



# The influence of the texture and color of goat's salad cheese on the emotional reactions of consumers compared to cow's milk cheese and Feta cheese

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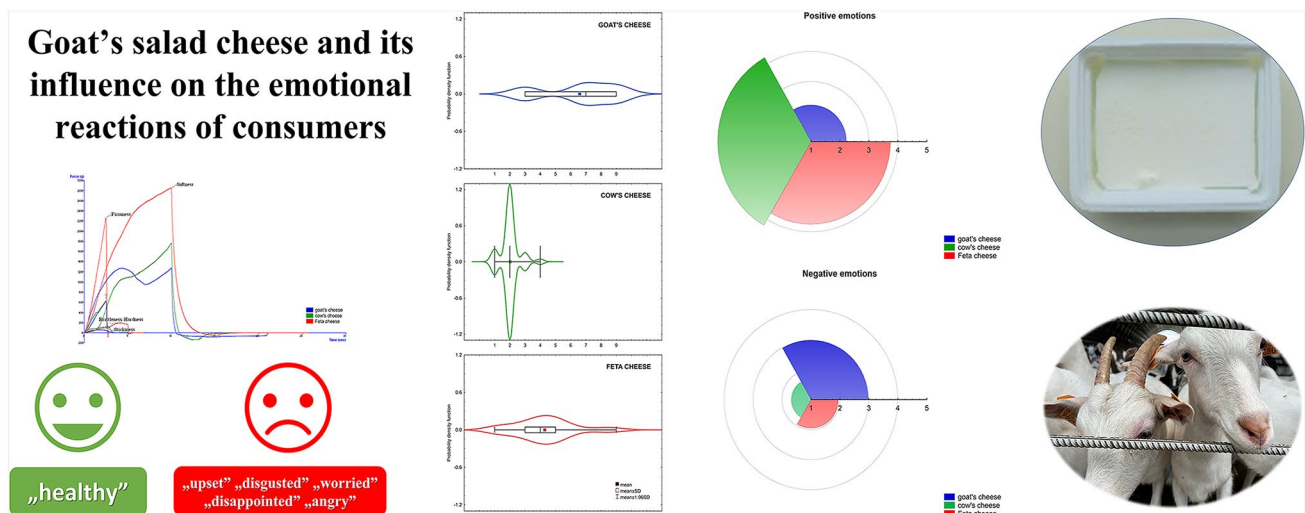
Received: 6 October 2022 / Revised: 19 January 2023 / Accepted: 21 January 2023 / Published online: 15 February 2023

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## Abstract

In this study, the sensory and mechanical aspects of the texture of goat's milk salad cheese were correlated with the emotional profiles of consumers. Using descriptive sensory analysis and instrumental assessment, the texture profile of goat's milk salad cheese was compared to cow's milk salad cheese and Feta cheese. Texture measurements confirmed that goat's cheese compared to cow's cheese had more softness and less hardness, and Feta cheese had the highest whiteness index compared to the other cheeses. Goat's milk salad cheese was much less acceptable to consumers compared to cow's milk cheese and Feta cheese. Consumers also indicated that the hardness of goat's cheese was lower than that of cow's cheese and Feta cheese. A reduction in "stickiness" in comparison with cow's cheese was also reported; however, it was much higher than that for Feta cheese. The "fracturability" and "graininess" of goat's cheese was similar to cow's cheese. Emotional profile analysis showed that goat's cheese evokes mainly negative emotions. Consumers indicated only one positive emotion in the case of this cheese, which was "healthy". The most frequently mentioned emotions after the consumption of goat's cheese were "upset", "disgusted" and "worried". Many consumers also indicated "disappointed" and "angry", which did not occur after the consumption of cow's cheese. This research shows how important it is to combine several analyses and techniques when evaluating dairy products, including salad cheeses. It is also important that consumer research is enriched by emotional profiling.

## Graphical abstract



**Keywords** Salad cheese · Goat's cheese · Acceptability · Texture · Emotional profile · Consumer

Extended author information available on the last page of the article

## Introduction

Goat's cheeses are part of the culinary heritage of many regions [1, 2]. Spain, Greece, Turkey and France produce the majority of these cheeses, and their consumption is increasing [3, 4]. Cheeses are firmly positioned in culinary Baedeker Guides and on menus [5]. Cheeses may differ in terms of the production methods used, as well as in their physicochemical and flavor properties [6, 7]. Specific properties such as hardness or spreadability determine their use (e.g., in salads or as spreadable cheeses) [8]. In the production of salad cheeses, goat, sheep, cow and buffalo milks are commonly used [9, 10]. For example, traditional Feta cheeses are produced from sheep's milk or a mixture of sheep and goat milk [11]. The increasing number of cheese varieties provides a reason to examine their acceptability [12]. The goat cheese market is constantly developing, making these cheeses important dairy products. Salad cheese is a common name for cheeses eaten with vegetables and added to salads, e.g., based on green lettuce, tomatoes, and olives. As a rule, they are added after dicing and eaten cold. The most popular cheese in this group is traditional Feta, ultrafiltered cheese UF-Feta and feta-type cheese. Feta cheese by Djebli et al. [13] is perfect for salads with a soft texture.

Salad cheeses are gaining more recognition among consumers, and their production goes beyond the Mediterranean countries (e.g., Eastern Europe). This increased attention is also due to a growing consumer awareness of the health benefits of a balanced Mediterranean diet, in which these cheeses are a significant staple [14]. The Mediterranean diet is one of the best balanced dietary models, and it is characterized by a greater consumption of plant products (fruits, vegetables, whole grains), olive oil, fish, legumes, and a moderate amount of alcohol, including wine [15, 16]. This diet also consists of low-fat products that are rich in unsaturated fatty acids, which are crucial for cardiovascular health, improve the lipid profile, and provide protection against chronic diseases. Goat's milk fat contains more C6:0, C8:0 and C10:0 MCFAs than cow's milk fat. It is 15–18 and 5–9% respectively, MUFAs are more easily released and absorbed in the digestive tract. This makes goat's milk fat more digestible than cow's milk fat [17].

The fat contained in cheese substantially affects its texture and taste. Fat gives dairy products characteristic features, including appropriate structure (consistency). The removal of the fat from cheese can result in a poor texture and appearance, and a lack of flavor [18]. These characteristics can motivate conscious consumers from outside the Mediterranean region to choose soft cheeses made from goat's milk. However, a significant barrier for many

consumers is the characteristic taste and flavor, which is different from that of cow's milk cheeses and Feta. Feta is one of the world's best-known brined cheeses [19]. Due to its crumbliness and ability to fracture easily into irregular shaped pieces, Feta is one of the best-known salad cheeses [20]. Feta cheese is a most popular white brined cheese. This cheese has a character of ready-to-eat food [21]. It might be an appetizer. Feta cheese predominates in most recipes, not UF-Feta. In addition, it is identified with luxury and has ballast in the form of cultural memory and history of communities, as described by Keskin and Dag [22].

The desirability of salad cheese, like other dairy products, results from the perception of the product mainly in terms of its taste, smell, appearance and consistency. Hence, it is important not only to assess the overall desirability, but also to know the intentions of consumers. A detailed sensory assessment is important, and recently also a description of the sensations associated with the consumption of a given product. According to Rodrigues et al., [23], in carrying out a product assessment, including sensory analysis, it is important to combine all factors that affect the sensory assessment (e.g., psychology, context and frequency consumption and marketing). Hence the importance of emotional profile. This is a new issue that is gaining increasing interest from researchers around the world [24, 25]. In addition, sensory analysis can be combined with the consumer behavior model and assess which product parameter is particularly acceptable and which is not [26]. Recognizing the emotions evoked during consumption may affect further purchases of a given product. The more positive emotions consumer has, the greater the chances of purchasing the product. The creation of an emotional profile can influence the targeted production and development of food products.

In this study, we wanted to examine the sensory and textural property of goat's salad cheese and the emotional profile of the their consumer. Our aim was to find an answer to the question: what parameters of texture, color, appearance, taste and flavor are responsible, not only for consumer acceptance, but also for generating positive emotions? We assumed that the type of emotion experienced following consumption may influence the consumer's future decisions, which could be important for the development of the goat's milk salad cheese market.

## Materials and methods

### Collection of the cheeses, composition, and pH

Three commercial salad cheeses were studied: (1) goat's cheese: 160 g, covering liquid 90 mL, polypropylene (PP) packages of 250 g (Agro-Danmis Gramowscy Sp. J. Bukowiec, Poland); (2) cow's cheese: 160 g, covering liquid

90 mL, PP packages of 250 g (Agro-Danmis Gramowscy Sp. J. (Bukowiec, Poland); (3) Feta cheese: marked with the Protected Designation of Origin (PDO) sign, made from a mixture of sheep (70%) and goat's milk (30%), 200 g, covering liquid < 0.1 mL, vacuum packed in 205 g packages (Chrysafis S.A, ΧΡΥΣΑΦΗΣ ΑΒΕΕ, Karpasi, Lemnos Lesbos, Greece). The first two were Feta cheeses obtained by ultrafiltration. Cow's cheese is one of the most popular UF-Feta cheeses purchased by consumers in the region, so it was selected along with Feta cheese for comparison. All three cheeses were purchased over a period of 6 months, 8 times at equal intervals of 10 days ( $n = 8$ ). Each measurement was performed in 3 repetitions.

The compositions of the cheeses were determined using the methods described by Tomaszewska-Gras et al. [27]. pH was measured using a CP-315 digital pH meter (Elmetron Co., Zabrze, Poland) equipped with an IJ44A electrode for solids (Ionode, Tennyson, Qld., Australia), and was carried out according to the manufacturer's recommendations.

### Texture measurement

Texture parameters were measured using a TA.XTPlus texture analyzer (Stable Micro Systems, Surrey, UK). Measurement conditions depended on the type of measurement carried out: firmness and stickiness—P/1S attachment (test speed 2.0 mm/s, post-test speed 10.0 mm/s, distance 5 mm); softness—P/25 attachment (test speed 1.0 mm/s, post-test speed 1.0 mm/s, distance 10.0 mm); hardness and brittleness—A/WEG attachment (test speed 2.0 mm/s, post-test speed 10.0 mm/s, distance 10.0 mm). The maximum force and distance at which the sample deflects and begins to break using A/WEG is hardness and brittleness. The maximum force indicates firmness, and in the lower part of the graph created after the return of the P/1S attachment indicates the

stickiness of the sample that adhered to the attachment upon return. The maximum force when returning the P/25 attachment to its original position determines the softness. The results were recorded using Texture Exponent E32 software version 4.0.9.0 (Godalming, Surrey, UK).

### Color measurement

Color was measured using the CIELab system with a SP-60 camera (X-Rite, Grandville, MI, USA). Measurement conditions, and calculation of the whiteness index (WI) and yellowness index (YI), were based on the methods described by Cais-Sokolińska et al. [26]. The calculations assumed:  $L = 100$ ,  $a^* = 0$ , and  $b^* = 0$ .

### Descriptive sensory analysis

Sensory analysis was conducted via the profiling method [28–30]. Panel members ( $n = 12$ ; aged 21–64 years;  $M_{\text{age}} = 40$  years;  $SD = 12.5$ ) were adequately trained individuals, prepared to perform sensory examinations [31, 32]. The panel received about 36 h of training. During the training sessions, potential references were presented to the panelists to identify descriptors. After the training phase, the samples were evaluated using 9 cm unstructured line scales anchored with the terms “low” (undetectable) at the left, and “high” (very intense) at the right. The assessors evaluated three cheeses in each session, with two replications of each sample. Each time, cheese was served without heating at a temperature of 10–12 °C. Cheese was served in the form of cubes ( $2 \times 2 \times 2$  cm;  $\sim 12.5$  g) with their respective 3-digit codes. Testing took place in a sensory laboratory that was designed in accordance with [33]. The descriptors are shown in Table 1.

**Table 1** Sensory attributes and descriptions used to characterize the salad cheeses

Attribute type and attributes	Description	Reference
Flavor		
Fresh cheese	Oral sensation comparable to the traditional taste connected with 2,3-butanediol	Sour cream 18% fat
Cream smell	Fatty, creamy tasting, of the nature of or containing cream	UHT cream 35% fat
Whey	Aromatics associated with cheddar cheese whey	Solubilized 5 g whey powder in 100 mL water
Animal-like	Aromatics associated with barns and stock	5% Sodium-caseinate solution in water
Salty	Taste on the tongue stimulated by salts such as sodium chloride	Sodium chloride (0.5% in water)
Texture and mouthfeel		
Hardness	Softness/hardness of cheese mass	1 = Processed cheese <sup>a</sup> ; 10 = Feta cheese <sup>b</sup>
Stickiness	Sticky cheese sticks to teeth and mouth surfaces	1 = Feta cheese; 10 = processed cheese
Fracturability	Ability to crumble when chewed	1 = Processed cheese; 10 = Feta cheese
Graininess	Perceived graininess of the sample evaluated in the mouth	1 = Processed cheese; 10 = Feta cheese

<sup>a</sup>Processed cheese—processed cream cheese (Hochland Polska Sp. z o. o., Kaźmierz, Poland)

<sup>b</sup>Feta cheese (Koliós S.A, gr. Η ΚΟΛΙΟΣ Α.Ε. Polykastro, Limnotopos Kilkis, Greece)

## Acceptance test

The participants ( $n = 112$ , aged 21–64 years) assessing the samples were frequent consumers of salad cheese and other dairy products. The consumers were recruited from students, employees, and professors at the Poznań University of Life Sciences. All consumers lived in the region, which has a dominant production of cow's milk. Each consumer rated the goat salad cheese, cow salad cheese, and Feta cheese. They were provided with mineral water and unsalted crackers at their disposal, enabling them to cleanse their oral cavity after the consumption of each cheese sample. The cheeses were served randomly and were coded. For the evaluation of overall acceptance of the cheeses, a hedonic scale was used with an intensity ranging from 1 to 9 points, where 1 like extremely, 2 like very much, 3 like moderately, 4 like slightly, 5 neither like nor dislike, 6 dislike slightly, 7 dislike moderately, 8 dislike very much, and 9 dislike extremely.

## Emotional profile

The consumers (the same participants as in the acceptance test) expressed their emotions after consuming the three types of cheeses. Thirteen terms related to emotions were used, with 6 positive, 6 negative and 1 neutral (Table 2). Most of the terms coincided with those used previously in the literature [34]. Emotions were rated using a 5-point scale, where 1 indicated no emotion, 2 slight emotion, 3 moderate emotion, 4 strong/clear emotion, and 5 very intense emotion. Consumers were seated individually at a table during the evaluation, in a room with natural light from 9 AM to 9 PM [35]. There was 3 m<sup>2</sup> of space for each consumer. The consumers were given a score sheet with the name of

each given emotion, terms and their definition. Emotions on the score sheet were ranked randomly [36] in order to avoid the favoring of terms. There was no time limit set for completing the sheet [35]; however, it did not take more than 30 min to complete. The consumers were given 3 cheese samples simultaneously [25]. The samples were coded and served on a glass Petri dish. The samples were in the shape of 2 × 2 × 2 cm cubes (~12.5 g) and served at 10–13 °C.

## Statistical analyses

In order to verify the statistical hypotheses, a level of significance of  $\alpha = 0.05$  was used. ANOVAs were carried out followed by Tukey's HSD post-hoc tests for multiple comparisons. Determination of the position of the tested samples in the perception of the space results were evaluated using principal component analysis (PCA) based on the NIPALS algorithm. Sensory profile results were presented using principal component analysis (PCA) to check the correlation between the parameters. Based on the acceptance test, the probability density function was determined for each cheese, and the mean, median, mode, N mode, SD and skewness were calculated. Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. Skewness of the dataset indicates whether deviations from the mean are going to be positive or negative. The probability density function displays the distribution of target values. For continuous targets, this function determines the probability that the target is within a given region. In addition, to better illustrate the emotional profile, a spie-plot was used with an indication of the sum of positive and negative emotions, as well as the intensity without taking into account the neutral emotion. However, all emotions

**Table 2** Consumer classification of emotions when consuming cheeses

Character	Terms	Definition
Positive	Glad	Consumption of the product evokes a feeling of joy and satisfaction
Positive	Happy	Consumption of the product brings a smile to your face and even an extreme feeling of joy and fulfillment
Positive	Healthy	Consumption of the product gives the feeling of a beneficial effect on the body
Positive	Excited	Consumption of the product gives you vitality, a sense of energy and strength for further work and action
Positive	Relaxed	Consumption of the product gives a sense of fulfillment and a satisfaction of basic desires
Positive	Modernized	Consumption evokes the feeling of novelty or being trendy
Neutral	Confused	Consumption of the product does not cause any positive or negative emotions
Negative	Disgusted	Consumption of the product confirms a negative reception of the product
Negative	Upset	Consumption of the product strongly influences emotions, causes sadness
Negative	Depressed	Consumption of the product causes a lack of strength or lack of a good attitude
Negative	Worried	Consumption of the product causes sadness and assures that the consumer will not consume the product again
Negative	Disappointed	Consumption of the product causes a change of attitude from positive to negative; it appears when the consumer had great hope that they would like the product but is disappointed
Negative	Angry	Consumption of the product causes a strong aversion, hostility to the product; the emotion stays with the consumer for a long time after consumption

(positive, neutral and negative) were presented on a radar chart. The data were analyzed using Statistica software, version 13 (TIBCO Software Inc., Palo Alto, California, USA).

### Ethical statement

All people participating in the sensory analysis gave their informed consent to participate. All methods were carried out in accordance with relevant guidelines and regulations. According to Polish law and Good Clinical Practice (GCP) regulations, this research does not require approval of the Bioethics Committee and was not a medical experiment. Confirmation was issued by the Bioethics Committee at Poznan University of Medical Sciences (number of decisions is KB-331/21).

## Results and discussion

### Basic composition of goat's salad cheese versus cow's cheese and Feta

Analysis of the goat salad cheese and cow salad cheese in terms of fat, protein and salt content showed comparable results ( $P > 0.05$ ; Table 3). However, the protein and fat content was almost twice as high in Feta cheese compared to goat's salad cheese.

The basic composition of the Feta cheese complied with the requirements of PDO-GR-0427 (European Commission). The moisture content was 55.3% as required (must not exceed 56%). Bozoudi et al. [37] reported pHs of 4.1 and 4.6 for Feta cheese. Moisture was 49.9 and 50.9%, with in moisture salt content 8.2 and 7.8%, respectively. The cheese that was examined had an average of 19.2 and 19.9% protein, and 31.3 and 31.2% fat, respectively. For comparison, Rashidi et al. [38] produced ultrafiltered (UF)-Feta cheese, which had a 60% moisture with a salt content of 1–3% and a fat content of 16–22%. In contrast, the Feta-like cheese tested by Hamad [39] had a pH of 4.33, 53.8% moisture, 2.49% salt, 5.89% protein,

and 24.59% fat. By comparison, in traditional Feta cheese (PDO), fat, protein and salt content are on the levels of 23.4, 16.6 and 2.4%, respectively [40]. Research by Gatzias et al. [41] has shown that the pH of Feta cheese may vary depending on the geographical origin in Greece. Feta cheese produced in Arta had a pH 4.22, and that in Evros had a pH of 4.62. The moisture content varied from 52.11% (in Ioannina) to 53.76% (in Larissa). On the other hand, the salt content ranged from 1.75 to 3.28%.

Kondyli et al. [1] reported that the fat content of white brined cheese made from goat's milk from an indigenous Greek breed was 25.13%, and the protein content was 17.45%. Therefore, the protein content was higher by more than half compared to the goat salad cheese tested in this study. The fat in milk influences the flavor and texture of brined cheese as it acts as a filler in the protein network and smoothens the texture. Reducing or removing fat from cheese results in more points of contact between the protein chains. This increases the crosslinking and results in a much more compact cheese matrix with a rubbery texture [42]. In addition, lowering the fat content results in a change in flavor and functionality, since low-fat cheeses are different compared to their full-fat counterparts [43]. In a study by Pawlos et al. [44], the pH value in control cheese made from goat milk was 4.63, which is slightly higher compared to our cheese.

Mehaia [45] compared the compositional characteristics of different fresh soft white cheeses made from goat's milk obtained traditionally and using the UF method. The traditional cheese had less moisture (64.05% compared to 66.27%), a higher protein content (16.2 and 15.7%), and more salt (2.28 and 2.08%). The UF method resulted in a higher pH. However, there was no difference in overall acceptability even though there was a difference in appearance and texture between the cheeses as assessed by sensory evaluation.

The literature has repeatedly shown differences in the effects of the type of milk used on the quality of cheeses [46, 47]. Despite the same technologies and manufacturing conditions, the differences are related to the composition and properties. Miloradovic et al. [48] confirmed the existence of differences in Quark-type cheeses obtained from goat's milk compared to cow's milk, for which the fractions constituting the main matrix of the cheese were responsible. An interesting result from the research by Miloradovic et al. [48] was the similar values for texture parameters, including the firmness (1604.2 g and 1679.6 g, respectively) and stickiness (1673.1 g and 1671.2 g, respectively) of goat's and cow's cheese. Therefore, instrumental and sensory texture analysis may play a role in the evaluation of these types of cheeses.

**Table 3** Psychochemical characteristics of the salad cheeses

Parameters	Goat's cheese	Cow's cheese	Feta cheese
Fat, g/100 g	11.6 <sup>a</sup>	13.2 <sup>a</sup>	21.1 <sup>b</sup>
Protein, g/100 g	11.1 <sup>a</sup>	11.6 <sup>a</sup>	19.4 <sup>b</sup>
Salt, g/100 g	1.60 <sup>a</sup>	1.69 <sup>a</sup>	2.51 <sup>b</sup>
Moisture, g/100 g	66.3 <sup>b</sup>	65.8 <sup>b</sup>	55.3 <sup>a</sup>
pH	4.37 <sup>a</sup>	4.38 <sup>a</sup>	4.27 <sup>a</sup>

Means within a row with different superscripts differ ( $P < 0.05$ )

<sup>a,b</sup> Different letters with mean values in a row indicate statistically significant differences at the level  $\alpha = 0.05$

## Texture and color of the salad cheeses

The firmness and stickiness of goat's and cow's salad cheese did not differ significantly ( $P > 0.05$ ). However, these values were significantly lower than those measured for Feta cheese (Table 4, Fig. 1). The examination of salad cheese texture showed that the softness parameter was significantly lower in goat's salad cheese than in other cheeses ( $P < 0.05$ ). Hardness was lower in goat's salad cheese than in cow's and Feta cheese ( $P < 0.05$ ). Brittleness was significantly lower ( $P < 0.05$ ) in goat's salad cheese compared to cow's salad cheese and Feta cheese. For cow's and goat's cheese, the differences occurred for the softness, hardness and brittleness parameters. This is due to the different lipid profile, fat globule structure and casein micelle diameter between goat's cheese and cow's cheese produced by the same methods. About 90% of goat's milk fat globules are less than 5.21  $\mu\text{m}$  in diameter and 90% of cow's milk fat globules are less than 6.42  $\mu\text{m}$  in diameter [49]. In addition, the weak texture of gels (the smallest hardness) of goat's milk products compared to cow's is due to the lower content of total casein, a different ratio of casein fractions and larger casein micelles [50].

The hardness of model low-fat UF-Feta cheese, as measured using the texture profile analysis (TPA) test by Rashidi et al. [38], totaled 1838 g, while for full-fat cheese it was 973 g. At the same time, these cheeses had different levels of gumminess, measured at 497 and 270 g, respectively. The fat content increased the acceptance (4.0 score) for full-fat cheese compared to low-fat cheese (1.3). In research by Lisak Jakopović et al. [51], the hardness of control Feta cheese was 10.35 N (1055.41 g), cohesiveness was 0.28 N (28.55 g), and gumminess was 3.00 N (305.91 g). Research indicates that reducing the fat in cheese from 18 to 14% improves sensory properties and texture, but a further reduction in fat worsens these features. The reasons for these effects are decreases in gumminess, chewiness, adhesiveness, springiness and compression [52]. In addition, reducing fat may have an impact on the perception of the taste of the cheese because in low-fat cheeses, the globules of fat are

smaller than in full-fat cheeses, and they are integrated into the protein matrix [53]. Fat content also significantly affects the overall appearance of cheese; hence, the importance of a color assessment.

Overall, production processes and the composition of the milk affect cheese texture. Ercan et al. [54] analyzed Sepet cheese and its firmness parameter varied from 65.55 to 504.11 N (6684.24 g to 51,404.91 g) depending on the tested cheese. It is known that the fat content of cheese affects its hardness. Salting also affects the texture of cheese, resulting in increased hardness [54]. As reported by Kınık et al. [55], the hardness of cheeses decreases with the passing of time. Current lactic acid bacteria proteolytic enzymes break down proteins into peptides and amino acids, resulting in a reduction in cheese hardness. On the other hand, changes in the structure of the cheese are caused by reduced moisture due to syneresis [56]. The process of proteolysis is also involved in the formation of typical sensory characteristics and is an indicator of the quality of taste and texture [57–59]. Fathollahi et al. [60] reported that Iranian UF cheese hardness on the 1st day of ripening was less than 5 N (509.86 g). In contrast, Jalilzadeh et al. [61] found that control Iranian UF feta-type cheese had 233.33 g hardness on the 1st day of ripening, 0.20 g cohesiveness, and 46.79 g gumminess. The structure UF-Feta cheese may be dense due to denatured whey proteins [59].

Texture measurement is objective and more accurate than sensory evaluation. However, by examining the sensory assessment of texture, it is possible to predict with high probability how the consumer will behave. Therefore, each texture measurement should be combined with a sensory evaluation [62].

When the color of goat's salad cheese and cow's salad cheese were compared (Table 5), no statistically significant differences in the WI were observed ( $P > 0.05$ ). However, differences were found for the parameters  $a^*$  and  $b^*$  ( $P < 0.05$ ). The YI was higher for cow's salad cheese in comparison to goat's salad cheese ( $P < 0.05$ ). Comparisons of the three studied cheeses showed that Feta cheese had the highest WI ( $P < 0.05$ ).

Sánchez-Macías et al. [63] showed that the  $L^*$  value decreased with increasing ripening time due to increased protein hydration and reduced light scattering. These authors also found that the internal color of full-fat cheese on the 1st day of ripening had  $L^* = 92.79$ . In comparison, our examined cheeses had a higher  $L^*$ . According to Ramírez-Rivera et al. [56], cheeses with a high moisture content were characterized by a higher  $L^*$  value. A color analysis of Feta cheese conducted by Kasapian et al. [64] showed that the parameters  $L^*$ ,  $a^*$ , and  $b^*$  were higher compared to the Feta cheese tested in this study, and they were higher regardless of the milk from which the cheeses were made. Feta cheese from sheep's milk had  $L^* = 91.34$ ,  $a^* = -2.44$ ,

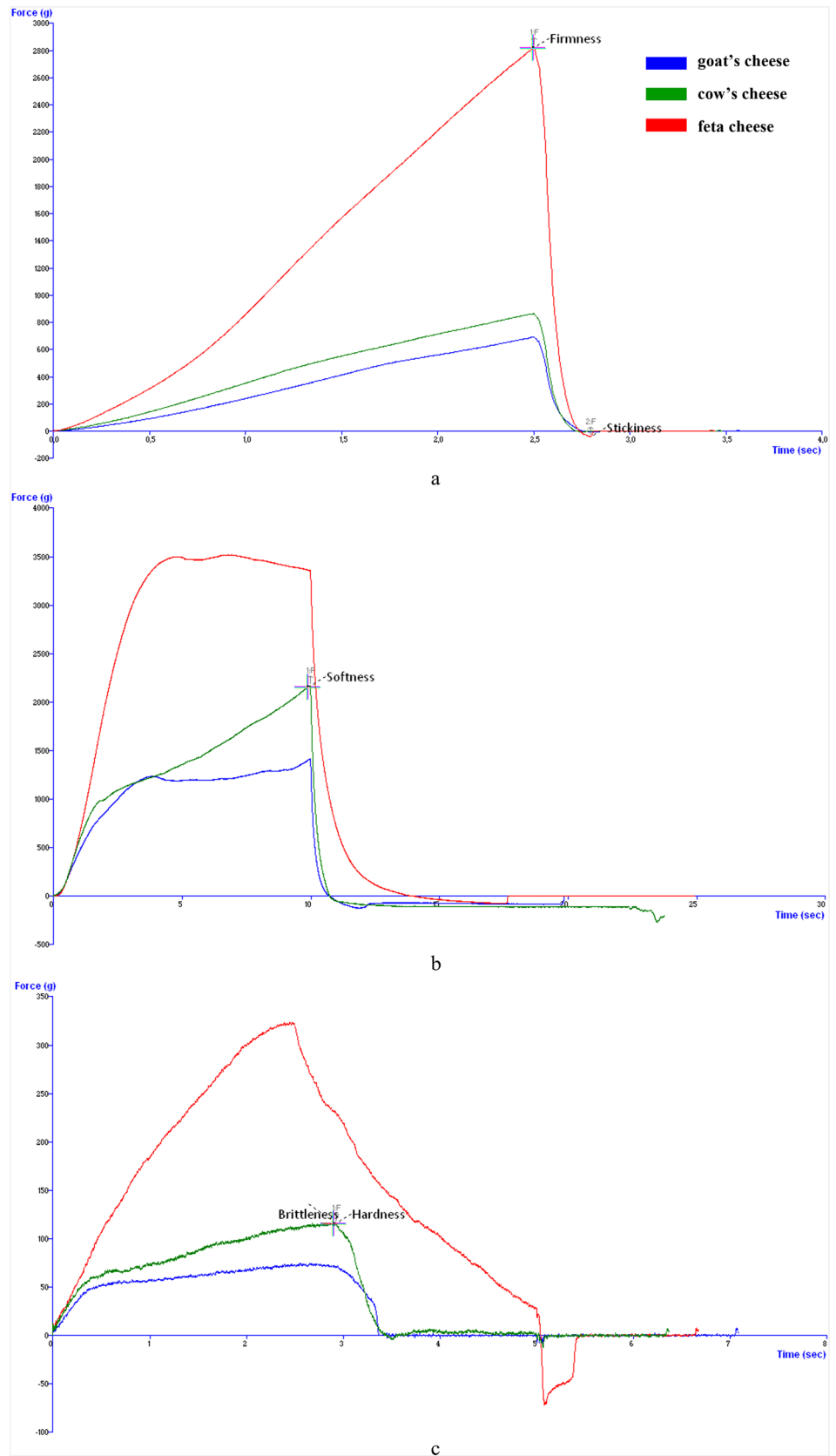
**Table 4** Texture parameters of the salad cheeses

Texture	Goat's cheese	Cow's cheese	Feta cheese
Firmness (g)	659.16 <sup>a</sup>	789.19 <sup>a</sup>	2365.49 <sup>b</sup>
Stickiness (g)	8.87 <sup>a</sup>	11.75 <sup>a</sup>	63.29 <sup>b</sup>
Softness (g)	1312.65 <sup>a</sup>	1988.59 <sup>b</sup>	3316.12 <sup>c</sup>
Hardness (g)	67.19 <sup>a</sup>	131.72 <sup>b</sup>	267.55 <sup>c</sup>
Brittleness (g)	3.29 <sup>a</sup>	5.88 <sup>b</sup>	6.98 <sup>b</sup>

Means within a row with different superscripts differ ( $P < 0.05$ )

<sup>a,b,c</sup>Different letters with mean values in a row indicate statistically significant differences at the level  $\alpha = 0.05$

**Fig. 1** Instrumental texture profile of the salad cheeses: **a** with using P/1S attachment; **b** with using P/25 attachment; **c** with using A/WEG attachment



**Table 5** Assessment of the color of the salad cheeses

Parameters <sup>a</sup>	Goat's cheese	Cow's cheese	Feta cheese
$L^*$	95.12 <sup>b</sup>	95.87 <sup>b</sup>	82.66 <sup>a</sup>
$a^*$	-1.21 <sup>a</sup>	-0.59 <sup>b</sup>	-1.33 <sup>a</sup>
$b^*$	6.11 <sup>a</sup>	9.25 <sup>b</sup>	9.38 <sup>b</sup>
WI	7.91 <sup>a</sup>	10.15 <sup>a</sup>	19.76 <sup>b</sup>
YI	9.18 <sup>a</sup>	13.78 <sup>b</sup>	16.22 <sup>c</sup>

Means within a row with different superscripts differ ( $P < 0.05$ )

WI whiteness index, YI yellowness index

<sup>a</sup>Parameters:  $L^*$  lightness,  $a^*$  - green/+red color,  $b^*$  - blue/+yellow

<sup>a,b,c</sup> Different letters with mean values in a row indicate statistically significant differences at the level  $\alpha = 0.05$

and  $b^* = 14.47$ , while Feta cheese from goat's milk had  $L^* = 94.08$ ,  $a^* = -2.50$ , and  $b^* = 11.91$ . On the other hand, Iranian ultrafiltration (UF) Feta cheese produced by Zonoubi and Goli [65] had a whiteness index 79.73 (that is, as distances from white as in our research 20.27). It was a value closer to the value of WI Feta cheese measured by us (19.76) than salad goat's or cow's cheese.

### Sensory analysis of the salad cheeses

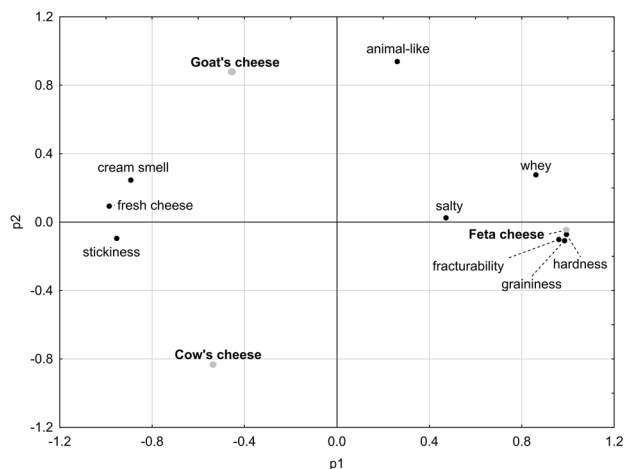
Flavor, texture and mouthfeel analyses showed very large differences between the cheese samples (Table 6) (Fig. 2). The predominant flavors in goat's cheese were animal-like (7.9 mean score) and cream smell (7.8). In contrast, cow's cheese has almost no animal-like flavor (1.6) and a whey flavor (1.3). The whey flavor was most perceptible in Feta cheese (4.9) and dominated over a fresh cheese flavor (2.2). All cheeses were equally salty ( $P > 0.05$ ). In terms of

**Table 6** Flavor, texture and mouthfeel attributes of the salad cheeses

Sensory attributes	Goat's cheese	Cow's cheese	Feta cheese
Flavor			
Fresh cheese	5.7 <sup>b</sup>	5.5 <sup>b</sup>	2.2 <sup>a</sup>
Cream smell	7.8 <sup>b</sup>	7.4 <sup>b</sup>	6.0 <sup>a</sup>
Whey	2.5 <sup>b</sup>	1.3 <sup>a</sup>	4.9 <sup>c</sup>
Animal-like	7.9 <sup>c</sup>	1.6 <sup>a</sup>	6.0 <sup>b</sup>
Salty	2.1 <sup>ab</sup>	2.0 <sup>a</sup>	2.7 <sup>b</sup>
Texture and mouthfeel			
Hardness	1.9 <sup>a</sup>	2.1 <sup>b</sup>	9.1 <sup>c</sup>
Stickiness	2.3 <sup>b</sup>	2.6 <sup>c</sup>	1.1 <sup>a</sup>
Fracturability	7.0 <sup>a</sup>	7.1 <sup>a</sup>	9.3 <sup>b</sup>
Graininess	4.7 <sup>a</sup>	5.0 <sup>b</sup>	9.7 <sup>c</sup>

Means within a row with different superscripts differ ( $P < 0.05$ )

<sup>a,b,c</sup> Different letters with mean values in a row indicate statistically significant differences at the level  $\alpha = 0.05$

**Fig. 2** Principal component analysis for the flavor and texture profiling of the salad cheeses

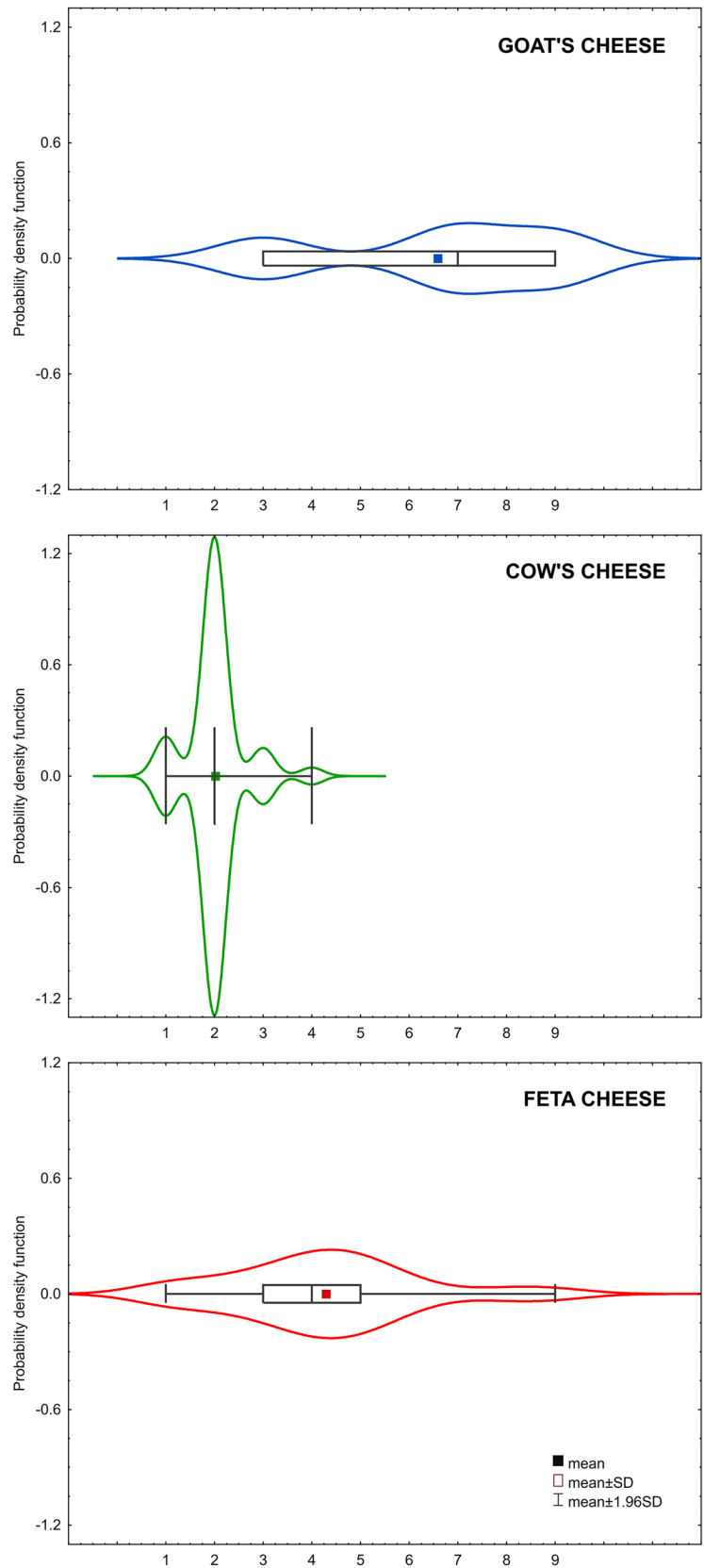
texture and mouthfeel as assessed by sensory evaluation, hardness, fracturability, and graininess were rated highest for Feta cheese (9.1, 9.3, and 9.7, respectively). By comparison, the hardness of goat's cheese was 1.9, and that of cow's cheese was 2.1. No significant differences were found between cow's and goat's salad cheeses regarding texture and mouthfeel attributes ( $P > 0.05$ ). Ultimately, hardness and animal-like flavor were the most distinguishing characteristics among the studied cheeses. The evaluation of the descriptors concerning the texture of Feta cheese differs from the results of the sensory evaluation of cow's and goat's cheeses, i.e., fracturability, graininess and hardness. This is due to the proteolysis and lipolysis of fat, the different composition of these cheeses and the water content. Compared to UF-Feta, Feta cheese has a lower protein and fat content, but a higher salt content [66]. The results of the assessment of flavor descriptors (especially "animal-like") differentiate goat's and cow's cheese despite the same production method, because the fatty acid profile and the structure of milk fat are different. The characteristic taste of goat's milk is particularly influenced by the content of short- and medium-chain unsaturated fatty acids (C6:0 to C10:0) [67].

There were strong correlations ( $r$ ) between the sensory and instrumentally assessed textures. In the case of hardness, the correlation value was  $r = 0.951$ , for stickiness it was  $r = 0.925$ , whereas the correlation between sensory graininess and firmness was  $r = 0.992$ .

Dimitreli et al. [10] reported that goat's cheeses produced traditionally in the Çanakkale province are characterized by cooked, whey, creamy, animal-like, waxy, salty and sour attributes. In addition, the cheeses analyzed by Ercan et al. [54] were predominantly characterized by salty, free fatty acid, and animal attributes.



**Fig. 3** Density fit curves of distributions of response rates for goat's salad cheese, cow's salad cheese and Feta cheese, where 1 like extremely, 2 like very much, 3 like moderately, 4 like slightly, 5 neither like nor dislike, 6 dislike slightly, 7 dislike moderately, 8 dislike very much, and 9 dislike extremely



**Table 7** Positional measures and point estimation related to the acceptability of salad cheeses

	Goat's cheese	Cow's cheese	Feta cheese
Mean	6.59	2.02	4.29
Median	7.00	2.00	4.00
Mode	7.00	2.00	4.00
N Mode	42	85	29
SD	2.32	0.57	1.93
Skewness	-0.60	0.90	0.45

SD standard deviation

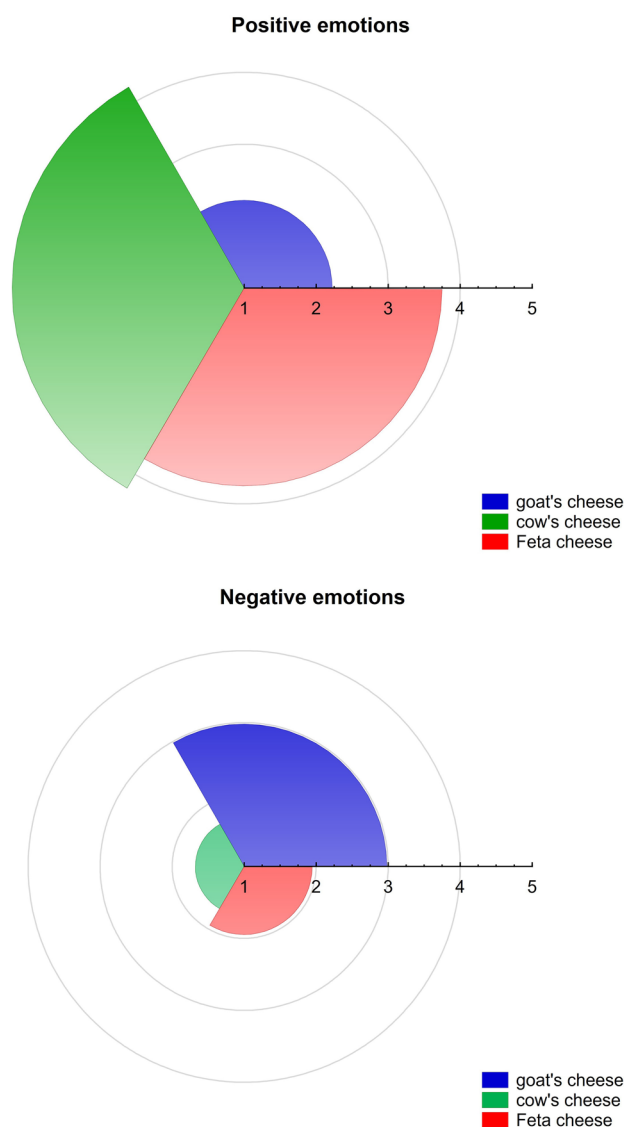
## Acceptance test

The acceptability of goat's cheese compared to the other salad cheeses was the lowest (6.59 vs. 2.02 for cow's cheese and 4.29 for Feta; Fig. 3). The acceptance test concerned all the features related to appearance, consistency, color, taste and smell. The result of this assessment reflects the consumer's attitude towards cheese, which influences his further decisions. However, this relationship need not be directly proportional. As demonstrated by Jaeger et al. [68] in the case of many food products, despite their high acceptability, a decision is made not to consume them. Most consumers rated goat's cheese with "dislike" rate. There were no consumers who indicated that goat's cheese was worth 1 to 3 for them (i.e., like extremely, like very much, or like moderately). Cow's cheese was rated as more than 3 times more like than goat's cheese. Cow's cheese was also rated as most acceptable by consumers (n mode of 85 out of 112), who identified it as "like very much". Although, the range of responses for cow's cheese was from 1 (like extremely) to 4 (like slightly). On the other hand, the acceptability of Feta cheese as determined by consumers showed the widest range (from 1 "like extremely" to 9 "dislike extremely"). The distribution of probability density function acceptance test of Feta cheese shows the most even distribution (Table 7). The skewness value for the Feta cheese sample (0.45) is closest to 0. The greatest skewness as a distance from the mean was shown for the cow's cheese acceptance test (0.89). This proves the largest group of consumers who said they liked this type of cheese. Feta cheese was considered "like" by 31% of consumers, as "dislike" by 38.8, and 30.2% found Feta "neither like nor dislike". In contrast, goat's cheese was "like" by 62.0% and cow's cheese by 78.3%. Cow's cheese was "dislike" by only 7.8% of consumers. The greater desirability of cow's cheese may result from a different flavor and aroma profile, and above all it may be a matter of getting used to eating cow's milk products (which are more popular in the region where the study was conducted). Goat's milk has a specific aroma caused, among others, by

the high content of free fatty acids, mainly caproic, capric and caprylic, released as a result of the action of lipoprotein lipase [69].

According to Farah et al. [70], acceptance is based mainly on three attributes (appearance, taste and texture) and is independent of the nutritional value of a given product. In addition, Gupta et al. [71] reported positive relationships between composition (protein content), texture, the consistency index and overall liking. Thus, texture and consistency are important criteria for the consumer acceptance of dairy products.

The results of Csapo et al. [72] clearly indicated that goat's cheese is more acceptable compared to cow's and sheep's cheese. The typical goaty flavor was not negatively perceived and consumers were willing to pay more for this



**Fig. 4** Spie-plot of the emotional profiling of the salad cheeses by consumers

cheese. These effects appeared to be related to its high quality. Ryffel et al. [73] indicated that the most popular reasons for the consumption of goat's and sheep's products were “special flavor”, “something different once in a while”, “healthy products” and “natural products”.

## Emotional profile

The consumption of goat's cheese was primarily associated with negative emotions (Fig. 4). Consumers selected all 6 negative emotions. The occurrence of positive emotions after the consumption of goat's cheese was negligible, except for “healthy”. The ratings for the remaining positive emotions ranged from 1.3 to 2.3 (where 1 signified no emotion and 2 not much). The share of positive emotions for cow's cheese was twice as high as that for goat's cheese. The consumption of Feta cheese caused positive emotions in most cases. The positive emotions that accompanied the consumption of cow's cheese dominated the negative emotions.

The consumption of cow's cheese caused the most positive emotions (Fig. 5). These were “glad” (4.2), “modernized” (4.0), “relaxed” (3.6), and “happy” (3.5). The positive emotions that occurred after consuming Feta cheese were “glad” (3.8), “healthy” (3.3), and “excited” (3.3). Goat's cheese consumers felt that the only positive emotion associated with this cheese was “healthy” (3.6). The intensity of the remaining positive emotions did not exceed a level of 2.3. After eating goat's cheese, negative emotions dominated. These were very intense (e.g., upset, 3.9; disgusted, 3.6; worried, 3.2). Many consumers also indicated “disappointed” and “angry” after consuming goat's cheese. Such negative emotions were not caused by the consumption of cow's cheese. However, eating Feta cheese increased the ratings for “disappointed” (3.0), but it did not cause the emotion defined as “angry”. As part

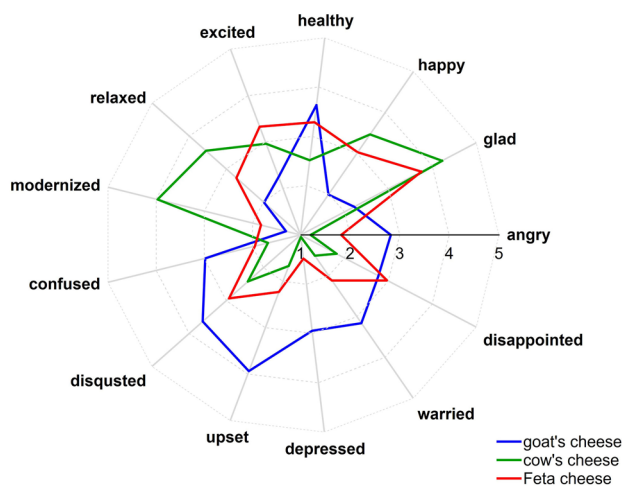


Fig. 5 Positive and negative emotions after eating the salad cheeses

of a deeper analysis, the correlations of these emotions with the acceptability of the cheeses were investigated. Although Feta cheese was less desirable by consumers than goat's cheese, its consumption did not cause as many negative emotions. The most negative emotions are caused by the consumption of goat's cheese. The negative emotions that are most intense after eating goat's cheese were “disgusted”, “upset” and “worried”. At the same time, it has been shown that the consumption of goat's cheese evokes less positive emotions than Feta cheese. They result more from an attitude related to prevention and sense. Perhaps the positive emotions that appear after eating goat's cheese are not able to outweigh or at least neutralize the negative feelings. It turned out that the greatest significant correlation was between acceptability and the emotion “modernized” ( $r = -0.569$ ). The associations of the remaining emotions with acceptability were smaller ( $r = 0.034-0.383$ ).

Seo et al. [74] showed that consumers prefer smells that evoke familiar, attractive and modern feelings. According to Rahnama and Rajabpour [75], the choice of dairy products is influenced by positive emotions focused on interest, enjoyment, pleasure, feeling good, and feeling relaxed. Larosa et al. [25] studied the emotions experienced by the consumer while consuming kefir made from sheep's milk with various sweeteners. They observed that the higher the sensory acceptability of the products, the more intense the emotions of “satisfied”, “active”, “comfortable”, “energetic”, “healthy” and “refreshing”. The same authors added honey as a sucrose substitute, which triggered emotions such as “satisfied”, “happy”, “comfortable”, “energy”, “healthy”, and “refreshing”, and improved the acceptance of appearance and smell. However, compared to other sweeteners (sucrose, demerara sugar, brown sugar, fructose, coconut sugar), the addition of honey reduced the intensity of “active”, “loving”, “energetic”, “healthy” and “upset” [25].

The label of a given product, as well as the information on it, is of great importance for the invocation of emotions. Research by Schouteten et al. [76] shows that the information on the label causes various reactions, including the appearance of specific emotions. In that study, consumers were given samples of the same cheese, but each piece had different information (control, light, reduced salt, light + reduced salt). The value for the emotional term “glad” was greater for the cheese samples with the control label information than for the others. However, when it comes to distinguishing between positive and negative emotions, no significant differences were found. In the case of sensory terms, the differences were for “creamy”, “salty”, and “untasty”.

Research by Yao [77], carried out on milk, cheese and yoghurt, showed that, among the consumers of cheese, the dominant emotions were “desire”, “satisfaction”, “joy” and “pride”. The same positive emotions also accompanied the

consumption of milk and yoghurt. However, among the non-users of cheese, the consumption of cheese evoked strong feelings of “sadness”, “fear” and “disgust”. Taking into account the combined emotional analysis of dairy products, strong positive emotions occurred in the sequence of yoghurt, cheese and milk.

It is not only yoghurt, kefir and cheese that are subject to emotional evaluation. You can also create an emotional profile for ice cream. Research by Cobo et al. [78] was based on the determination of emotions during the consumption of ice cream according to portion size. The results showed that the initial consumption of a small portion produced feelings “relaxed” and “happy”, and at the end of eating “peace”. However, consuming a large portion gave completely different feelings. Despite the appearance of “relaxed” and “happy” emotions at the end of consuming, negative emotions such as “bored”, “guilty”, and “disgusted” appeared. This shows that not only the food product itself is important in an emotional evaluation, but also the portion size.

Research by Seo et al. [74] was based on determining the relationship between sensory attributes and emotional reactions for milk, skim milk, processed cheddar cheese, pizza cheese, butter, and yoghurt. It was found, for example, that the sensory attribute “sour aromatic” was positively correlated with the emotions “rash”, “modern”, “stimulant”, “excited”, “emotional”, “flowery” and “characteristic”. For “fermented aromatic”, it was positively correlated with “excited” and “emotional”. An emotional profile can be created/described not only for salad cheese, but also for other types of cheese (e.g., Zacazonapan cheese). As shown by Torres-Salas and Hernández-Montes [79] who conducted a study on consumers after tasting Zacazonapan cheese, the dominant positive emotions were “active”, “nice”, “cheerful”, “kind”, “friendly”, “good”, “good character”, “quiet”, “understanding”, “pleasant”, “fun”, “stable”, “happy”, “interested”, “free”, “obedient”, “peaceful”, “satisfied”, “safe”, “sensitive” and “calm”. In this study, very little was dominated by negative emotions.

According to Delplanque and Sander [80], researching emotions can be risky when using measures to infer emotions. Therefore, in our opinion, it is important to present the sensory tests and their results in the form of numerical data, as well as creating an emotional profile. Delplanque and Sander [80] described that, when examining emotions, we are presenting a description of the processes that take place within a short period of time. During this time, the individual is subject to a number of changes in five components, including the elicitation component and four components of the emotional response. The emotional components include expression, feeling, autonomous psychophysiology, and action tendencies. Therefore, instrumental analysis (and its results) will never completely replace sensory analysis [81].

Emotions during consumption are also somewhat fleeting and illusory. In terms of considerations at the interface of cognitive psychology, neurocognitive science, and neuroaesthetics, it can be stated that emotions are something real in terms of psychology and physiology in the context of the brain, and are an important part of the human esthetic experience. In addition, their reception and recall influences decision-making about the foods consumed in the future. Such emotional regulation is related to its direct influence on the cognitive and behavioral functioning of a human being. For example, it is known that the primary role of food is to satisfy physiological feelings of hunger and to provide the body with nutrients. However, it can also serve to meet the psychological needs of a human, including security, belonging to a given social or cultural group, and emotions. It is also involved in maintaining social relationships. Experienced emotional states can be both the cause for and the effect of eating food. In addition, the emotions experienced may influence the choice of a meal and the motivation to prepare it, the pace of eating, and the quantity and quality of the food consumed.

In the current study, the tested cheeses were treated as stimuli that caused the consumer to experience emotions. These stimuli triggered the entire spectrum of affective reactions. Some of these reactions may in the future create a so-called “memory footprint” (which may be important when selecting and purchasing the product in the future). However, it may be that the reaction is neither positive nor negative, but neutral. In this case, it can be assumed that consumer is only engaging in recognition and is not subject to further emotions. It is then not an emotive relationship, but a cognitive one.

The type of emotion that occurs after eating (in this case cheese) that influences purchasing decisions is the result of confirming or canceling the expectation. Therefore, emotions can appear either because the cheese met the consumer’s expectations or because its characteristics have surprised us with its esthetic impressions. According to Rahnama and Rajabpour [75], emotions influence the behavior of consumers regarding the choice of dairy products. The health value and price of such products will further shape the appearance of emotions. The role of the emotional profile of food is to try to explain why some foods are accepted when consumed and some are not, even when the consumer has been consuming the product over a long period of time. In addition, positive emotions will dominate when consuming fresh products, and, as the quality deteriorates, negative emotions will emerge. The core emotional responses to a food product are primarily due to its sensory properties, such as taste, odor, texture, and appearance [82].

The key purpose of including an emotional profile in consumer research is primarily to show how a given food product is perceived by the consumer. In addition, the

quality of a given product can be improved in this way. For example, a product that evokes only negative emotions may be replaced with another product (even of the same type, but a different brand) that will put the consumer in a positive mood. Nevertheless, such a profile can outline a trend in the perception of a food product. In addition, it all depends on the frame of mind of the consumer, their life situation, and their attitude towards life. For example, consumers who declare themselves as optimists may perceive more positive emotions than consumers who identify as pessimists. We have shown that the acceptability of salad cheeses does not have to be associated with positive emotions. It turned out that Feta cheese was the least liked cheese, even though it caused much less negative emotions than goat's salad cheese. It follows that consumers in their choices are guided not only by the hedonistic like-dislike approach, but also by the desire to be healthy and preventive health care. This is confirmed by the results of detailed positive emotions evoked after eating goat's cheese, and healthy was the dominant emotion. Thus, the emotional profile can influence the targeted production and development of food products.

## Conclusions

The current research shows that it is possible to combine sensory and mechanical attributes with an emotional profile. The sensory analysis of goat's cheese showed that the dominant smells were "animal-like" and "creamy". There were no such significant differences in terms of texture and mouthfeel attributes between cow's and goat's salad cheeses as between them and Feta cheese. Sensory evaluation showed that goat's cheese was characterized by less hardness, stickiness and graininess compared to cow's cheese. Texture measurements confirmed that goat's cheese compared to cow's cheese had more softness and less hardness, even though it had the same firmness and stickiness. Analysis of the acceptability of soft cheeses showed that goat's cheese in comparison with cow's cheese and Feta cheese was the least acceptable. In addition, the consumption of goat's cheese caused negative emotions, including "upset", "disgusted", "worried", "disappointed", and "angry". The only positive emotion after consuming the goat's cheese was "healthy". It has also been shown that the fat content in the product determines its acceptability. Color analysis showed that goat's milk cheese had a lower whiteness index compared to cow's cheese and Feta cheese.

These results show how important it is to combine several analyses and techniques in the evaluation of dairy products, including salad cheese. The texture, consistency, and color of a product, as well as its sensory and emotional properties, can be mutually related. In addition, such research can

significantly influence the development of goat's milk products that are compatible with consumer expectations.

**Author contributions** Conceptualization, formal analysis, writing the original draft: ŁKK and DC-S; methodology and visualization: PB, JT, SC, and JB; investigation: AY. All the authors have read and agreed to the published version of the manuscript.

**Funding** This work was supported by the Ministry of Education and Science (Poznań, Poland) MEN-UPP 506.784.03.00/KJPM.

**Data availability** The data presented in this study are available on request from the corresponding author (Ł.K.K.).

## Declarations

**Conflict of interest** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Compliance with ethics requirements** The authors declare that neither human nor animal experimentation were included in the paper. The number of the decision by the Bioethics Committee at the Poznan University of Medical Sciences is KB-331/21.

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