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Sensory Profile of Semi-Hard Goat Cheese Preserved in Oil for Different Lengths of Time

Stefani Levak [1], Ivica Kos [2], Samir Kalit [1,*], Iva Dolenčić Špehar [1,*], Darija Bendelja Ljoljić [1], Ante Rako [3] and Milna Tudor Kalit [1]

1 Department of Dairy Science, University of Zagreb Faculty of Agriculture, Svetošimunska 25, 10000 Zagreb, Croatia; stefani.levak89@gmail.com (S.L.); dbendelja@agr.hr (D.B.L.); mtudor@agr.hr (M.T.K.)
2 Department of Animal Science and Technology, University of Zagreb Faculty of Agriculture, Svetošimunska 25, 10000 Zagreb, Croatia; ikos@agr.hr
3 Department of Applied Sciences, Institute for Adriatic Crops and Karst Reclamation, Put Duilova 11, 21000 Split, Croatia; ante.rako@krs.hr
* Correspondence: skalit@agr.hr (S.K.); ispehar@agr.hr (I.D.Š.)

Abstract: The aim of this study was to investigate the sensory profile of semi-hard goat cheese preserved in an oil mixture (extra virgin olive oil from Mljet and refined sunflower oil; 50:50). Five batches of cheese were made, and each batch was divided into three groups: (i) ripening in air (group 1—control group), (ii) ripening in oil after 10 days of ripening in air (group 2), (iii) ripening in oil after 20 days of ripening in air (group 3). After 60 days of ripening, quantitative descriptive analysis (QDA) was performed by six trained experts and texture was analyzed with a texture analyzer. The correlations between the descriptive sensory scores of texture and the texture analyzer results were significantly related. Compared to the control group, the oil-ripened cheeses had significantly ($p < 0.05$) higher oily odor and taste intensity and greater elasticity and stickiness determined by fingers, but thinner rind, lower cross-sectional color intensity, and lower crumbliness in the mouth. Ripening in oil improved rind thickness, taste, texture, and cross-sectional properties. Group 3 cheeses were preferred in terms of appearance, cross-section, odor, and taste, suggesting that prolonged ripening in air before immersion in oil positively affected the sensory characteristics of the cheese.

Keywords: semi-hard goat cheese; ripening in oil; sensory profile; quantitative descriptive analysis; texture

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1. Introduction

About a quarter of the world's supply of edible food is wasted. The causes of food waste can be at any level between production, harvest, distribution, processing, and the consumer behavior [1]. The valorization of food losses has gained much importance in the last decade due to the amount of waste generated daily and the burden these losses place on industry and the environment [2,3]. How long food remains edible and nutritious depends on numerous factors that affect the growth rate of spoilage microorganisms. Some storage methods, especially traditional ones (e.g., drying, salting, smoking, etc.), require relatively little energy, while newer, industrial methods require much greater energy input [4].

The Mediterranean diet is a model for a healthy diet [5], which is mainly attributed to the consumption of extra virgin olive oil (EVOO) [6]. Although EVOO is mostly used fresh, it is not uncommon to use it to preserve various food groups e.g., vegetables, fish as well as dairy products [7]. Dairy products represent a significant part of the modern diet, and by choosing traditional cheeses, consumers not only show their concern for nature, the origin of raw materials and products, but also contribute to the preservation of traditions and support economic development [8,9], especially in areas with limited resources [10] such as islands [11].

Cow's milk cheese is produced all year round, while goat's milk cheese production is seasonal. Since the production period is not long, a suitable preservation method for semi-hard cheeses is extremely important to increase their availability for a longer period of time without altering their sensory characteristics [12].

Traditional cheesemakers on the Croatian islands of Brač and Krk, preserve cheese in olive oil, while in southern Croatia—in the city of Dubrovnik and on the island of Mljet—cheese is usually preserved in a mixture of locally produced olive oil and commercial refined sunflower oil for up to two years. However, the time of immersion of the cheese and the duration of cheese ripening in the oil are not standardized. For example, cheeses from Dubrovnik and Mljet are immersed in oil after seven days of ripening in air [13,14]. On the other hand, cheeses from the islands of Brač and Krk continue to ripen in oil after at least two months of ripening in air. Similarly, Manchego, a Spanish hard cheese made from sheep's milk, is also often placed in olive oil after three months of ripening in air, where it is usually kept until consumption [15,16].

The ripening conditions such as temperature and relative humidity in the ripening chamber and the ripening media (e.g., oil, animal skin, plastic or stone containers, brine, or spices) influence the biochemical processes of glycolysis, proteolysis, and lipolysis, which can consequently lead to the development of specific sensory characteristics of the cheese [15–19]. Thus, cheeses ripened in animal skin (e.g., Sir iz mišine, Tulum, Darfiyeh, and Bouhezza) have a unique and piquant smell, taste, and aroma, which is due to intense lipolysis and proteolysis during ripening conditions in the skin [19–21], i.e., lower air permeability of the skin compared to the cheese rind [8], but higher compared to plastic or stone containers, which serve as an alternative ripening medium [22].

Moisture content is one of the most important factors affecting the course of ripening and the development of sensory properties of cheese [17]. For example, oil as a ripening medium prevents moisture loss which influences sensory characteristics of cheese [23]. Also, animal skin has higher water permeability than a plastic container and lower permeability than the natural cheese rind, which affects the dry matter content in cheese and its sensory characteristics [8,24,25]. Semi-hard goat cheeses are usually smaller, which affects their moisture content during air ripening, since the small size of the cheese increases the surface area per unit weight, which favors dehydration [26] and leads to poor sensory characteristics of the cheese, especially texture. Cheese with pronounced dryness can unfortunately only contribute to an increase in food waste because, although it is still edible, it is perceived as relatively undesirable compared to other similar foods because it deviates in sensory perception. This type of cheese is then considered a "suboptimal food" [27].

Texture, as an expression of some rheological properties of food, is one of the most important organoleptic properties. Also, from the consumer's point of view, texture is one of the most important parameters they use to make purchasing decisions [28]. The texture of a cheese is the determining factor for its identity and quality, as it affects the mechanical properties, such as cutting, stretching, mixing, and melting [28–30]. It depends on a variety of factors, from the quality and treatment of the raw material (milk) to the ripening conditions (e.g., temperature) [31,32] and duration, the type of cheese and its manufacturing technology (including the type of salt used) and the moisture content [33]. The complex structure of cheese leads to differences in texture, even within the same type of cheese, depending on the ingredients and how they change during ripening. The storage conditions of cheese also have a great influence on texture characteristics [34].

Quantitative descriptive analysis (QDA) is a modern technique for qualifying the type and quantifying the intensity of sensory properties immediately after sensory stimulation [35,36], which is recognized as an excellent tool for measuring and optimizing the sensory characteristics of various dairy products [37–39].

Knowledge about the influence of oil on cheese ripening is limited and almost unexplored, except for two studies on the ripening of Manchego cheese in olive oil conducted more than four decades ago [15,16] and our previous research on the influence of ripening of semi-hard goat cheese in oil on its physicochemical composition and sensory properties [23]. This study was designed to evaluate the effects of ripening in oil on the sensory profile of semi-hard goat cheese. Since texture plays an important role in the overall sensory quality, another objective of this study was to compare the QDA results with the texture analyzer results. Finally, the goal was to determine the optimal duration of cheese ripening in oil in order to develop the preferred sensory characteristics and to extend consumption time during periods when goat's milk is not produced.

2. Materials and Methods

2.1. Semi-Hard Goat Cheese Production

For this study, five batches of semi-hard goat cheese were produced in the pilot plant of the Department of Dairy Science at the University of Zagreb Faculty of Agriculture (Croatia). Each batch was produced from 100 L of raw goat's milk (Saanen goat breed). The milk was collected during evening and morning milking and stored in a cooling tank at 4 °C before cheese making.

The cheese-making process was as follows: (i) The filtered milk (100 L) was heated to 31 °C and then lysozyme (Lysozyme granular, Proquiga Biotech S.A., Spain—5 g of lysozyme dissolved in 1.5 dL of distilled water at room temperature for 15 min), freeze-dried mixed starter cultures (Lyofast MT 096 FEN 5 UC, Sacco Srl, Italy—1352 g; 1/5 of the bag weight for 100 L of milk), and rennet powder (Caglificio Clerici Spa, Italy—4 g of rennet powder dissolved in 1.5 dL of distilled water at room temperature for 10 min) were added according to the manufacturer's procedures and guidelines. (ii) After coagulation (setting time was between 50 and 60 min), the curd was cut into uniform walnut-sized grains with sharp edges using a cheese harp. The curd grains were heated to 39 °C with constant stirring. (iii) When the desired temperature was reached, the cheese grains were stirred for 30 min and then evenly placed in the plastic molds and pressed with weights. (iv) After pressing and turning the cheese at each change of weights (2–3 h process) and reaching a pH of 5.4–5.5, the cheeses were dry-salted, stored overnight in a refrigerator, washed in the morning, and subjected to ripening.

A total of sixty-five cheeses were produced (thirteen per batch: control group—six cheeses, group 2—four cheeses, and group 3—three cheeses). The initial cheese weight was about 800 g and the initial dimensions were 12 cm × 4 cm. Cheeses of the same batch were randomly divided into 3 groups according to the ripening method: (i) ripening in air (control group—group 1) for 60 days, (ii) ripening in oil for 50 days after 10 days of ripening in air (group 2), (iii) ripening in oil for 40 days after 20 days of ripening in air (group 3). The temperature in the ripening chamber was 15–17 °C and the relative humidity was 70–80%. The cheeses of groups 2 and 3 were placed in plastic vats (Figure 1) with lids filled with a mixture of extra virgin olive oil (EVOO) from the island of Mljet and commercial refined sunflower oil (50:50 ratio).

Figure 1. Cheese ripening in oil and in the air.

2.2. Cheese Sampling

For each ripening treatment and for each ripening time, the whole cheese was taken as a sample. To avoid dehydration, cheeses were packed in plastic bags and transported to the laboratory using a mobile refrigerator at a temperature of 4 °C. Cheese samples were labeled and stored in the refrigerator at 4 °C prior to analyses. Before sensory evaluation, the cheeses were tempered at room temperature.

2.3. Quantitative Descriptive Analysis (QDA)

The sensory properties of samples were analyzed on the last day of the 60-day ripening period using QDA by a group of 6 expert assessors (scientific staff: 4 women, 2 men; ages 33–55) trained at the University of Zagreb Faculty of Agriculture, Croatia. The assessors were selected and generically trained according to the ISO 22935-1 [40].

In addition, during the terminology development phase (8 h), the assessors agreed to evaluate 5 groups of attributes—appearance, odor, texture, taste, and aroma. In assessing appearance, the panelists evaluated the external characteristics and cross-section of the cheese. The main descriptors were color (white to yellow) and overall likability, but also the thickness of the rind (more or less than 5 mm). For the odor attribute, the descriptors used were sour, rancid, goat-like, oily, off-odors, and overall likeability. For texture, the descriptors elasticity and stickiness determined by fingers, solubility and crumbliness in mouth, and overall likability were used. To evaluate taste, the descriptors salty, sour, bitter, and overall likability were used. The following descriptors were used to evaluate aroma: buttery, goat-like, oily, fruity, rancid, off-flavor, and persistence.

Following the terminology development phase, panelists were trained in five two-hour sessions on quantification of the selected terms and inter-assessor calibration to improve consistency and reproducibility, evaluating various commercially available cheeses using the descriptive terms developed to describe and quantify the above-mentioned attributes. Sensory analysis was carried out in the sensory laboratory of the University of Zagreb Faculty of Agriculture (room-related technical requirements: relative humidity 50–55%, temperature 20–22 °C, illumination of 4000 K and 500 lux on the working table) according to the ISO Standard 8589:2007 [41]. All attributes were evaluated using a digital questionnaire on a numerical and unipolar intensity scale of 0–9 to assess the intensity of the rated attribute, where zero meant “not detected” and 9 meant “high intensity” or examples were provided to describe the intensity of the descriptor.

Prior sensory evaluation, research was approved by the Ethics Committee of the University of Zagreb Faculty of Agriculture on Sensory Analysis of Agri-food Products and the assessors gave informed consent. Individually coded samples were served at room temperature (3 mm thick slices cut from the center of the cheese to the rind) in sensory booths. Samples were presented in monadic way in a randomized order and 5 min break was considered between samples, and 30 min between sessions of the same day. The assessors used water, almonds, bread, and apples as palate cleansers. In total, five sessions were held over two days, and within each session, three samples and one replicated sample were assessed. Replicated sample was used for the calculation of assessor’s repeatability (the calculation is based on the differences in absolute value between the scores assigned to the different descriptors of the sample and its replica) within software for the statistical processing of descriptive sensory analysis tests (Big Sensory Soft 2.0) [42].

2.4. Texture Analysis

The measurement of cheese texture parameters was performed in the laboratory of the Institute of Adriatic Culture and Karst Reclamation in Split by analyzing the texture profile with a texture analyzer (TA Plus; Lloyd Instruments, Bognor Regis, UK) according to the manufacturer’s instructions.

Cheese samples for texture measurement were taken with a sterile cork borer (17.40 mm diameter) parallel to the pressing direction of the cheese between the top and bottom sides. Before sampling, the cork borer was lubricated with paraffin oil to facilitate cutting out the samples. The cheese cores were cut into cylindrical samples (diameter = 17 mm; height = 25 mm) using a cutter with tensioned wire (Figure 2). These samples were wrapped in plastic film, stored at 4 °C, and analyzed within the next 24 h.

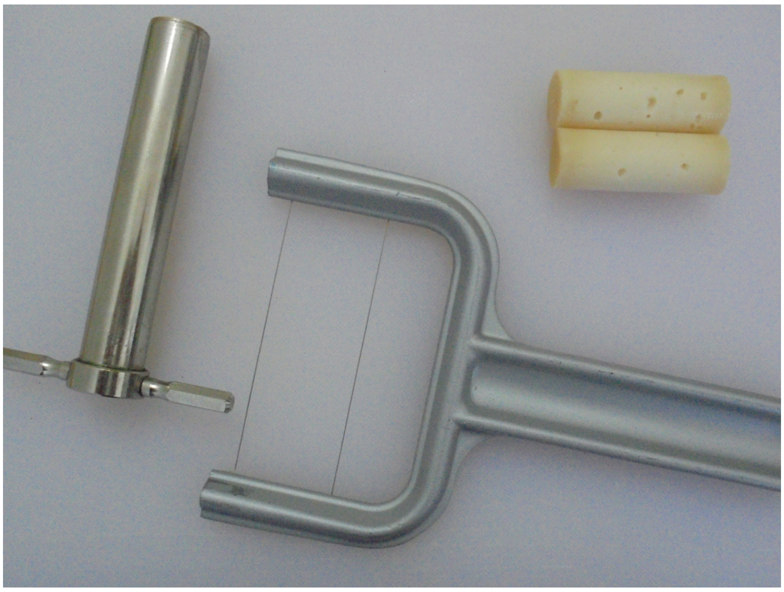

Figure 2. Semi-hard goat cheese samples (control group), cork borer, and cutter with tensioned wire.

Texture measurements were performed at room temperature using the uniaxial compression method with the texture analyzer (TA Plus; Lloyd Instruments, UK) equipped with a 500 N load cell (XLC-0500-A1; Lloyd Instruments) and a round aluminum pressure plate (ST 6/1-50 mm; Lloyd Instruments). Cheese samples were wrapped in plastic film and left until they reached room temperature. Each cylindrically shaped sample was subjected to a break and adhesive test with the pressure plate at a preload of 0.1 N and a constant crosshead speed of 50 mm/min. During the break test, the compression plate moved from the point of reaching preload until the moment the sample fractured and then was retracted to zero position. The adhesion test was performed by moving the compression plate from the moment it reached preload to the moment it reached 30% of strain. The instrument then waited 10 s and the plate was retracted to zero position at the same crosshead speed.

The texture parameters of the cheese were determined using Nexygen Plus 3 software [43] and included three parameters (load at break, adhesion force and elasticity). Load at break is defined as the load at which the sample breaks. Elasticity is calculated as the extension from the preload to the point of break. Adhesion force is defined as the maximum negative force required to overcome the attractive forces between the surface of the cheese sample and the surface of the plate.

2.5. Data Analysis

The procedures of the statistical program SAS Studio [44] were used for the processing of the sensory data. The PROC MIXED procedure with the Tukey post hoc test was used with the ripening treatment as a systematic effect and the assessor as a random effect at a significance level of $p = 0.05$.

Statistical procedures for texture were performed in SPSS [45]. One-way ANOVA and general linear model (GLM) were used to study the significance of textural changes in cheeses subjected to three different ripening treatments during 60 days of ripening. Pairwise comparisons of mean values were performed using the least significant difference (LSD) test. The relationship between the variables was analyzed using Pearson's correlation coefficient.

3. Results and Discussion

Sensory Properties of Air- and Oil-Ripened Semi-Hard Goat Cheese

Figure 3 shows the appearance and cross-section of the semi-hard goat cheese after 60 days of ripening and Figures 4–8 show the mean scores for the attributes of appearance, odor, texture, taste, and aroma of each ripening treatment. Table 1 summarizes all 27 sensory attributes and their reference standards.

Figure 3. Appearance and cross-section of semi-hard goat cheese. From left to right: Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air.

Table 1. Definitions and references of the descriptive terms for semi-hard goat cheese.

Attribute	Descriptor	Low—0 (Not Detected/Like)	High—9 (Very Intensive/Like)
Appearance	External—color intensity	Cottage cheese	Cheddar
	External—overall likeability	0	9
	Cross-section—rind thickness	<5 mm	>5 mm
	Cross-section—color intensity	Cottage cheese	Cheddar
	Cross-section—overall likeability	0	9
Odor	Sour	0	Fermented milk
	Rancid	0	Unpleasant
	Goat-like	0	Goat
	Oily	0	Oil
	Off-odors	0	Barn, basement etc.
	Overall likeability	0	9
Texture	Elasticity determined by fingers	Parmesan	Mozzarella
	Stickiness determined by fingers	0	Cheddar
	Solubility in mouth	Parmesan	Mozzarella
	Crumbliness in mouth	Mozzarella	Parmesan
	Overall likeability	0	9
Taste	Saltiness	Mozzarella	Feta
	Sour	0	Fermented milk
	Bitter	0	Arugula
	Overall likeability	0	9
Aroma	Buttery	0	Butter
	Goat-like	0	Goat
	Oily	0	Oil
	Fruity	0	Nuts, fruits
	Rancid	0	Overripen blue cheese
	Off-flavor	0	Barn, basement etc.
	Persistence	Mozzarella	Parmesan

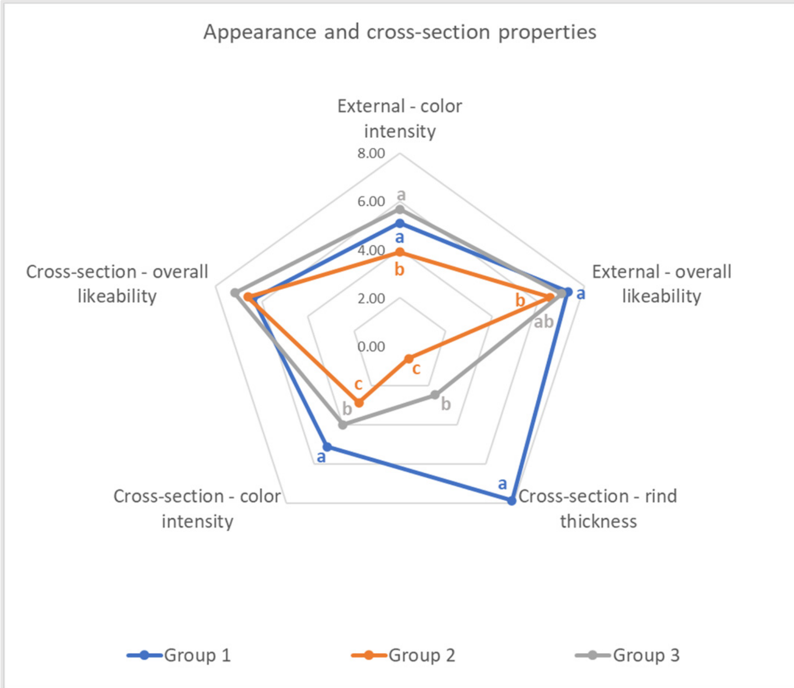

Figure 4. Descriptive sensory scores of appearance and cross-sectional properties of semi-hard goat cheese. Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Different letters referring to the same attribute imply significant difference ($p < 0.05$) between ripening treatments.

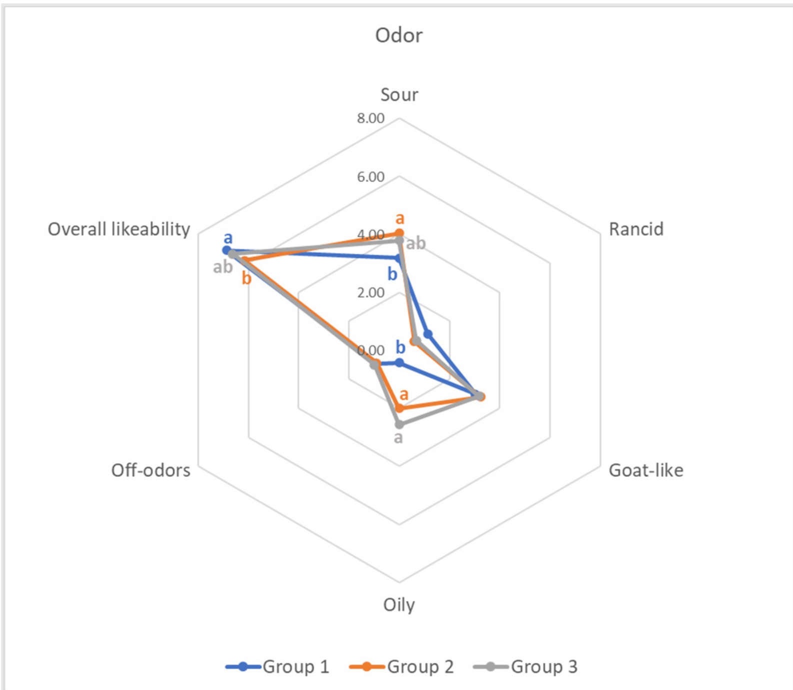

Figure 5. Descriptive sensory scores of the odor of semi-hard goat cheese. Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Different letters referring to the same attribute imply significant difference ($p < 0.05$) between ripening treatments.

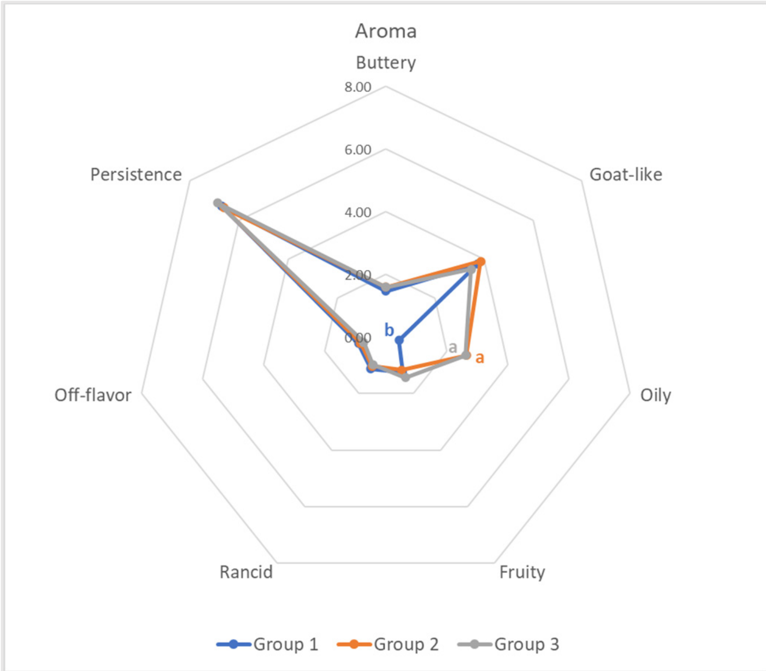

Figure 6. Descriptive sensory scores of the aroma of semi-hard goat cheese. Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Different letters referring to the same attribute imply significant difference ($p < 0.05$) between ripening treatments.

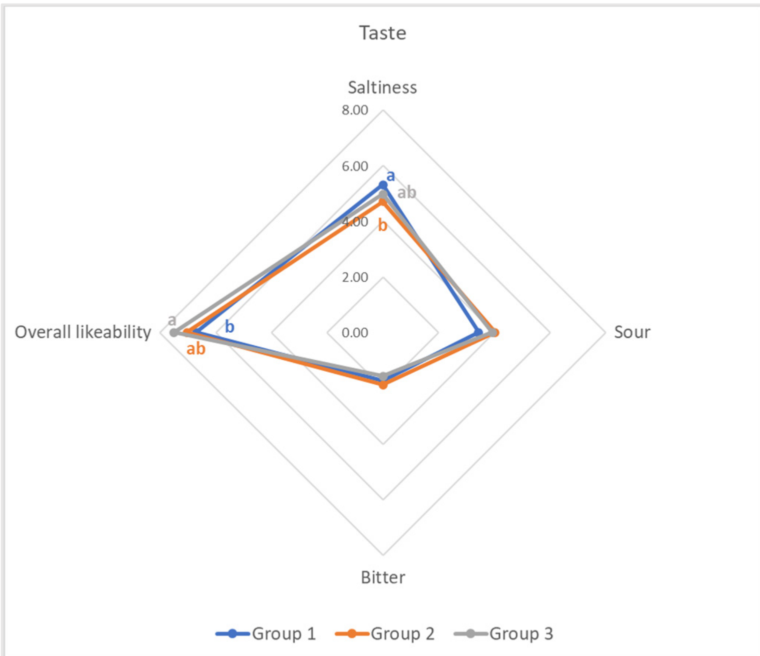

Figure 7. Descriptive sensory scores of the taste of semi-hard goat cheese. Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Different letters referring to the same attribute imply significant difference ($p < 0.05$) between ripening treatments.

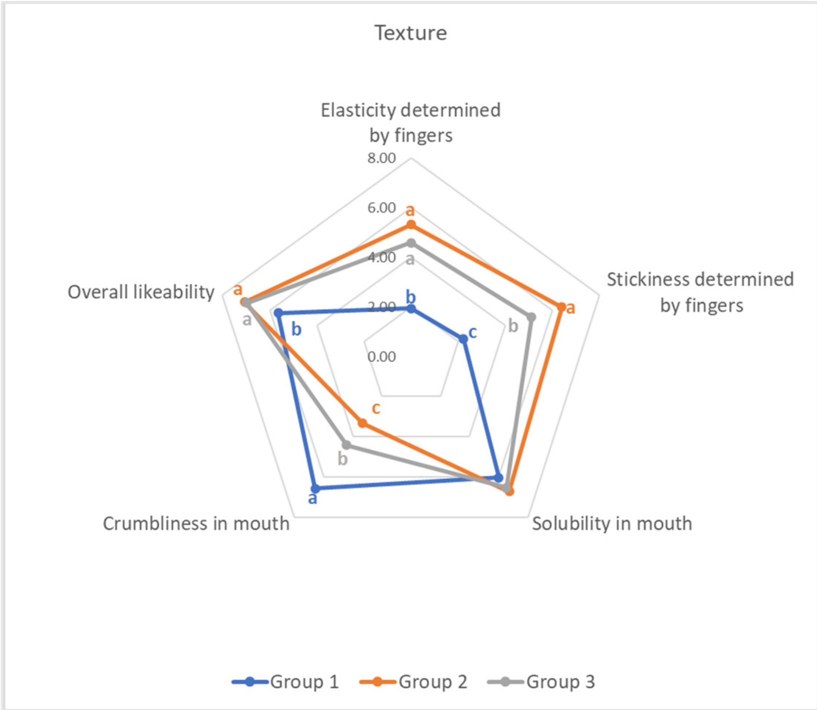

Figure 8. Descriptive sensory scores of the texture of semi-hard goat cheese. Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Different letters referring to the same attribute imply significant difference ($p < 0.05$) between ripening treatments.

The longer ripening in oil (group 2) had a negative effect on the overall likeability of the external appearance, as the color intensity of the rind was significantly ($p < 0.05$) lower compared to the cheeses of groups 1 and 3, which can also be seen in Figure 3. This is in accordance with the scores for color intensity in the cross-section and thickness of the rind, which were significantly lower ($p < 0.05$) compared to the cheeses of groups 1 and 3 (Figure 4). Also, this is clearly visible in Figure 3, which shows that the cheeses of group 2 had the lowest color intensity and rind thickness. In addition, the air-ripened cheeses had the highest color intensity in cross-section and rind thickness, which may be due to the fact that these cheeses had the lowest moisture content compared to the cheeses ripened in oil after 10 or 20 days of ripening in the air [23], and it is well known that greatest moisture loss occurs at the beginning of ripening [23,46,47]. In the study of traditional Serbian goat cheese, the most pronounced changes in cheese color (yellowing) occurred after 14 days of ripening, which was due to moisture loss, the microbiological activity of non-starter lactic acid culture, and complex biochemical processes (proteolysis, lipolysis, and oxidation processes) [48]. The results for the color parameters (yellowness) in the study of *Serrana* goat cheese, which was subjected to a particularly long ripening period, were explained by a slight browning effect typical of cheese ripening [49].

Cheese ripened in oil (groups 2 and 3) had a significantly ($p < 0.05$) higher intensity of an oily odor (Figure 5), which was also manifested in the significantly ($p < 0.05$) higher oily aroma attribute (Figure 6). Although the duration of ripening in oil was different, no significant differences ($p > 0.05$) were found in the oily aroma and odor attributes between the cheeses of groups 2 and 3. The values for the off-flavor, off-odor, and rancid odor and aroma attributes were not higher in groups 2 and 3 than in the control group, but the overall odor likeability score (6.17) was lowest for the cheeses in group 2 which is consistent with the results of our previous research. Cheeses from group 2 had the lowest odor score (1.65), compared to the cheeses from group 1 and group 3 (1.88 and 1.79, respectively) [23]. This can be explained by the longer ripening in oil, which resulted in the most pronounced sour odor ($p < 0.05$). In products where the moisture content is not balanced, various defects can be observed, including excessive sourness [25]. The goat-like odor and aroma, associated with higher levels of short-chain free fatty acids in goat's milk [50], were not affected by the ripening treatment.

Compared to the cheeses ripened in oil, the cheeses in the control group were saltier due to greater moisture loss during ripening (Figure 7). Moisture loss during ripening is a result of microbiological growth, production of lactic acid, and evaporation of water from the cheese [17,24]. A great loss of water is observed, especially in small-sized cheeses, because the surface exposed to the atmosphere is greater, so that the evaporation of water causes the rind to dry out and the water diffuses from the core, leading to the drying of the cheese [26,51,52]. Oil as a ripening medium probably affected biochemical processes in the cheese [23], which improved the overall likeability of the taste (Figure 7). Group 3 had the highest score, which may be related to the greater penetration of the oil into the cheese structure due to the greater water loss caused by the longer ripening time in air before immersion in the oil [23]. This indicates the importance of defining the optimal ripening time in some medium which is also the case for the ripening in the animal skin. A study of Croatian traditional cheese which ripens in a lamb skin ("Sir iz mišine") showed that the optimal ripening time is 45 days, because the intense proteolysis, accumulation of nitrogen fractions, degradation of short-chain fatty acids and accumulation of medium- and long-chain free fatty acids due to the ripening time and specific conditions (high temperatures in the cheese ripening chamber: 16–18 °C; contact material: lambskin) lower sensory scores at longer ripening [8]. Another study showed that the sensory scores of Turkish Tulum cheese started to decrease after 60 days of ripening [53].

The oil-ripened cheeses (groups 2 and 3) were significantly ($p < 0.05$) less crumbly in the mouth than the control group (Figure 8). Table 2 shows that the cheeses of group 1 had significantly ($p < 0.05$) the highest values of load at break parameter. This group had the highest dry matter content [23]. It is known that higher dry matter content can result in protein dehydration and thus a firmer cheese matrix [47]. Comparing the values of load at break between groups 2 and 3, the cheeses of group 3 had significantly ($p < 0.05$) higher values (4.43 and 3.33, respectively), which is in agreement with the scores for crumbliness in the mouth (Figure 8) and can be explained by the fact that a higher moisture content leads to a less firm cheese structure, which was also demonstrated in a study on traditional Majorero goat cheese [47]. Statistical analysis also showed that the sensory perception of crumbliness, the ease with which the cheese breaks down into small particles [54] in mouth, correlated significantly ($p < 0.01$ for cheeses in groups 1 and 2; $p < 0.05$ for cheeses in group 3) with the load at break measured with the texture analyzer (Table 3).

Table 2. Texture parameters of semi-hard goat cheese after 60 days of ripening measured with a texture analyzer.

Parameter	Group			Significance Level
	1	2	3	
Load at break (N)	$45.50^{a} \pm 2.22$	$20.99^{b} \pm 2.20$	$32.50^{c} \pm 2.21$	**
Adhesion force (N)	$-0.31^{a} \pm 0.07$	$-0.86^{b} \pm 0.06$	$-0.54^{ab} \pm 0.07$	*
Elasticity (mm)	$6.94^{a} \pm 0.26$	$9.15^{b} \pm 0.25$	$7.76^{a} \pm 0.26$	**

Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Results are expressed as mean ± standard error. a–c means within a row marked with different letter in superscript differ significantly (* $p < 0.05$, ** $p < 0.01$).

The stickiness determined by fingers was also significantly ($p < 0.05$) higher in the oil-ripened cheeses (groups 2 and 3) than in the control group cheeses due to their higher moisture content [23,54]. The cheeses of group 2 obtained significantly ($p < 0.05$) higher scores for stickiness (6.40) determined by fingers than group 3 cheeses (5.10), which agrees with the results for adhesion force measured with the texture analyzer. For the group 3 cheeses, there was a significant positive correlation ($p < 0.05$) between the adhesion force and the stickiness determined by fingers (Table 3).

Table 3. Correlation coefficients between the descriptive sensory scores of texture and the results of the texture analyzer.

	Load at Break	**Crumbliness in Mouth** Group 1	Group 2	Group 3
Texture analyzer	Group 1	0.801 **	-	-
	Group 2	-	0.613 **	-
	Group 3	-	-	0.513 *
	Adhesion force	**Stickiness Determined by Fingers** Group 1	Group 2	Group 3
	Group 1	0.405	-	-
	Group 2	-	0.143	-
	Group 3	-	-	0.504 *
	Elasticity	**Elasticity Determined by Fingers** Group 1	Group 2	Group 3
	Group 1	0.638 **	-	-
	Group 2	-	0.612 **	-
	Group 3	-	-	0.509 *

Group 1 (control group) = cheese ripened in air (60 days); group 2 = cheese ripened in oil for 50 days after 10 days of ripening in air; group 3 = cheese ripened in oil for 40 days after 20 days of ripening in air. Values marked with asterisk have statistically significant correlation (* $p < 0.05$ and ** $p < 0.01$).

The elasticity determined by fingers was significantly ($p < 0.05$) higher in the oil-ripened cheeses (groups 2 and 3) than in the control group cheeses. Group 2 cheeses had the highest elasticity to a significant extent ($p < 0.01$). Significant correlations ($p < 0.01$ for cheeses of groups 1 and 2; $p < 0.05$ for cheeses of group 3) between elasticity determined by fingers and elasticity measured by the texture analyzer were observed in all treatments (Table 3).

The cheeses of groups 2 and 3 had better scores for the overall texture likeability than the cheeses of the control group. There was no significant difference between the cheeses of groups 2 and 3 for the same parameter. These results are consistent with the results of sensory analysis according to ISO methods in our previous study [23].

In rheology, cheeses are classified according to their moisture content in the non-fat substance, which shows the great influence of moisture content on the textural properties of cheese [47,55]. According to the literature, cheese with a higher moisture content is less firm than cheese with a lower moisture content [54,56], which is attributed to the extent of swelling of casein submicelles with the increase in the casein to moisture ratio. In addition, moisture fills the spaces between fat and protein in the cheese structure and acts as a good lubricant due to its low viscosity. The amount of fat trapped in the paracasein matrix and its physical state have a great influence on the textural properties of cheese [54].

The loss of moisture during ripening in air (groups 2 and 3) before ripening in oil led to the formation of a cheese structure that allowed the penetration of oil into the cheese [23]. Water retention and the penetration of oil into the cheese changed the physicochemical composition of the semi-hard goat cheese, thus affecting its textural properties. Oil as a ripening medium showed moisture-protective properties in the cheese and therefore influenced the cheese texture and sensory profile [23].

4. Conclusions

It can be concluded that preserving goat cheese in oil has a positive effect on its sensory properties. Ripening in oil reduced the thickness of the rind and generally improved the taste, texture, and cross-sectional properties of the cheese. Cheese with a longer ripening time in air before immersion in oil was characterized by a higher level of acceptance in terms of appearance, cross-section, odor, and taste than cheese with a shorter ripening time in air before immersion in oil. Ripening in oil prevented undesirable texture and dryness in the cheese, which not only extends the consumption period when goat milk is not produced but may also prevent excessive food waste. Furthermore, since the correlations between the descriptive sensory scores of texture and the results of the texture analyzer were significant, it can be concluded that the QDA is an excellent tool for the development of cheeses with specific ripening conditions.

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