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Short communication

Sensory evaluation of a novel prebiotic sheep milk strawberry beverage

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ABSTRACT

The sensorial evaluation of a prebiotic sheep milk juice beverage considering a consumer's perception was performed. Four beverages with different concentration of skimmed sheep milk, strawberry pulp and sugar, added with a fixed inulin level (3 g/100 g) were manufactured and submitted to hedonic and preference ranking test with 60 consumers. Beverages containing decreased sugar levels and higher content of strawberry pulp were most preferred and presented the higher scores in the acceptance test. According the Principal Component Analysis, sample B3 was characterized by strawberry flavor and aroma, acid taste, strawberry seeds presence, sheep aroma, fatty flavor, and pinkish color; while sample B4 was associated with reddish color, astringent flavor, bitter taste, brightness, viscous, sweet, acid and rancid aromas attributes. Finally, sample B2 presented salt and sweet taste, and thinner texture, while samples B1 presented sheep flavor, cooked aroma, cooked flavor and residual flavor. Our findings suggest that formulation should contain 550/370/50 g/L of skimmed sheep milk, strawberry pulp and sugar in beverage.

1. Introduction

The market of foods and beverages with beneficial ingredients added associated is represented by fortified or functional products, and grows each year reaching around $264 billion (Rolim, 2015). In this context, the combination of the nutritional value of dairy products with the bioactive components from fruit juices can create promising ready-to-drink beverages (Zulueta, Barba, Esteve, & Frígola, 2013).

Small ruminant food products are gaining major interest due to their nutritional and sensory properties (Ranadheera, Naumovski, & Ajlouni, 2018). The current production situation shows substantial room for improvement, and relevant increases in milk production (from 30 to 50%) are expected by 2030 (Pulina et al., 2018)Sheep milk is mainly used to produce fine cheeses, yoghurts, and whey cheeses, having high nutritional value and high yield compared to other domestic mammal species as it has higher contents of proteins, lipids, minerals, and essential vitamins (Balthazar et al., 2017b). Due to these characteristics, sheep milk could provide a rich nutritional regime for both children and adults, supplying most of the essential nutrients (Albenzio et al., 2016). Other interesting characteristic is 99% similarity between its αS1 and αS2 protein sequences with goat milk, suggesting that sheep milk also promotes lower allergic sensitization (Masoodi & Shafi, 2010). Furthermore, many innovative sheep milk dairy products with functional attributes have been reported (Balthazar et al., 2017b).

Strawberries are among the most widely consumed fruits in the world, being a rich source of bioactive compounds such as vitamin C, β-carotene and phenolic compounds (Ariza et al., 2016). Since milk in general lacks most of those compounds and fiber (Wijesinha-Bettoni & Burlingame, 2013), fruits could be incorporate to diet by developing milk-juice beverages with functional benefits to consumers. Moreover, dietary fibers such as inulin added to products can be selectively utilized by host microorganisms promoting health benefits and wellness to individuals (Gibson et al., 2017). In addition, inulin provide similar technological characteristics as fat, being an excellent substitute (Balthazar, Ferreira, & Cruz, 2017a; Balthazar et al., 2017c, 2018).

Taste is an important determinant to intake control. Besides the sweet, one of the five basic modalities of taste improves pleasure of meals and snacks, encouraging the consumption of high energy and carbohydrates foods and drinks (Shin, Lee, & Kim, 2018; Sweetman, Wardle, & Cooke, 2018). In Europe, high intakes of sugar is observed more in children than adults such as in dairy and beverages (Azaïs-Braesco, Sluik, Maillot, Kok, & Moreno, 2017). Although, it is known

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the fact that excessive intake of sweet meals contribute to several health problems such as dental caries, overweight, obesity, and cardiovascular diseases, which are public-health threats (Adams, Hart, Gilmer, Lloyd-Richardson, & Burton, 2014; Lampuré et al., 2016; Shin et al., 2018). Therefore, strategies to reduce sugar intake should put into practice and consumer acceptability is critical point to the effectiveness of sugar reduction in food and drinks (Di Monaco, Miele, Cabisidan, & Cavella, 2018).

This study aimed to develop a prebiotic semi-skimmed sheep milk strawberry beverages, mixing different concentrations of semi-skimmed sheep milk, strawberry pulp and sugar to evaluate acceptance and preference of the products according to consumers' perception, aiming to identify the most suitable beverage formulation.

2. Material and methods

2.1. Beverage processing

Whole raw sheep milk (fat 65.5 g and about non-fat solids 103.8 g per liter of milk) was obtained from a local sheep herd located in Puglia, Italy. By double centrifugation at 1792*g* for 10 min at 4 °C (Centrifuge 5810 R, Eppendorf AG, Hamburg, Germany), the sheep milk was subjected to the skimming process until it reached fat 1.49 g/L milk and then heat-treated in a stainless-steel container, double jacket with internal propeller (CASARO, Philips, Netherlands) at 75 °C for 15 s and immediately cool down in ice bath (0 °C ± 2) for 30 min until mix with other ingredients. Branched long chain inulin fiber powder for food industry, degree of polymerization of 60 (Inulin 90%, A.C.E.F., Fiorenzuola D'Arda, Italy), commercial sugar (Eridania Italia SpA, Bologna, Italy, and fresh strawberries (*Fragaria vesca*) were purchased at a local market. The strawberries were blanched (100 °C for 30 s) before use. Immediately, all ingredients were mixed under 50 °C ± 1 for 10 min to ensure complete mixing of liquid and dry ingredients. The beverage samples were cooled and stored under refrigeration (4 °C ± 2) until consumers' analyses.

The beverages were manufactured with different content of semi-skimmed sheep milk, strawberry pulp and sugar, as follows: sample 1 (B1) −720 g semi-skimmed sheep milk, 100 g strawberry pulp, 150 g sugar per liter of beverage (/L); sample 2 (B2) - 620 g semi-skimmed sheep milk, 250 g strawberry pulp, 100 g sugar/L; sample 3 (B3) – 500 g semi-skimmed sheep milk, 37 0 g strawberry pulp, 100 g sugar/L; sample 4 (B4) – 550 g semi-skimmed sheep milk, 370 g strawberry pulp, 50 g sugar/L. To be considered prebiotic, inulin concentration in product should be at least than 1.5 g/100 g of the product (Balthazar et al., 2017a); therefore, inulin was fixed in 30 g/L of beverage. Each beverage was processed twice.

2.2. pH measurement

pH were determined according to the International Dairy Federation standard (IDF, 1989) after processing beverages, being the analysis performed in triplicate.

2.3. Sensory evaluation

The sample size of consumer panels should be enough large for generate confinable results, being recommended 40–50 panelists (Moskowitz, 1997); in addition to find regular sheep milk consumers is not an easy task. In this sense, 60 consumers (30 male, 30 female, aged 20–70) recruited from staff and students at the University of Foggia, regular sheep milk consumers (at least once per week) participated in the test. All participants were familiar with basic sensory evaluation techniques, and before sensory evaluation, they participated in briefing sections to familiarize themselves with the specific vocabulary used to describe the milk beverage attributes. For each analysis, approximately 40 mL of sample were served at 15 °C in 50 mL white polyethylene cups. The samples were labeled with three-digit random numbers, presented in a monadic sequential way in a balanced complete block design, preventing first-order carryover effects (MacFie, Greenhoff, & Vallis, 1989). In addition, water and unsalted crackers were used to clean the palate between samples evaluation.

Appearance, aroma, flavor, texture and overall liking was evaluated in a 9-point hedonic scale ranging from 1 ('dislike extremely') to 9 ('like extremely'). In addition, a total of 22 sensory descriptors on appearance, aroma taste/flavor, and texture, previously developed for sheep milk products (Gambaro et al., 2017) and strawberry flavored Greek yogurt (Esmerino et al., 2017) were evaluated on a 5-point intensity scale ranging from 1 ('non') to 5 ('extremely') (Lovely & Meullenet, 2009). Afterwards, the products were ranked and evaluated by Friedman test (Newell & Macfarlane, 1987) to verify differences between samples, considering four samples and 60 participants (critical value: 37, $p \leq 0.05$), as shown in Table 2.

2.4. Statistical analysis

The consumer test data were analyzed using one-way analysis of variance (ANOVA) considering sample as fixed effect and Tukey's test at 95% confidence level.

Principal component analysis (PCA) using correlation matrix (Granato et al., 2018) and confidence ellipses were constructed using bootstrap technique (500 resamplings and thus construct 500 sensory descriptions of virtual panels, Husson, Le, & Pages, 2005). The data set consisted of a 4 × 22 matrix, in which rows represented the beverage samples, and columns the mean values of sensory attributes. All the analyses were performed using XLSTAT 2018.3 (Addinsoft, Paris, France).

3. Results and discussion

Table 1 shows the mean scores for acceptance and sensory attributes intensities of prebiotic semi-skimmed sheep milk strawberry beverages. Significant difference was observed among the samples in all attributes ($p < 0.05$). In respect of beverages appearance, consumers evaluated sample B1 as slightly disliked (3.97 ± 1.75), while samples B3 and B4 were considered moderately appreciated (6.97 ± 1.74 and 7.12 ± 1.39, respectively). Aroma and texture of samples B1 and B2 were considered as indifferent or slightly disliked and flavor showed no significance difference among samples B2, B3 and B4, being considered as indifferent by consumers. Considering the texture of beverages, samples B3 and B4 presented the higher scores with statistical differences from samples B1 and B2. The overall liking was classified sample B1 as slightly dislike (4.5 ± 1.79) and sample B4 slightly like (6.22 ± 1.61) ($p < 0.05$), no significant difference from those to samples B3 and B2 was noted.

Texture is an important sensory attribute in the development of prebiotic dairy foods being perceived in a different way by consumers (Jervis, Gerard, Drake, Lopetcharat, & Drake, 2014). According to the results, viscosity was perceived as more intense on samples B3 and B4, while samples B1 and B2 characterized by a thinner texture ($p < 0.05$). This behavior could be explained by the fact that samples B3 and B4 had higher amount of strawberry pulp (370 g/L of beverage each sample), being more free water available to interact with inulin molecule (Balthazar et al., 2017a) due to high water activity of that fruit (Concha-Meyer, D'Ignoti, Saez, Diaz, & Torres, 2016).

PCA bidimensional map explained 91.64% of samples variability using two dimensions (F1: 70.60% and F2: 21.04%, respectively, Fig. 1). In the first dimension, sample B3 was strongly associated with strawberry flavor and aroma, acid taste, strawberry seeds presence, sheep aroma, fatty flavor, and pinkish color. Sample B1 was characterized by sweet taste, residual, cooked aroma and flavor, sheepy flavor and thinner texture, while sample B4 was associated by reddish color, astringent flavor, bitter taste, brightness, viscous, and sweet, acid

Table 1
Sensory evaluation of prebiotic skimmed sheep milk strawberry pulp beverage.

Acceptability	B1	B2	B3	B4
Appearance	$3.97^{c} \pm 1.75$	$5.35^{b} \pm 1.96$	$6.97^{a} \pm 1.74$	$7.12^{a} \pm 1.39$
Aroma	$4.90^{b} \pm 1.64$	$5.53^{b} \pm 1.73$	$6.38^{a} \pm 1.53$	$6.60^{a} \pm 1.21$
Flavor	$4.75^{b} \pm 2.00$	$5.38^{ab} \pm 2.03$	$5.68^{ab} \pm 2.09$	$5.97^{a} \pm 1.89$
Texture	$4.45^{b} \pm 2.12$	$5.30^{b} \pm 1.93$	$6.20^{a} \pm 1.87$	$6.48^{a} \pm 1.60$
Overall Liking	$4.50^{b} \pm 1.79$	$5.35^{ab} \pm 1.94$	$5.97^{a} \pm 2.02$	$6.22^{a} \pm 1.61$
Appearance				
Pinkish	$2.08^{c} \pm 0.83$	$2.80^{b} \pm 0.78$	$3.55^{a} \pm 1.05$	$3.48^{a} \pm 1.06$
Reddish	$1.05^{b} \pm 0.22$	$1.22^{b} \pm 0.49$	$1.87^{a} \pm 0.95$	$1.78^{a} \pm 0.82$
Brightness	$1.55^{b} \pm 0.81$	$1.68^{b} \pm 0.79$	$2.57^{a} \pm 0.96$	$2.50^{a} \pm 0.89$
Fruit	$2.20^{b} \pm 0.80$	$2.55^{ab} \pm 0.96$	$2.88^{a} \pm 0.90$	$2.73^{a} \pm 0.80$
Aroma				
Sweet	$2.25^{a} \pm 1.20$	$2.33^{a} \pm 1.02$	$2.60^{a} \pm 1.04$	$2.62^{a} \pm 1.06$
Strawberry	$1.92^{b} \pm 0.93$	$2.35^{b} \pm 0.88$	$2.83^{a} \pm 1.01$	$2.80^{a} \pm 0.86$
Acid	$1.43^{a} \pm 0.79$	$1.33^{a} \pm 0.60$	$1.43^{a} \pm 0.67$	$1.43^{a} \pm 0.77$
Rancid	$1.20^{a} \pm 0.61$	$1.17^{a} \pm 0.46$	$1.22^{a} \pm 0.58$	$1.25^{a} \pm 0.65$
Sheepy	$1.63^{a} \pm 0.96$	$1.73^{a} \pm 1.01$	$1.62^{a} \pm 0.88$	$1.73^{a} \pm 0.97$
Cooked	$1.58^{a} \pm 0.92$	$1.47^{a} \pm 0.79$	$1.38^{a} \pm 0.67$	$1.50^{a} \pm 0.77$
Flavor				
Sweet	$3.72^{a} \pm 1.19$	$3.40^{a} \pm 1.14$	$2.82^{b} \pm 1.00$	$2.43^{b} \pm 0.87$
Bitter	$1.17^{a} \pm 0.49$	$1.10^{a} \pm 0.35$	$1.27^{a} \pm 0.61$	$1.30^{a} \pm 0.65$
Acid	$1.37^{a} \pm 0.66$	$1.52^{a} \pm 0.75$	$1.62^{a} \pm 0.94$	$1.53^{a} \pm 0.68$
Salty	$1.20^{a} \pm 0.44$	$1.27^{a} \pm 0.55$	$1.23^{a} \pm 0.65$	$1.17^{a} \pm 0.42$
Astringent	$1.28^{a} \pm 0.58$	$1.30^{a} \pm 0.56$	$1.60^{a} \pm 0.83$	$1.43^{a} \pm 0.70$
Strawberry	$2.20^{ab} \pm 1.02$	$2.62^{ab} \pm 0.86$	$2.82^{a} \pm 0.98$	$2.63^{ab} \pm 0.94$
Cooked	$1.88^{a} \pm 1.14$	$1.73^{a} \pm 0.99$	$1.70^{a} \pm 0.89$	$1.83^{a} \pm 0.87$
Fatty	$1.58^{b} \pm 0.79$	$1.80^{ab} \pm 0.93$	$2.17^{a} \pm 1.15$	$2.10^{a} \pm 0.91$
Sheepy	$2.18^{a} \pm 1.27$	$2.07^{a} \pm 1.07$	$2.07^{a} \pm 1.18$	$2.08^{a} \pm 1.14$
Residual	$2.00^{a} \pm 1.21$	$1.83^{a} \pm 1.21$	$1.68^{a} \pm 1.31$	$1.57^{a} \pm 0.98$
Texture				
Viscosity	$1.57^{b} \pm 0.79$	$1.73^{b} \pm 0.82$	$3.47^{a} \pm 1.00$	$3.28^{a} \pm 1.03$
Thin	$3.43^{a} \pm 1.20$	$2.88^{b} \pm 1.06$	$1.47^{c} \pm 0.68$	$1.47^{c} \pm 0.68$

*Data were expressed as mean values ± standard deviation. Different letters in the same row means significant difference ($p < 0.05$).

and rancid aroma attributes. The second dimension was responsible to sort samples mainly by the salty taste, acid and rancid aroma. However, most of the attributes were statistically perceived with the same intensity in terms of appearance, aroma or flavor.

The strong association of acid taste (D1 - 0.795%) with sample B3 (D1 - 1.059%) is explained by the fact of its lowest pH (4.97), which was statistically similar ($p > 0.05$) to sample B4 (4.99) and different ($p < 0.05$) from samples B1 and B2 (6.05 and 5.69, respectively). This finding is related on the amount different amount of semi-skimmed sheep milk and strawberry pulp in samples formulation, meaning that strawberry pulp push down the pH values of the products.

There was no significant difference between the responses of consumers for samples B3 and B4, which was expected due only to different sugar amount between them. In fact, consumers were not able to differ sweet aroma between those samples (slight perception) and perceived moderately sweet taste in samples B1 and B2 in contrast to slightly sweet in samples B3 and B4 ($p < 0.05$). Although samples B2 and B3 were formulated with the same content of sugar (100 g/L), and different content of skimmed sheep milk/strawberry pulp, it is possible that some interaction between components happened and consumers have not been able to differentiate them in terms of sweet taste.

This interaction between components, sensory similarity between samples and variability among participants (non-trained panel) can still be observed through the length and overlapping confidence ellipses for all samples; however, a more detailed analysis suggested that samples B1 and B3 presented lower variability at the consumers' evaluation than B2 and B4.

One strategy to lower the daily caloric intake is a gradual sugar reduction in food products which could be effective when this product is well accepted by consumers (Di Monaco et al., 2018). In addition, a low sugar beverage is in accordance with World Health Organization daily caloric intake directive (Mooradian, Smith, & Tokuda, 2017).

According to the preference ranking test results (Table 2), sample B4 received the highest value in the sum of the orders (177), although its preference did not present statistical difference ($p < 0.05$) for samples B2 and B3. The sample B1 was the less preferred along with B2, reinforcing the results obtained in the sensory test. In this context, sample B4 stands out among the others as a potential beverage with lower sugar content, combining the nutritive potential of sheep milk with the benefits of strawberry pulp and the prebiotic fiber inulin, considering a consumer perspective.

Future studies should provide the evaluation of nutritional quality and bioactive compounds as well as the assessment of quality parameters of the product along the refrigerated storage.

4. Conclusion

Our findings demonstrate that it is possible to develop an optimal formulation sheep-milk strawberry pulp beverage, combining nutritional and functional benefits of the both ingredients. Although the preference test did not distinguish which beverage formulation were significant preferred among consumers, B4 presented positive responses to all the sensory attributes evaluated, as appearance, aroma, flavor, texture and overall liking. In a global context of reduced calorie dairy

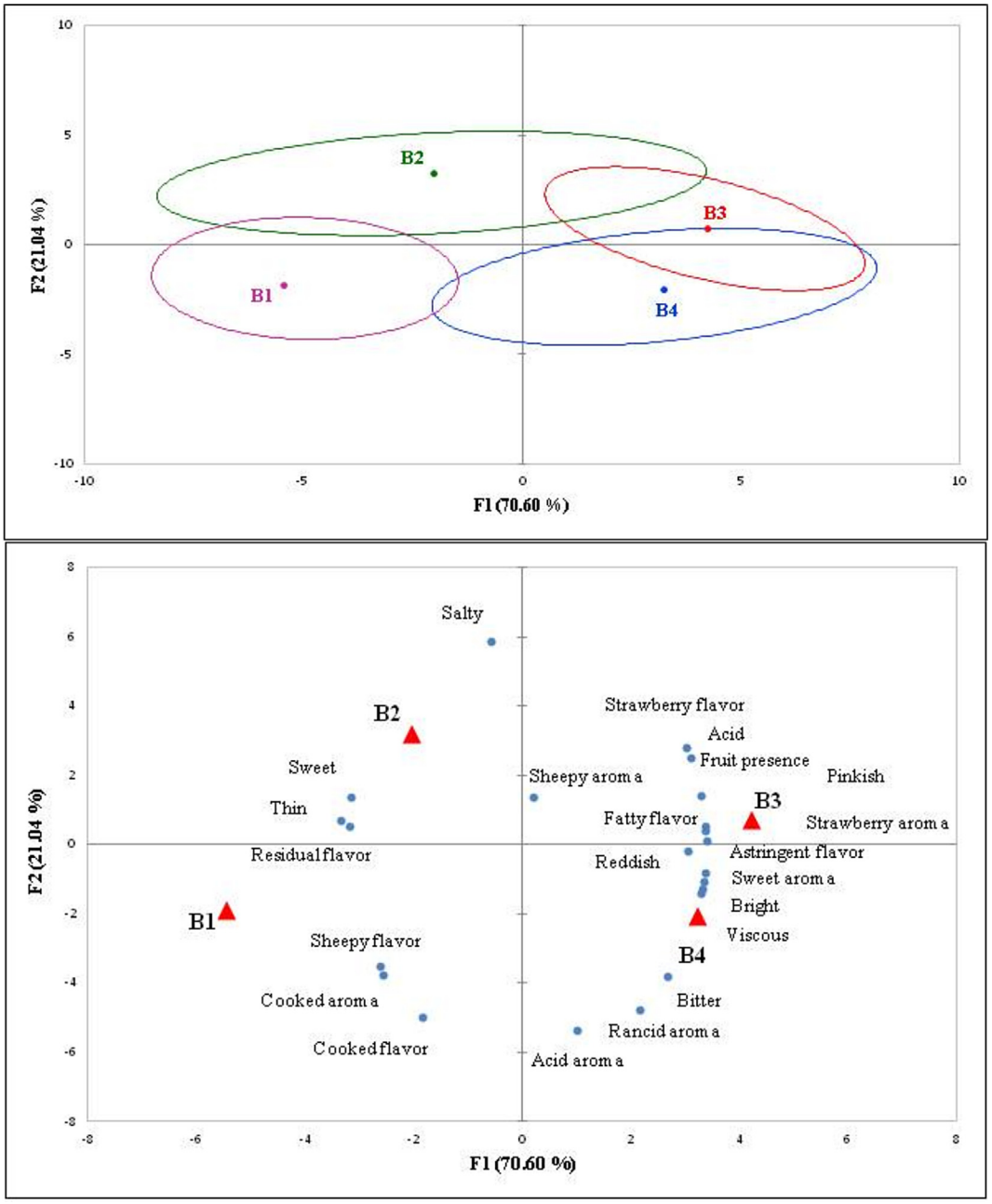

Fig. 1. Representation of the samples and the attributes in the first and second dimensions of the principal component analysis (PCA) on the correlation matrix of average attribute scores of sensory attributes of prebiotic skimmed sheep milk strawberry pulp beverage.

Table 2
Results of the preference ranking test of prebiotic semi-skimmed sheep milk strawberry beverage.

Samples	B1	B2	B3	B4
B1	–	36 ^{ns}	54*	65*
B2		–	18 ^{ns}	29 ^{ns}
B3			–	11 ^{ns}
B4				–

*Significant critical difference (5%) minimum of 37, for four samples and 60 consumers, according to Friedman test (Newell & Macfarlane, 1987).
^{ns} non-significant.

products, this research may help in the choice of balancing the main ingredients in sheep milk-juice beverage formulation to be manufactured by the sheep milk industry.

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