" knowledge of the farmers that had passed down through the generations. During processing, all operations were photographed and noted, time and temperature were measured, and samples for the laboratory analyses were taken. Samples of milk and curd were taken as soon as they were available, whereas the cheese was taken after about 2 h from production. All samples were microbiologically controlled by determining the counts of total mesophilic viable bacteria (plate count agar method), *Enterobacteriaceae* (method ISO 21528-2), *Escherichia coli* [19], coagulase-positive staphylococci (method EN ISO 6888-2: 1999), *Listeria monocytogenes* (method ISO 11290-1: 1996), and *Salmonella* spp. (method ISO 6579: 2002). The cheese samples were also subjected to chemical and sensory analyses. The chemical determinations were as follows: moisture by oven drying method, fat by the Soxhlet method, total protein (nitrogen × 6.38) by the Kjeldahl method, lactose by enzymatic assay (R-Biofarm AG, Germany), sodium chloride by a Sherwood 926 chloride-analyzer (Sherwood Scientific, UK), pH by Double Pore penetration electrode (Hamilton, USA), activity water (Aw) by using HygroLac-C1 (Rotronic, USA). All analyses were performed in triplicate, and the results were statistically processed for calculation of the means and standard deviation. Finally, the mean values of the chemical determinations were used for calculating the nutritional profile of the cheeses on the basis of the Atwater-specific factor system for milk products [20]:

$$\begin{aligned}\mathrm{ME}\left(\text{metabolizable energy, kcal g}^{-1}\right) &= (\text{protein} \times\ 4.27) + (\text{fat} \times\ 8.79) \\ &\quad + (\text{carbohydrate} \times\ 3.87)\end{aligned}$$

The main sensory traits of the cheeses were assessed by a panel composed of nine trained assessors belonging to the Italian Association of Cheese Tasters (ONAF) and selected following international standard (ISO, 8586-1: 1993). The panelists performed a quantitative descriptive analysis by choosing the sensory descriptors from the ONAF vocabulary and quantifying them on a 6-points

scale (from 0 = not perceived to 5 = highly perceived). Only descriptors with a weight percentage greater than 30% of the maximum value of frequency of citations × perceived intensity were considered [21]. The results were statistically elaborated, and the mode values were considered.

Results and discussion

Survey

According to the data of the Italian Istituto Zooprofilattico Sperimentale [22], in March 2019, sheep and goats in the Apulia region were reared in about 4000 farms. The major part of them reared sheep for meat, whereas only 83 were specialized in milk production. Out of 4000 farms, about 1700 were located in the Murgia Hills area: the sheep farms were concentrated in the BAT and Bari provinces (northern part), whereas those rearing goats were mainly reared in the province of Taranto (southern part). This latter area was also characterized by the greater presence of farms that made food products for self-consumption (78 out of 138, corresponding to 56.5% of total). In our interviews, we strongly looked at such type of farm and, in general, at small enterprises, where owners and operators are more inclined to preserving traditional practices. The results of the survey are shown in Fig. 2. As it can be seen, only about 9% of the respondents declared to currently make cheese by using caprifig sap, but 38% said that to have manufactured it in the past. The highest percentage of positive answers (currently manufactured +in the past) was found in the province of Taranto (18 + 61 = 79%). Even though the investigation should be considered as a preliminary survey, since it was not built on a statistically validated criterion, the results provided food for thought. The first consideration is that knowledge of this ancient cheesemaking method is firmly present on the territory, but risks to disappear. The second consideration is that the method is better known (and preserved) in the area where goat rearing is more present (the province of Taranto). This could indicate that caprifig sap was historically connected to goat's milk cheesemaking or that it is simply better preserved where self-consumption has greater incidence. Finally, and very interestingly, the interviews revealed that two different protocols for coagulant preparation are adopted in the territory, with a clear differentiation between the northern and southern part of the area. In the northern zone, farmers directly use caprifig branches for coagulating the milk, whereas water extraction of sap is performed in the southern zone. None was able to give us a possible explanation for such differences; on the contrary, the majority of the respondents in each zone totally ignored that a different protocol existed in other geographical areas.

Cheesemaking

Coagulant preparation

Under the biochemical point of view, the coagulant activity of caprifig sap is due to an enzyme system that is mainly composed of several isoforms of ficin [23, 24]. The major difficulty in using this coagulant is that ficin concentration is unknown, so the application of a well-established protocol for preparation is the only way to reduce variability. Ficin concentration can vary according to the growth stage and vegetative conditions of the plant and to the seasonal weather conditions. Both the preparation protocols used in the territory were documented. The farm located in the province of Bari used a method that appeared to be very similar to that of ancient Greek shepherd reported by Small [6]. It consisted in picking young branches (less than 2 cm diameter and about 60–70 cm length), washing them with water, and cutting off the buds. Then, a bunch made of five to six

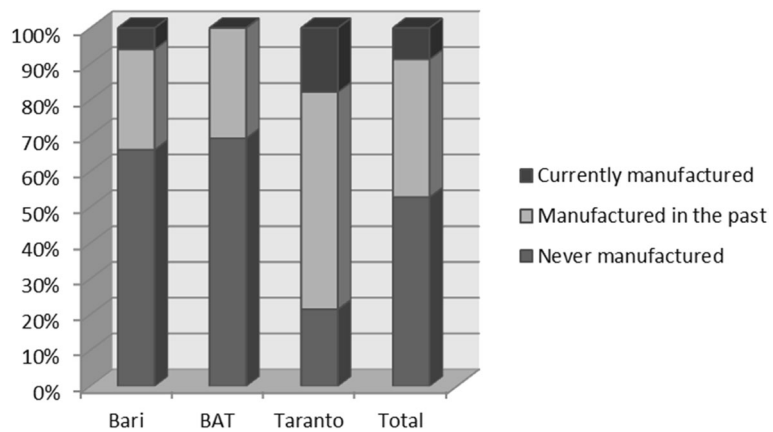

Fig. 2 Results of the survey about cheesemaking with caprifig sap in the Murgia territory. The interviews were carried out in the three Apulian provinces in whose the highplain lies: Bari, BAT, and Taranto. The responses were grouped into three categories (see legend and symbols)

branches is composed and used for milk coagulation: in this case, the sap is directly transferred from the branches to milk (Fig. 3). The bunch was only used once, and after cheesemaking, it was thrown away. Differently, the two dairies located in the province of Taranto extracted sap by water. Briefly, two young branches with some leafs (less than 2 cm diameter and about 30–40 cm length) were taken, minced, and put into a plastic vessel; about 1 L tap water was added, then the mixture was transferred into a glass and left to rest for 1 h (Fig. 4). Immediately before use, it was filtered and added to milk at the ratio 1:100 v/v.

Manufacturing of the cheeses

The production technology of milk sap ricotta (Fig. 5) contemplated heating of the milk (slightly salted) under agitation by a wooden stick until the temperature reached 70 °C; at this point, agitation was slowed down while heating continued, and the caprifig bunch was used for stirring instead of the stick. The operation proceeded very gently until the cheesemaker observed the formation of the first milk clots on the surface, then he pulled out the bunch, stopped agitation, and after 3 min stopped heating. At this time, the maximum temperature was reached, corresponding to 91 °C, and in a few seconds a soft coagulum foamed up on the milk surface. At this temperature, the coagulum contained both casein and whey proteins due to the formation of thermo-denatured aggregates [25]. After a 3-min pause for thickening, it was patiently extracted by a ladle and inserted in small plastic baskets. We noticed that it was not easy to catch the clots' formation at the right time, since the milk is opaque. In the case of error, excessive release of sap takes place due to prolonged contact between bunch and milk, and the cheese becomes bitter. In order to avoid error, the operator used a teaspoon by which he continuously collected and observed under the right light small amounts of milk. After molding, the cheese cooled down very slowly since it was kept at room temperature. A particular point of the manufacturing process struck us, that is, the temperature at which the caprifig bunch was inserted into the milk. It exactly corresponded to the upper temperature limit for ficin activity (about 70 °C), for which the optimum conditions are in the range 45–55 °C [26] and at 6.5 pH [27]. It was an evidence of how empiricism of the ancient tradition can be able to find the suitable manufacturing procedures: in fact, if fig sap comes in contact with milk too soon, both the pH and temperature conditions should cause rapid coagulation. If milk colts at the wrong time, the whey proteins cannot bound to casein since they are not yet in the denatured state, and a different cheese should be obtained. In few words, the particular characteristics of fig sap ricotta derive from a very clever cheesemaking technique, that is, fully explainable under the biochemical point of view.

The manufacturing processes of Pampanella and Cacioricotta were rather different from that used for milk sap ricotta. The main difference regarded the way by which milk coagulation occurred: in this case, it was much slower and the curd, after cutting, tended reached the bottom of the vat. The first phase of the two processes (from preparation of the coagulant to milk clotting) was almost the same, whereas the "curd-handling" operations were strongly different. In both cases, the milk was transferred to a small vat, heated to about 85 °C; then, it was cooled to about 60 °C by immersing the vat in pot water. The cooling required about 15 min, then the caprifig extract was added (1 L per 100 L^{-1} milk). Here again, ficin was added at the right time and acted after whey proteins had been denatured. After coagulation, the processing operations of the two cheeses changed. For Pampanella (Fig. 6), the curd was only slightly broken, then was directly collected by the plastic basket in which it remained until consumption. Differently, for Cacioricotta (Fig. 7), the curd was cut into

Fig. 3 Preparation of the caprifig bunch for manufacturing milk sap ricotta. In order of appearance from left to right: detail of a caprifig tree, cutting of the buds from the branches, bud-free branches ready for the preparation of the "coagulating bunch"

Fig. 4 Preparation of the caprifig extract for manufacturing Pampanella and Cacioricotta. In order of appearance from left to right: two small branches with some leaves, chopped branches and leaves, and infusion in water for sap extraction

pieces having the size of a rice grain and left to settle for about 10 min. Then, the most part of the whey was removed and the curd grains were transferred into plastic baskets by means of a pitcher. After gentle pressing, the cheese remained at room temperature for about 3 h, then it was dry salted and kept in a cool place with air circulation for short ripening (7–10 days). However, only fresh Cacioricotta was considered in the present study.

Although the manufacturing process of the three cheeses presented significant differences, they had some points in common besides the use of caprifig sap. The most important one was the application of strong heat treatment of milk before coagulation, under temperature conditions that fully match the modern legal requirements for the production of fresh cheeses. Since the use of raw milk in cheesemaking was the rule at the time in which these cheeses were developed, it must be considered an unusual operation. If we consider that pasteurization was only discovered in 1862, we can conclude that the ancient Apulian shepherds anticipated such fundamental

Fig. 5 Manufacturing of milk sap ricotta. The different phases are as follows (small pictures): preparation of the "coagulating bunch," insertion in the heat-treated milk, gentle agitation until coagulation, and coagulum formation on the surface. The large picture shows the product during the cooling phase at room temperature

Fig. 6 Manufacturing of Pampanella. The pictures show the main phases as follows: milk coagulation, cheese extraction, and final product into the fig leaf ready for consumption

scientific breakthrough. It is a further evidence of how the traditional cheesemaking protocols were effective in selecting suitable conditions for safety food manufacturing.

Cheese analyses

The safety aspects were assessed by chemical and microbiological analyses. As can be seen from Table 1, all three cheeses presented high pH and Aw values, and for this reason, they should be considered as potentially susceptible to the growth of pathogen microorganisms. Moreover, they should not be suitable for lactose-intolerant consumers due to high lactose content, which depended on the low level of microbial fermentation connected to the heat treatment and absence of starters added. From the moisture levels observed, it was found that milk sap ricotta and Pampanella are soft cheeses, whereas Cacioricotta presented intermediate characteristics between a soft and a semi-hard cheese. Under the nutritional point of view, Cacioricotta presented the highest ME value, since it had the highest fat and protein content. Under the microbiological point of view, all cheeses were safe since *Listeria monocytogenes* and *Salmonella* spp. were never detected. As to the other microorganisms, they were present at different levels, depending on the technological conditions. Figure 8 shows the evolution of the microbial counts from milk to cheese, whereas Fig. 9 shows the time/temperature profiles of the three manufacturing processes. It was evident that the thermic treatment was very effective in improving the microbiological characteristics of milk and had a strong impact on all bacteria groups. In all cases, the parameters used exceeded those provided by the law for pasteurization. However, significant bacterial growth was found in the cheeses: the highest values were observed in Cacioricotta, probably due to the fact that it was handled a number of times, from molding to salting. On the whole, even though the counts were not very high, they suggested that post-vat operations represent a critical point under the hygienic point of view, in particular

Fig. 7 Manufacturing of Cacioricotta. The pictures show the main phases as follows: addition of the coagulant to milk, milk coagulation, curd cutting into small grains, transfer of curd grains into the plastic baskets, and final product ready for consumption

Table 1 Gross composition (%) and metabolizable energy (ME, kcal 100 g^{-1}) of the cheeses

	Milk ricotta	Pampanella	Cacioricotta
Moisture	81.8[a] (2.1)	78.3[a] (2.5)	54.5[b] (3.2)
Fat	8.1[b] (0.4)	8.6[b] (0.9)	20.5[a] (1.7)
Protein	6.2[c] (0.5)	7.9[b] (0.3)	19.3[a] (1.1)
Lactose	2.5[a] (0.1)	2.2[b] (0.05)	1.5[c] (0.1)
NaCl	0.3[c] (0.03)	0.5[b] (0.03)	3.4[a] (0.05)
ME	107.4	117.8	268.4

All the values are mean ± SD of three replicates. Values with different superscripts on the same row differ significantly ($p < 0.05$)

during the cooling phase. We did not analyze the microbial evolution during storage, but it is clear that the cheeses must be kept under correct refrigeration for delaying microbial growth. In this perspective, the high moisture level represents a risk factor for excessive growth of *Escherichia* and staphylococci, in particular for milk sap ricotta and Pampanella. If correctly stored, the consumption of all cheeses under study should take place within a few days. The results of the sensory evaluation are shown in Table 2. As regards taste, sweetness was perceived in all samples, due to the high content of lactose: the highest was the moisture; the sweetest was the cheese. A second taste detected in all cheeses was bitterness, even though at low levels: in fact, it never resulted in unpleasantness and the maximum score was 2, for Pampanella. Bitterness was highly associated to the astringent and metallic trigeminal perceptions. On the whole, the association of the sweet,

Table 2 Sensory descriptors developed for describing the cheeses

Attribute	Milk ricotta	Pampanella	Cacioricotta
Taste			
Sweet	4	3	2
Salty	1	0	3
Acid	0	0	0
Bitter	1	2	1
Trigeminal sensations			
Astringent	1	2	1
Metallic	1	2	1
Texture			
Creamy	3	1	0
Adesive	2	1	1
Soluble	1	1	1
Lumpy	1	1	1
Chalky	0	1	3
Aroma			
Boiled milk	3	3	2
Cream	2	1	0
Vegetal	1	2	1
Sheepfold	2	1	3
Overall intensity	2	1	1

The scores are expressed as modal values of two replicates. A hedonic 6-points scale was used (from 0 = not perceived to 5 = highly perceived)

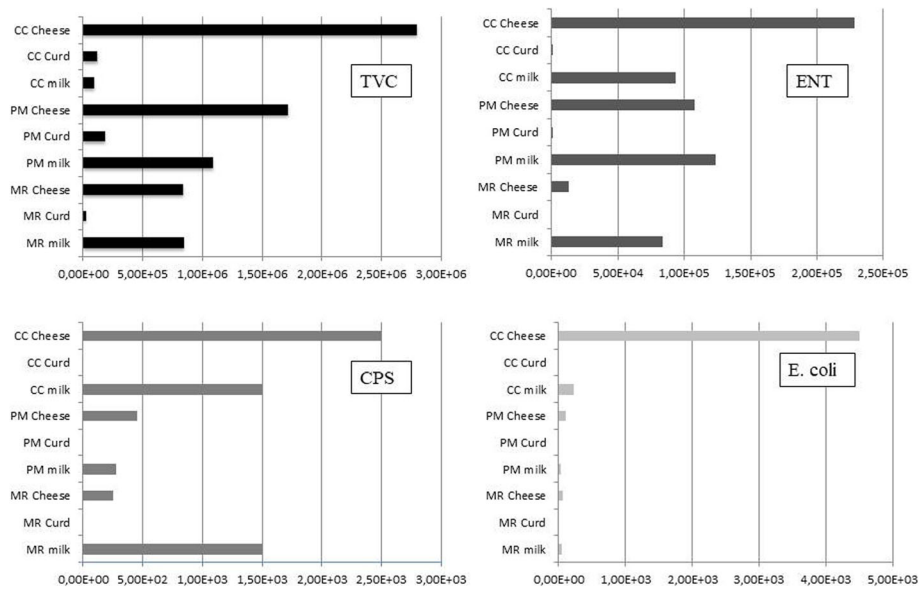

Fig. 8 Bacterial counts (ufc/mL, exponential value) of milk, curd, and cheese samples taken during processing. Vertical axis: CC Cacioricotta, PM Pampanella, MR milk sap ricotta. TVC total viable, ENT *Enterobacteriaceae*, CPS coagulase-positive staphylococci, E.coli *Escherichia coli*

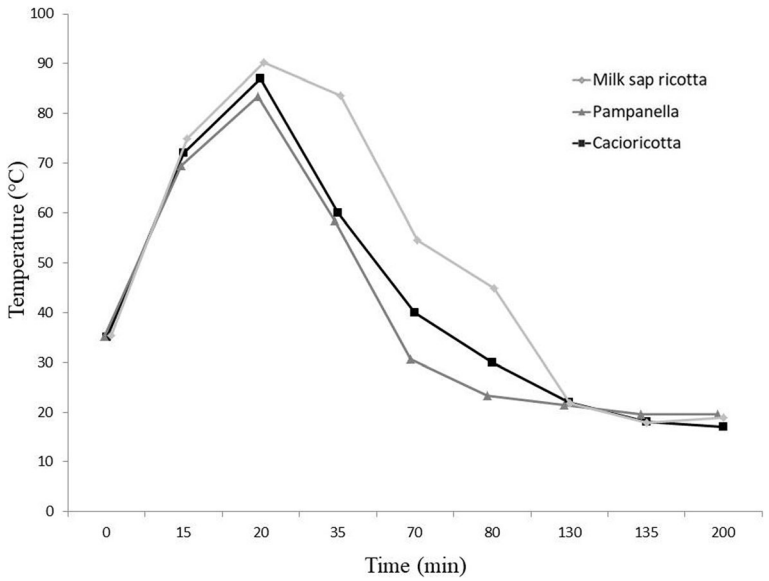

Fig. 9 Evolution of temperature during the manufacturing of the three cheeses. In all cases, the maximum values widely exceeded the pasteurization parameters contemplated by EU legislation. The long cooling time depended on the absence of refrigeration

bitter, and trigeminal tastes represents a unique characteristic that could easily identify the use of caprifig sap. The most relevant texture descriptors cited by the panel were creamy and adhesive for milk sap ricotta and chalky for Cacioricotta. Pampanella had not a well-characterized texture, since it just appeared as a sort of coagulated milk. Finally, aroma was never very intense, and the most important descriptor was boiled milk, as expected. The sheepfold odor was found at a different level in the three cheeses, but it should depend on the type of milk used.

Conclusions

The most relevant results of the present study are the documentation of the ancient Apulian procedures for making cheese with caprifig sap and the understanding of the main technological operations within the geographical-historical context. The Apulian cheeses produced by caprifig sap have the common characteristic of deriving from milk subjected to strong heat treatment. Probably, this procedure was empirically developed for countering the bacterial growth under the warm climate of this Region, where temperature commonly begins to exceed 20 °C in correspondence of the maximum peak of lactation (from half of March to end of June). Furthermore, the heat treatment gave higher cheese yield due to the recovery of both casein and whey proteins. The use of caprifig sap should mainly derive from the fact that it is heat-resistant and allows to overcome the problem of cooling the milk (animal rennet does not work above 45 °C). Finally, the study gives a contribution for the hygienic validation of the manufacturing process, suggesting to take particular care of the post-vat operations.

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Authors' contributions
MF designed the research, interpreted the data, and wrote the manuscript. DA performed the survey and made the photographic documentation. PP collaborated to data processing and revision of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
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Competing interests
The authors declare that they have no competing interests.

Author details
[1]Department of Soil, Plant and Food Sciences, University of Bari, Via Amendola 165/A, 70126 Bari, Italy. [2]Italian National Association of Cheese Tasters (ONAF), Via Raguso 2/N, 74015 Martina Franca, Italy. [3]Department of Economics, Management and Business Law, University of Bari, Largo Abbazia S. Scolastica 53, 70125 Bari, Italy.

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