In this preliminary study we evaluated the effect of different donkeys’ milk additions in cheese making on the acceptability of fresh Caprino, a typical goat cheese produced in a region of southern Italy. In cheese making three batches were considered: A1 only goats’ milk, A2 and A3 with the addition of 5% and 10% of donkeys’ milk, respectively. With the exception of colour, the lowest donkeys’ milk addition improved the acceptability of Caprino cheese. In particular, significant highest ratings (P < 0.05) were observed on odour, flavour, texture and on overall liking.

**Keywords** Caprino cheese, Goat cheese acceptability, Donkey milk.

In Italy, goats and donkeys are mostly reared in the South-Center, probably due to the well adaptation of the species to browsing or grazing in marginal lands. Goats’ milk is mainly delivered for cheese making, while the renewed interest toward donkeys’ milk is mainly motivated by its chemical composition and nutrient contents, which have made it similar to human milk (Cosentino et al. 2016). Moreover this milk is utilised in the geriatric field for the treatment of some aging diseases (Hernández-Ledesma et al. 2006). In cheese making the interest toward donkey milk is related to its lysozyme content, as it ranges from 1.0 to 3.7 mg/mL, much higher than in cow (0.18 µg/mL) or in goat milk (0.25 µg/mL) (Cosentino et al. 2016; Labella et al. 2016). For this reason, donkeys’ milk has been recently tested as an inhibitor of late gas production defects during ripening in bovine cheeses (Cosentino et al. 2015; Niro et al. 2021) and in a mixed bovine-ovine cheese (Ozturkoglu-Budak et al. 2021) as alternative of hen egg white lysozyme, which can cause severe allergic reactions (Cosentino et al. 2015; Niro et al. 2021). These studies have also highlighted that the addition of donkeys’ milk did not reduce the acceptability of the product, even improving it in some appearance descriptors (structure and uniformity), sweetness intensity (Cosentino et al. 2016). Moreover, a recent study (Ozturkoglu-Budak et al. 2021), in which lysozyme and lactoferrin extracted from donkeys’ milk were compared to chemical additives in production of Kashar cheese, evidenced the best values in terms of taste and flavour in cheese produced with natural protein addition. The nutritional and health aspects of goat cheese have led to growing interest of consumers. However many of them, especially the occasional ones, prefer mainly goat cheeses with a not particularly marked goaty aroma. In this study, in light of this consideration and also of the first encouraging results on the above mentioned studies on bovine cheeses, we evaluated the acceptability of fresh Caprino produced with two different additions of donkeys’ milk. Caprino cheese is a traditional Italian agri-food product (P.A.T.) from Basilicata region included in a special list of the Ministry of Agricultural, Food, and Forestry (MIPAAF 2021). It is made with raw caprine milk and rennet and, sometimes, it is even additionally flavoured with...
rocket and thyme. Its cylindrical shape is 8–12 cm high and has a diameter of 15–20 cm. Weight ranges from 0.5 to 1 kg. The aged type is left to mature for up to 6 months and during ripening it develops much saltier and spicy flavour, turns its colour from white to ivory with sparse and irregularly distributed holes. Fresh Caprino is ripened between for two to four days.

Milk collection and analysis – Fresh raw goats’ and donkeys’ milk were collected the same day by a mechanical milking apparatus. Bulk milk was taken from 2 different farms situated in Basilicata region. Milk from pluriparous autochthonous dairy goats and Martinafranca breed jennies was collected and refrigerated at 4 °C. Milk samples were transported to the laboratory to determine the content of protein, fat, lactose (IDF 1995; ISO 2013), dry matter (DM) and ash (AOAC 1990). All measurements were carried out in triplicate. Goats’ milk contained, on average, 29.7 g/kg protein, 48.8 g/kg fat, 38.6 g/kg lactose, 136.0 g/kg DM, and 8.0 g/kg ash content. Donkeys’ milk had the following composition: 17.0 g/kg protein, 13.0 g/kg fat, 64.0 g/kg lactose, 96.0 g/kg DM, and 4.0 g/kg ash.

Cheese making - Goats’ milk was first pasteurized at 65 °C for 30 min and subsequently cooled down to 28 °C. Donkeys’ milk was not thermized, because in donkey milk the heat-treatment changes the proteins conformation, with negative results during enzymatic reaction (Iannella 2015). A fixed amount of milk (100 L for each vat) was poured in 3 different vats in order to consider three different thesis: A1 (only goats’ milk, control group), A2 (5% donkeys’ milk addition) and A3 (10% donkeys’ milk addition). Each vat was inoculated at 28 °C with a mesophilic starter culture of Lactococcus lactis subsp. lactis (6 g/L; M030N, Sacco; Como, Italy). After 1 h, Bifidobacterium bifidum (2 g/L; Prodot; Piacenza, Italy) was added to the milk. After 3 h fermentation, liquid calf rennet (10 mL/L; strength units 1:10 000; chymosin to pepsin ratio 80:20; Prodot; Piacenza, Italy) was added to the milk, and the curd was allowed to stand for 24 h at 27–28 °C. After whey draining, the curd obtained was placed into round plastic molds with a diameter of 15 cm, dry salted and matured for 2 days at 10–15 °C and 70% of relative humidity. The whole experiment was repeated twice.

Cheeses were sampled according to the IDF (1995) procedure to perform the following parameters: pH (pHMeter HI98161, Hanna Instruments, Padova, Italy), protein, fat, (NIR System 5000, Foss), DM and ash content (AOAC 1990).

For the evaluation of acceptability we have chosen habitual consumers of fresh cheese (not just goat cheese) because, having a taste more oriented towards products with a less strong taste, they could have better appreciated differences, even slight, among the theses. Consumer recruitment (38 males and 42 females, aged between 21–62 years) was carried out by placing advertisements across the University of Basilicata campus. A small amount (20 g) of each type of cheese was identified by random 3-digit codes and served in random order under white fluorescent lighting to consumers. They were asked to evaluate colour, odour, flavour, texture and overall liking by a 9-point hedonic scale (Cosentino et al. 2021). The consumer test was performed in individual booths. Data were subjected to one-way ANOVA, and means were compared by Tukey’s HSD.

The addition of donkeys’ milk influenced significantly DM, protein, and fat contents in cheese, with lower values in A3 related to the greater addition of donkeys’ milk (Table 1). Protein contents of A2, and A3 cheeses resulted slightly higher than that observed (171 g/kg) on a fresh cheese made with a mixture of donkeys’ and goats’ milk by Faccia et al. (2018). With the exception of colour, donkeys’ milk addition influenced statistically the acceptability of cheese (Table 2). In particular, significant highest ratings (P < 0.05) were observed in A2 thesis on odour, flavour, texture and on overall liking. The overall liking rating of A2 cheese was near to be ‘like very much’ in the evaluation scale. Niro et al. (2021), on Grana Padano cheese, and Cosentino et al. (2016) on cow cheese found that the addition of donkey milk aliquots significantly improved several microbiological and chemical-physical aspects that, in agreement with Faccia et al. (2020), could be attributed to a diminished caprine taste, and to a higher sweet taste. Conversely, cheese made with the highest amount of donkeys’ milk showed significant lowest scores on odour, flavour, texture and overall liking parameters. Texture, may have been affected by the dilution effect of donkeys’ milk towards caseins and fat content. A sensory analysis by an expert panel may be very useful for identifying sensory attributes characterizing Caprino cheese made with different jenny milk additions.

In conclusion, the addition of a small amount of donkeys’ milk in Caprino cheese making would allow an even more pleasant product to be obtained and, probably, characterized by a longer shelf life due to the bacteriostatic action of donkey milk, already highlighted in a cow cheese (Cosentino et al. 2015). An ongoing study on the topic may perhaps consolidate this hypothesis. Moreover, non-eager consumers who prefer more neutral goat cheese, with a taste

<table>
<thead>
<tr>
<th>Table 1 Cheese chemical parameters (mean ± SD).</th>
</tr>
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<tbody>
<tr>
<td>Parameter</td>
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<tr>
<td>----------</td>
</tr>
<tr>
<td>Dry matter, g/kg</td>
</tr>
<tr>
<td>Protein, g/kg</td>
</tr>
<tr>
<td>Fat, g/kg</td>
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<tr>
<td>Ash, g/kg</td>
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<tr>
<td>pH</td>
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</tbody>
</table>
| A1: only goat milk; A2: 5% addition of donkey milk; A3: 10% addition of donkey milk.  
\*P < 0.05. |
similar to that of cow, could also appreciate this product (Ryffel et al. 2008). Processing of dairy products by using mixtures of goat and donkey milk could be an interesting and feasible opportunity for the local dairy sector, producing cheese as a high-quality functional food, thus having a potential impact on the market. Moreover the use of donkey milk may also have positive implications for existing donkey farms as well as for the conservation or reintroduction of this species in marginal areas (Cosentino et al. 2015).

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AUTHOR CONTRIBUTIONS


FUNDING INFORMATION


DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES


Table 2 Consumer liking scores (mean ± SD).

<table>
<thead>
<tr>
<th>Cheese</th>
<th>Colour</th>
<th>Odour</th>
<th>Flavour</th>
<th>Texture</th>
<th>Overall liking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>7.56 ± 1.50</td>
<td>7.25ab ± 1.48</td>
<td>6.96a ± 1.75</td>
<td>7.48ab ± 1.28</td>
<td>7.08ab ± 1.66</td>
</tr>
<tr>
<td>A 2</td>
<td>7.92 ± 0.95</td>
<td>7.23ab ± 1.38</td>
<td>7.35ab ± 1.74</td>
<td>7.48ab ± 1.48</td>
<td>7.62ab ± 1.63</td>
</tr>
<tr>
<td>A 3</td>
<td>7.50 ± 1.54</td>
<td>6.81ab ± 1.58</td>
<td>6.46a ± 1.83</td>
<td>7.12ab ± 1.64</td>
<td>6.85ab ± 1.74</td>
</tr>
</tbody>
</table>

A1: only goat milk; A2: 5% donkey milk addition; A3: 10% donkey milk addition.

\(^{ab}p < 0.05\)


