Hindawi
Journal of Food Quality
Volume 2023, Article ID 9996340, 14 pages
https://doi.org/10.1155/2023/9996340

Research Article

Challenges in Evaluating Quality of the Serbian Traditional Dairy Product Kajmak

Biljana Aleksic,[1,2] **Ilija Djekic**,[1] **Nada Smigic**,[1] **Zorana Miloradovic**,[3] **Nikola Tomic**,[1] **and Jelena Miocinovic**[3]

[1]*Department of Food Safety and Quality Management, University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080, Belgrade, Serbia*
[2]*Dairy Institute, Smolucska 11, 11070, Belgrade, Serbia*
[3]*Department of Animal Source Food Technology, University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080, Belgrade, Serbia*

Correspondence should be addressed to Jelena Miocinovic; jmiocin@agrif.bg.ac.rs

Received 26 June 2023; Accepted 7 September 2023; Published 26 September 2023

Academic Editor: Gianfranco Picone

Kajmak, a traditional Serbian dairy product, is a top, crust layer of milk containing a high amount of aggregated milk fat and proteins, formed during long cooling of boiled milk. Due to variations in production technologies, environmental conditions, and the composition of raw milk which varies from region to region, the quality of kajmak produced traditionally in households is very inconsistent. Attempts to produce kajmak in the industry environment (dairy plants) turned out to be highly challenging in terms of achieving a uniform quality and safety of the product. In order to have a deeper insight into the quality of kajmak produced by the traditional manufacture and the industry, the main objective of the study was to investigate sensorial, physicochemical, and textural properties of kajmak produced in households and dairy plants and distributed through open markets and retail stores, respectively. A total of 36 samples of kajmak were analyzed for thirteen quality characteristics. The results obtained showed a high variability in kajmak quality. The study applied a mathematical calculation of a single total quality index (TQI) that makes all quality attributes comparable. Based on the obtained results, it was determined that kajmak produced in households had a better TQI, which leads to the conclusion that in terms of kajmak quality, the traditional production method is still superior to the industrial one. The correlation between the examined quality characteristics was investigated using Pearson's bivariate correlation analysis and principal component analysis (PCA). By applying PCA, four principal components highlighting the most important quality characteristics were extracted. The results of the study suggest that further research on the quality of this valuable dairy product, as well as government support and investment in the small scale dairy sector, could be beneficial.

1. Introduction

In the Republic of Serbia, about 1,500 million liters of milk is produced annually mainly in small dairy farms [1, 2]. It has been estimated that about 50% of milk remains in households [3, 4], which can be consumed as such or processed into products that significantly increase the value of milk and the profitability of dairy production [2, 5, 6]. The distribution of traditionally produced dairy products is mainly performed through open markets [7–9].

Among dairy products, the traditional Serbian product kajmak is one of the best known representatives of domestic agriculture, characterized by its unique soft creamy texture and special taste [10]. It is also produced in some countries of Southeastern Europe and Asia [11, 12]. Kajmak is a top, crust layer of milk containing a high amount of aggregated milk fat and proteins, formed during long cooling of boiled milk [13]. Historically, kajmak production has been associated with warmer regions and is considered a way to preserve the spontaneously separated milk fat from boiled milk [14]. The traditional production method is shown in Figure 1 [10]. Kajmak is usually consumed fresh (immediately after production or after a ripening period of up to 7 days) or ripened (after a ripening period of up to 30 days at 3–18°C) [10, 15]. It is usually produced in rural households as part of a tradition that has been passed down through generations [10, 16]. Due to the traditional production process, which varies by region, the quality of kajmak is often inconsistent and non-standardized [11, 17]. Both the traditional production method and distribution through open markets have been associated with various food safety risks [18, 19].

The autochthonous microbiota isolated from kajmak [16, 20], the characteristics during ripening under controlled conditions [21], and the nutritional composition [15, 21] have been previously studied. A detailed overview of kajmak's quality and classification has been published previously [10, 11, 22]. The influence of milk composition and heat treatment on the composition of kajmak has been recently studied [23]. Various studies have been conducted on sensory [11, 12], chemical [17, 24], microbiological [11, 21], and textural [12] properties of kajmak. The color of kajmak has also been studied, together with various dairy products [25], as food appearance highly influences consumers in their purchasing decisions [26–28].

Food texture is affected by various factors such as product composition, production technology, and storage temperature [29], and it includes various food properties that can be perceived by mechanical, tactile, and visual senses [27]. Instrumental measurements and sensory evaluations can be used in analyzing the texture of dairy products. Texture profile analysis (TPA) is widely used [26, 29–32] and gives a deep insight into textural characteristics of a product, especially when combined with the evaluation results of trained sensory panels [26, 32].

Although food quality can be determined using objective indices [33], the main constraints in determining the overall quality of food include the inability to define one attribute that is more important than others, and there is no unified system of units in which different food properties can be expressed [34].

Various quality characteristics such as the texture profile, color, microbiological quality, and sensory profile can be quantified and combined into a common overall parameter [35–37]. Such a methodology is suitable for product testing, development, and improvement of products and technologies [38]. As such, it was used to evaluate the quality of extra virgin olive oil [37], different potato cultivars [39], blueberry and cranberry juices and nectars [40], dried apples [35], various mushrooms [34, 36, 41], and cultivated tambaqui [33].

To our knowledge, the determination of kajmak quality through the calculation of TQI has not been applied. Therefore, the objective of this study was to derive TQI of the samples using sensorial, physicochemical, and textural properties of kajmak produced in households and dairy plants and distributed through open markets and retail stores, respectively. Attempts to produce kajmak in the industry environment (dairy plants) turned out to be highly challenging in terms of achieving a uniform quality and safety of the product (Pudja et al., 2007). Therefore, the aim of the present study is to address to this challenge by determining the difference in quality characteristics between products from households and those from dairy plants. Determining the gap, which we hypothesize would exist between the quality of the two groups of kajmak samples, could serve as the basis for optimizing the production process in the industrial scale. It would be a path to place this valuable product to the world market instead of having it only as a food of local significance.

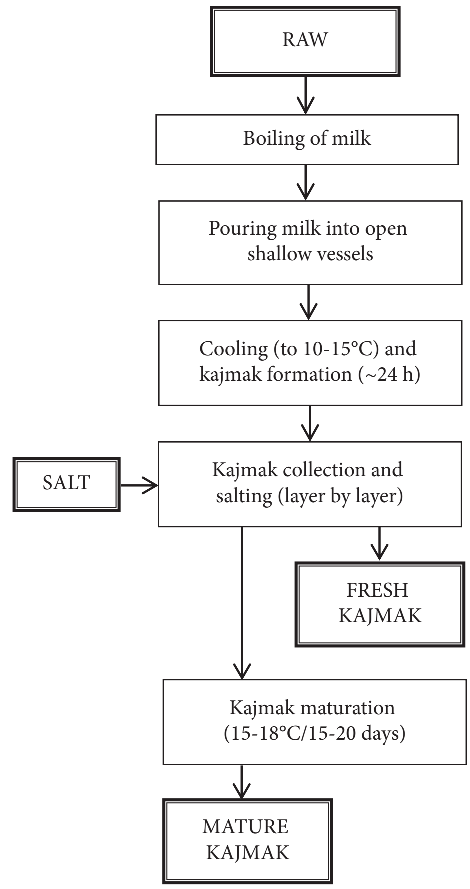

Figure 1: The procedure of traditional kajmak production, according to Pudja et al., 2008.

2. Materials and Methods

In this paper, a mathematical approach is used to calculate a single total quality index (TQI) that makes all quality parameters comparable. A total of 36 samples of kajmak from 18 open markets and 6 retail stores were analyzed. Samples were collected in quantities of 200 grams, packed in PVC containers, labeled, and transported in a cold chain to the laboratory where they were analyzed the same day for texture profile analysis and refrigerated at 4°C or kept frozen (−18°C) for other analysis. Data on the maturity of kajmak were obtained by interviewing sellers at open markets or reading the food labels for products purchased at retail stores. Physicochemical analyses were performed by an accredited laboratory [42] and the Laboratory of Dairy

Technology of the Faculty of Agriculture of the University of Belgrade. TPA analysis was performed at the Laboratory of Food Safety and Quality Management of the Faculty of Agriculture, University of Belgrade.

2.1. Physicochemical Analysis. Composition of kajmak was determined by using the following reference methods: dry matter content (DM) by the drying method [43], milk fat (MF) by the Van Gulik method [44], total protein (TP) by the Kjeldahl method [45], and salt (NaCl) content by the Volhard method [46]. The chemicals of analytical grade were used. Based on composition parameters, the moisture in nonfat substance (MNFS), milk fat in dry matter (FDM), and total protein in dry matter (TP/DM) were calculated.

Equal amounts of kajmak and prewarmed distilled water were mixed for pH determination with precalibrated pH meter Basic 20+ (Crison Instruments, Barcelona, Spain). Water activity was determined using precalibrated AMTAST Water Activity Meter WA-60AB (Amtast USA Inc.) according to the manufacturer's instructions.

2.2. Texture Profile Analysis. Texture profile analysis (TPA) of kajmak was performed using Brookfield CT3 Texture Analyzer (Brookfield Engineering, Middleboro, MA, USA). The tests were performed with an average compression of 50%.

Plastic cups (50 ml) were filled up to 2/3 with kajmak. The samples were analyzed using the normal test mode (single compression cycle) with a TA15/100 45° acrylic cone probe. The testing trigger force was set up at 0.05 N, and the test speed was set at 1.0 mm/s. The probe traveled a set downward distance into the sample (10.0 mm) at a preset test speed of 1.0 m/s. As a result, the following texture characteristics were measured: peak load, deformation at peak, and adhesive force.

2.3. Sensory Analysis. A trained 9-member panel consisted of researchers from the Faculty of Agriculture, University of Belgrade. The panel members were trained in five 1 h training sessions over the period of two weeks, in line with Djekic et al. [47], using kajmak samples of different degrees of ripening in terms of the characteristics and description of quality attributes through various terminologies in sensory assessment. Kajmak was presented to the panelists in random order. Appearance, odor, flavor, and oral texture were rated using a 5-level quality scoring method, where each of the five scores was divided into quarters, resulting in category scale with 20 responses [35]. After evaluation, the samples were rated as follows: excellent quality = 5 (score > 4.5), very good quality = 4 (3.5 < score ≤ 4.5), good quality = 3 (2.5 < score ≤ 3.5), poor/unsatisfactory quality = 2 (1.5 < score ≤ 2.5), and very poor quality = 1 (score ≤ 1.5). The assessors freely chose to swallow or expectorate the samples after testing, and low sodium bottled water and bread were used for rinsing the palate. The sensory tests were performed in the Sensory Testing Laboratory at the Faculty of Agriculture, University of Belgrade.

2.4. Total Quality Index. The total quality index consists of analyzing the "m" number of different quality attributes ($j = 1, \ldots, m$). All quality attributes were divided into three groups by the co-authors of this study, as experts in the field. The Delphi method was used to evoke the opinions of experts, and the consensus without holdouts was achieved [48]. The total quality index was calculated using three basic quality indices (QIs), according to [37, 49].

The quality attributes of the first group were those with a defined target value (T) where the following rule is applied: "the nearer to the target values the attributes are, the better the quality is":

$$\mathrm{QI}_j = \left|\frac{2 * (x_i - T)}{x_{\max} - x_{\min}}\right|, \tag{1}$$

where QI_j is the quality index for the "j" quality attribute, x_i refers to the measured value in the subset of "n" values ($i = 1, \ldots, n$), T is the target value, and $x_{\max}$ and $x_{\min}$ are the maximal and minimal values in the subset of values, respectively. The basic quality index was calculated following this rule for salt content and textural properties (peak load and adhesive force) of kajmak, where T was the mean value of the subset of values for the given attribute.

For the quality characteristics of the second group, the following rule was applied: "the higher its value, the better the quality is," where QI_j was calculated according to the following equation:

$$\mathrm{QI}_j = \left|\frac{x_{\max} - x_i}{x_{\max} - x_{\min}}\right|; x_i \leq x_{\max}, \tag{2}$$

where QI_j is the quality index for the "j" quality characteristic, x_i refers to the measured value in the subset of "n" values, $x_{\max}$ is the maximal value, and $x_{\min}$ is the minimal value. The rule was applied for the physicochemical characteristics such as a_w, pH, DM, MF, TP, MNFS, FDM, and TP/DM.

For the texture quality of the property deformation at peak, the following rule was applied: "the smaller the value is, the better the quality is," using the following equation:

$$\mathrm{QI}_j \frac{x_i}{x_{\max}}, \tag{3}$$

where QI_j is the quality index for the "j" quality property, x_i is the measured value in the subset of "n" values, and $x_{\max}$ refers to the maximal value in the subset of values.

The total quality index (TQI) is represented by all calculated quality indexes (QI_m) as components of a new assumed Euclidean space R^m, where m is the number of quality attributes. All QIs are considered as vectors $\mathrm{QI} = (\mathrm{QI}_1, \mathrm{QI}_2, \ldots, \mathrm{QI}_m) \epsilon R^m$ [50], according to the following equation:

$$\mathrm{TQI} = \sqrt{\sum_{j=1}^{m} \left(\mathrm{QI}_j\right)^2}. \tag{4}$$

For the final interpretation, the "rule of thumb" is that the further from the origin the vector is, the worse is its TQI, and the nearer the origin the vector is, the better is the TQI [37].

2.5. Statistical Analysis. The data were analyzed using IBM SPSS Statistics version 21.0 for Windows (IBM Corporation, Armonk, NY) and Microsoft Office Excel 2010 (Microsoft Corp., Redmond, WA). Physicochemical analyses were performed in two replicates, while texture profile analysis was performed in triplicates.

Sturges' rule was applied in order to group the kajmak samples according to TQI values [51]. One-way analysis of variance (ANOVA) with post hoc Tukey's HSD test was used to determine whether there were statistically significant differences between groups with respect to the quality characteristics. To assess the differences between quality characteristics of kajmak samples with respect to the place of production, the *t*-test was conducted. The statistical significance was set at $p < 0.05$.

Pearson's bivariate correlation analysis was performed to determine the association between the properties of the tested samples. The relationships between observed quality attributes were determined by using principal component analysis (PCA).

3. Results and Discussion

The composition of kajmak depends on numerous factors [5, 10, 17, 23, 52]. In terms of its chemical composition, kajmak belongs to the group of milk fat-based products, since fat is the most abundant ingredient, followed by milk proteins [10]. However, these two components are not directly regulated by quality requirements outlined in current legislation. By law, fresh kajmak should contain at least 60% DM, 65% FDM, no more than 2% of NaCl, and a pH of at least 4.8. Ripened kajmak should contain at least 65% DM, 75% FDM, no more than 3.5% NaCl, and a pH of at least 3.8 [13].

3.1. Quality of Kajmak

3.1.1. Physicochemical Properties. High variability was found in most of the quality characteristics of kajmak (DM, FDM, NaCl, and pH) (Table 1). When the samples were classified by pH, it was found that 88.88% could be classified as fresh kajmak. When classified by DM, most samples met the standard for ripened kajmak (66.67%), similarly was found for FDM (91.67%). It is of note that 11.11% and 2.78% of the samples were below the legal values for the DM and FDM content, respectively, and they were excluded from further analysis (Table 1).

The results of MF content showed a high coefficient of variation (Table 1). The high variability of MF content was also found in other studies [11, 17, 53] and is probably a consequence of the different milk composition, nonstandardized production process, and environmental conditions. It is well known that the most abundant component of DM in kajmak is MF [17, 24], and hence, they were strongly positively correlated ($r = 0.825$, Table 2).

High variability was also observed in the protein level ($CV = 51.77\%$, Table 1) which was in line with previously reported data [52]. It is of note that about 7% of protein is incorporated into the upper kajmak skin, while about 2% of protein is incorporated into the lower kajmak level, which affects the textural properties of the final product [5, 23]. Our results showed a strong negative correlation of TP in relation to MF, while a slightly weaker negative correlation was established in relation to DM (Table 2). This is in line with the results published by Radovanovic et al. [23], where a decrease in protein content of kajmak when increasing fat content was found.

Due to differences in the production process and environmental conditions, the differences in composition and properties of the final product were to be expected and partly explained the differences in the obtained results [10, 17, 54]. Some studies have shown that the greatest variabilities between different brands of kajmak also exist in DM and TP [12]. The composition of raw milk, which is determined by a number of factors [55], significantly affects the protein and fat content, as well as the yield of kajmak [56]. Furthermore, keeping kajmak up to 21 days at 4°C does not affect FDM and TP/DM content, while after 28 days, a significant decrease in TP/DM content occurs. However if the ripening temperature is higher (16°C), after 21 days, FDM content decreases significantly, while TP/DM increases gradually during the 21 days period, and then, after 28 days, it decreases again due to proteolytic changes [24].

Hence, once produced, kajmak undergoes complex biochemical transformations during ripening, depending on the ripening conditions and duration. Therefore, besides the production process and environmental conditions, the level of maturity is highly important factor for its composition and quality.

Regarding NaCl, the values obtained ranged from 0.06 to 3.21. Similar findings have been reported previously [11]. The present study found no significant correlation between NaCl and texture profile characteristics (Table 2). Miocinovic et al. [12] reported that NaCl content ranged from 3.24 to 3.98 in both young and ripened kajmak, while the samples examined by Barać et al. [24] had much lower values. It is of note that the salt content of kajmak depends on the amount of NaCl added during production.

The ripening conditions affect the changes in the pH of kajmak, which could be explained by the activity of the indigenous microbiota remaining after the application of intensive heat treatment and the microbiota originating from the environment [11, 16]. In the present study, the pH value ranged from 4.53 to 6.44, with $CV = 11.14\%$.

With respect to the place of production, statistically significant differences were determined for pH and TP, which were higher for samples produced at households, as well as MF, FDM, and MNFS, where lower values were determined for traditionally manufactured (household) products (Table 3).

3.1.2. Sensory Quality. The results of sensory quality judging are shown in Table 1 and Figure 2. Overall sensory quality scores ranged from 1.24 to 4.97. Of the 31 samples, 12.91% were rated as "excellent," 41.94% as "very good," 25.81% as "good, and" 19.36% as "poor," and there were no "very poor" rated samples (Figure 2). It is known that traditional

Table 1: Overview of total quality of kajmak samples.

Sample codes	Sensory quality: Sensory score	Sensory quality: Sensory quality level	a_w	pH	DM (%)	MF (%)	Salt (%)	TP (%)	MNFS (%)	FDM (%)	TP/DM (%)	PL (g)	DP (mm)	AF (g)	TQI	Group	Place of purchasing/ place of production
1	4.62 (±0.24)	5	0.93 (±0.00)	5.87 (±0.17)	56.77 (±0.02)	46.00	0.83 (±0.85)	8.88 (±0.17)	80.06	81.04	15.64	52.69 (±30.53)	9.90 (±0.06)	18.69 (±0.59)		**E**	OM H
2	3.69 (±0.34)	4	0.90 (±0.01)	6.07 (±0.17)	62.74 (±0.01)	54.00	1.10 (±0.10)	7.36 (±0.28)	81.01	86.08	11.73	89.74 (±48.90)	10.00 (±0.06)	23.11 (±5.03)	2.30	II	OM H
3	4.97 (±0.08)	5	0.92 (±0.02)	6.01 (±0.01)	65.33 (±0.02)	57.00	1.21 (±0.01)	5.65 (±0.85)	80.64	87.26	8.65	153.30 (±92.00)	10.00 (±0.06)	32.63 (±1.77)	2.41	III	OM H
4	3.83 (±0.15)	4	0.91 (±0.01)	5.60 (±0.18)	67.46 (±0.03)	61.00	1.04 (±0.02)	3.93 (±0.04)	83.44	90.42	5.83	225.02 (±131.83)	9.70 (±0.46)	42.15 (±0.59)	3.11	VI	OM H
5	3.75 (±0.47)	4	0.93 (±0.01)	6.13 (±0.07)	68.22 (±0.18)	63.00	0.06 (±0.01)	4.57 (±0.09)	85.89	92.35	6.70	109.79 (±61.48)	10.00 (±0.06)	25.83 (±0.59)		III	OM H
6	1.93 (±0.72)	2	0.90 (±0.00)	5.13 (±0.07)	70.91 (±0.10)	66.00	0.28 (±0.02)	3.59 (±0.17)	85.56	93.08	5.06	135.28 (±77.18)	10.00 (±0.00)	31.27 (±1.56)	2.93	V	OM H
7	4.03 (±0.37)	4	0.94 (±0.00)	6.64 (±0.04)	74.94 (±0.08)	63.00	3.21 (±0.01)	6.62 (±0.15)	67.74	84.07	8.83	73.42 (±43.15)	10.00 (±0.06)	26.85 (±0.59)	2.57	IV	OM H
8	3.88 (±0.27)	4	0.93 (±0.00)	6.28 (±0.12)	62.03 (±0.06)	54.00	0.98 (±0.01)	5.84 (±0.02)	82.54	87.05	9.41	105.37 (±52.56)	10.00 (±0.00)	28.89 (±1.56)	2.28	II	OM H
9	3.86 (±0.37)	4	0.93 (±0.02)	6.43 (±0.01)	66.86 (±0.01)	53.00	0.77 (±0.01)	10.70 (±0.18)	70.51	79.27	16.00	63.56 (±37.64)	10.00 (±0.06)	23.11 (±4.12)	1.88	I	OM H
10	2.14 (±0.52)	2	0.93 (±0.01)	5.14 (±0.05)	61.61 (±0.01)	53.00	0.99 (±0.01)	5.75 (±0.16)	81.68	86.02	9.33	75.12 (±44.72)	10.00 (±0.06)	28.21 (±3.16)	2.53	III	OM H
11	4.68 (±0.22)	5	0.93 (±0.00)	6.59 (±0.07)	56.42 (±0.13)	40.00	2.15 (±0.01)	9.04 (±0.11)	72.63	70.90	16.02	39.77 (±27.74)	9.90 (±0.17)	23.11 (±5.23)		**E**	OM H
12	3.53 (±0.35)	4	0.93 (±0.01)	6.34 (±0.14)	62.32 (±0.22)	40.00	1.23 (±0.00)	8.24 (±0.25)	62.81	64.19	13.22	82.94 (±35.02)	10.00 (±0.00)	28.89 (±5.23)		**E**	OM H
13	3.43 (±0.48)	3	0.92 (±0.00)	6.58 (±0.01)	61.97 (±0.18)	55.00	0.47 (±0.04)	4.50 (±0.49)	84.51	88.75	7.26	133.92 (±80.27)	10.00 (±0.00)	30.93 (±1.56)	2.58	IV	OM H
14	3.26 (±0.54)	3	0.91 (±0.00)	5.97 (±0.08)	65.99 (±0.09)	61.00	0.77 (±0.02)	2.76 (±0.00)	87.22	92.45	4.18	139.02 (±86.62)	10.00 (±0.00)	36.37 (±2.57)	2.91	V	OM H
15	1.24 (±0.52)	1	0.93 (±0.00)	5.07 (±0.06)	55.66 (±0.02)	43.00	0.46 (±0.00)	8.04 (±0.04)	77.80	77.26	14.44	39.09 (±23.19)	9.80 (±0.32)	14.28 (±2.03)		**E**	OM H
16	2.55 (±0.42)	3	0.95 (±0.01)	4.84 (±0.30)	67.94 (±0.04)	64.00	0.29 (±0.01)	2.60 (±0.01)	89.07	94.21	3.83	200.20 (±117.04)	10.00 (±0.00)	28.55 (±6.39)	3.07	VI	R DP
17	2.03 (±0.80)	2	0.91 (±0.01)	5.41 (±0.02)	67.59 (±0.01)	61.00	2.27 (±0.01)	2.67 (±0.21)	83.10	90.25	3.95	141.40 (±81.28)	10.00 (±0.00)	36.71 (±2.69)	3.15	VI	R DP
18	3.81 (±0.24)	4	0.91 (±0.01)	5.00 (±0.09)	75.56 (±0.11)	70.00	0.09 (±0.03)	4.22 (±0.04)	81.48	92.65	5.58	120.67 (±67.33)	10.00 (±0.00)	30.93 (±3.58)	2.68	IV	R DP
19	2.17 (±0.71)	2	0.90 (±0.00)	5.75 (±0.06)	71.03 (±0.11)	62.00	1.13 (±0.01)	2.95 (±0.16)	76.25	87.29	4.15	137.32 (±77.94)	10.00 (±0.00)	37.05 (±1.56)	3.04	VI	R DP
20	3.86 (±0.53)	4	0.92 (±0.00)	4.75 (±0.04)	63.05 (±1.00)	58.00	0.91 (±0.09)	3.10 (±0.08)	87.98	91.99	4.92	105.71 (±62.25)	10.00 (±0.00)	30.93 (±5.13)	2.85	V	R DP

Table 1: Continued.

Sample codes	Sensory quality: Sensory score	Sensory quality: Sensory quality level	a_w	pH	DM (%)	MF (%)	Salt (%)	TP (%)	MNFS (%)	FDM (%)	TP/DM (%)	PL (g)	DP (mm)	AF (g)	TQI	Group	Place of purchasing/place of production
21	2.07 (±0.35)	2	0.90 (±0.01)	5.18 (±0.04)	65.83 (±0.01)	61.00	0.75 (±0.01)	3.20 (±0.15)	87.63	92.67	4.86	109.45 (±60.92)	10.00 (±0.00)	30.59 (±2.69)	2.95	V	R DP
22	3.77 (±0.37)	4	0.91 (±0.00)	4.53 (±0.03)	64.51 (±0.31)	60.00	0.44 (±0.04)	3.12 (±0.00)	88.73	93.01	4.84	122.37 (±92.26)	9.90 (±0.12)	25.49 (±4.67)	2.93	V	R DP
23	3.68 (±0.84)	4	0.90 (±0.01)	5.10 (±0.03)	65.07 (±0.32)	58.00	2.97 (±0.22)	3.15 (±0.10)	83.18	89.14	4.84	76.14 (±41.66)	10.00 (±0.06)	21.75 (±3.58)	3.18	VI	R DP
24	3.16 (±0.43)	3	0.94 (±0.01)	4.62 (±0.18)	68.47 (±0.54)	63.00	0.97 (±0.01)	2.72 (±0.14)	85.23	92.02	3.97	108.43 (±62.84)	10.00 (±0.00)	29.91 (±3.58)	2.84	V	R DP
25	2.48 (±0.43)	2	0.92 (±0.01)	5.37 (±0.04)	65.82 (±0.21)	60.00	1.05 (±0.01)	2.98 (±0.13)	85.46	91.16	4.53	192.73 (±112.06)	10.00 (±0.00)	43.85 (±3.68)	3.20	VI	R DP
26	3.11 (±0.53)	3	0.94 (±0.00)	4.75 (±0.03)	67.98 (±0.18)	63.00	0.67 (±0.00)	2.66 (±0.21)	86.54	92.67	3.91	106.05 (±61.26)	10.00 (±0.06)	32.29 (±2.12)	2.86	V	R DP
27	3.99 (±0.17)	4	0.93 (±0.01)	6.29 (±0.04)	65.31 (±0.02)	48.00	0.96 (±0.05)	14.38 (±0.31)	66.72	73.50	22.02	96.53 (±57.33)	10.00 (±0.00)	28.21 (±3.12)	1.86	I	OM H
28	4.96 (±0.10)	5	0.93 (±0.01)	6.41 (±0.06)	58.81 (±0.02)	45.00	0.60 (±0.01)	10.23 (±0.01)	74.90	76.52	17.40	65.94 (±43.75)	10.00 (±0.06)	20.39 (±3.06)		**E**	OM H
29	4.79 (±0.15)	5	0.93 (±0.01)	5.90 (±0.14)	67.75 (±0.01)	54.00	1.34 (±0.06)	9.23 (±0.07)	70.12	79.71	13.62	63.22 (±41.78)	10.00 (±0.06)	20.39 (±1.02)	2.04	I	OM H
30	4.64 (±0.05)	5	0.91 (±0.58)	4.95 (±0.06)	68.74 (±0.02)	56.00	1.56 (±0.01)	8.39 (±0.22)	71.06	81.47	12.21	72.74 (±43.39)	9.80 (±0.25)	26.17 (±0.59)	2.26	II	OM H
31	3.88 (±0.54)	4	0.94 (±0.00)	6.06 (±0.04)	69.99 (±0.01)	60.00	0.43 (±0.02)	7.47 (±0.16)	75.04	85.73	10.67	76.48 (±43.24)	7.00 (±0.25)	24.13 (±2.36)	1.90	I	OM H
32	4.09 (±0.13)	4	0.95 (±0.00)	6.05 (±0.13)	74.55 (±0.71)	67.00	0.78 (±0.03)	4.64 (±0.42)	77.12	89.87	6.22	65.26 (±37.61)	9.90 (±0.06)	19.71 (±2.12)	2.39	III	OM H
33	4.90 (±0.14)	5	0.95 (±0.01)	6.36 (±0.04)	72.91 (±0.02)	65.00	0.43 (±0.01)	4.35 (±0.02)	77.41	89.16	5.97	60.16 (±40.58)	9.90 (±0.06)	19.37 (±1.02)	2.46	III	OM H
34	2.14 (±0.84)	2	0.93 (±0.00)	6.07 (±0.01)	63.50 (±0.04)	52.00	1.16 (±0.01)	6.57 (±0.11)	76.05	81.90	10.35	48.61 (±27.56)	10.00 (±0.06)	14.62 (±0.59)	2.56	IV	OM H
35	2.99 (±0.26)	3	0.94 (±0.00)	5.51 (±0.11)	81.34 (±0.06)	76.00	0.49 (±0.02)	3.34 (±0.02)	77.75	93.43	4.11	38.07 (±22.01)	10.00 (±0.06)	14.96 (±2.36)	2.82	V	R DP
36	2.47 (±0.45)	2	0.94 (±0.00)	5.85 (±0.07)	70.98 (±0.01)	63.00	1.19 (±0.01)	3.65 (±0.01)	78.45	88.76	5.14	51.67 (±31.60)	9.80 (±0.32)	17.68 (±2.76)	2.71	IV	R DP
Mean	3.46		0.92	5.68	66.55	57.64	1.00	5.59	79.54	86.31	8.59	99.37	9.88	26.98			
Min	1.24		0.90	4.53	55.66	40.00	0.06	2.60	62.81	64.19	3.83	38.07	7.00	14.28	1.86		
Max	4.97		0.95	6.64	81.34	76.00	3.21	14.38	89.07	94.21	22.02	225.02	10.00	43.85	3.20		
CV	28.72		1.64	11.14	8.31	14.11	70.40	51.77	8.52	8.31	55.91	46.28	5.05	27.07			

a_w, water activity; DM, dry matter; MF, milk fat; TP, total protein; MNFS, moisture in nonfat substance; FDM, fat in dry matter; TP/DM, total protein in dry matter; PL, peak load; DP, deformation at peak; AF, adhesive force; TQI, total quality index; H, household, OM, open market; R, retail store; DP, small dairy plant; E, excluded from further analysis; CV, coefficient of variation.

Table 2: The correlation between examined quality characteristics of kajmak samples.

	a_w	pH	DM (%)	MF (%)	Salt (%)	TP (%)	MNFS (%)	FDM (%)	TP/DM (%)	Sensory quality score	PL (g)	DP (mm)	AF (g)
a_w	1												
pH	0.244	1											
DM (%)	0.328	0.032	1										
MF (%)	0.176	−0.281	**0.825** **	1									
Salt (%)	−0.167	0.112	−0.059	−0.240	1								
TP (%)	0.138	**0.506** **	−0.148	**−0.638** **	0.094	1							
MNFS (%)	−0.264	**−0.562** **	−0.306	0.282	**−0.351** *	**−0.796** **	1						
FDM (%)	−0.097	**−0.523** **	0.210	**0.725** **	−0.323	**−0.930** **	**0.856** **	1					
TP/DM (%)	0.101	**0.493** **	−0.246	**−0.706** **	0.086	**0.994** **	**−0.744** **	**−0.930** **	1				
Sensory quality score	0.211	0.313	0.070	−0.155	0.058	**0.444** *	**−0.394** *	−0.343	**0.415** *	1			
PL (g)	−0.337	−0.263	−0.252	0.059	−0.161	**−0.387** *	**0.556** **	**0.415** *	**−0.356** *	−0.197	1		
DP (mm)	−0.185	−0.121	−0.104	−0.013	0.142	−0.158	0.170	0.095	−0.131	−0.130	0.108	1	
AF (g)	**−0.445** *	−0.237	−0.265	−0.029	0.002	−0.308	**0.416** *	0.284	−0.280	−0.219	**0.854** **	0.096	1

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). a_w, water activity; DM, dry matter; MF, milk fat; TP, total protein; MNFS, moisture in nonfat substance; FDM, fat in dry matter; TP/DM, total protein in dry matter; PL, peak load; DP, deformation at peak; AF, adhesive.

Table 3: Quality characteristics of kajmak with respect to the place of production.

Place of production	N	Sensory score	a_w	pH	DM (%)	MF (%)	Salt (%)	TP (%)	MNFS (%)	FDM (%)	TP/DM (%)	PL (g)	DP (mm)	AF (g)
Household	18	3.73 $(\pm 0.90)^a$	0.93 (±0.02)	5.98 $(\pm 0.49)^a$	67.27 (±4.20)	57.89 $(\pm 5.50)^b$	0.97 (±0.68)	6.46 $(\pm 2.86)^a$	78.01 $(\pm 6.59)^b$	86.01 $(\pm 5.25)^b$	9.67 $(\pm 4.40)^a$	99.25 (±44.30)	9.79 (±0.70)	26.78 (±6.59)
Dairy plant	13	2.93 $(\pm 0.69)^b$	0.92 (±0.02)	5.13 $(\pm 0.43)^b$	68.86 (±4.99)	63.00 $(\pm 4.97)^a$	1.02 (±0.80)	3.10 $(\pm 0.45)^b$	83.91 $(\pm 4.33)^a$	91.48 $(\pm 2.50)^a$	4.51 $(\pm 0.56)^b$	116.17 (±46.77)	9.98 (±0.06)	29.28 (±7.94)

Results are presented as the mean ± standard deviation, $n = 31$. Means in the same column with different letters are significantly different ($p < 0.05$). a_w, water activity; DM, dry matter; MF, milk fat; TP, total protein; MNFS, moisture in nonfat substance; FDM, fat in dry matter; TP/DM, total protein in dry matter; PL, peak load; DP, deformation at peak; AF, adhesive force.

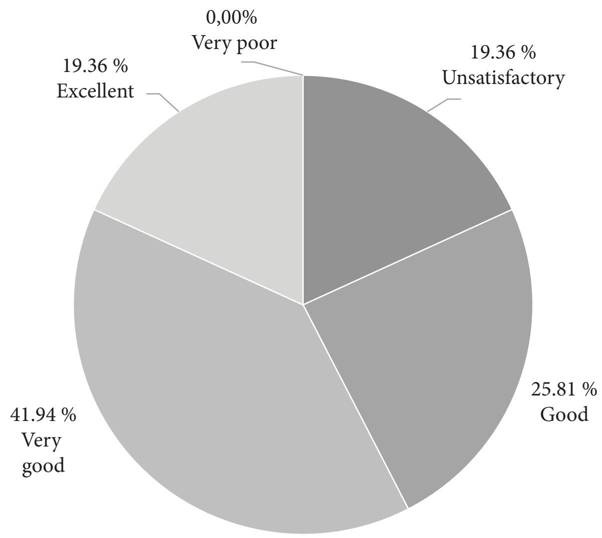

Figure 2: Sensory quality of kajmak samples.

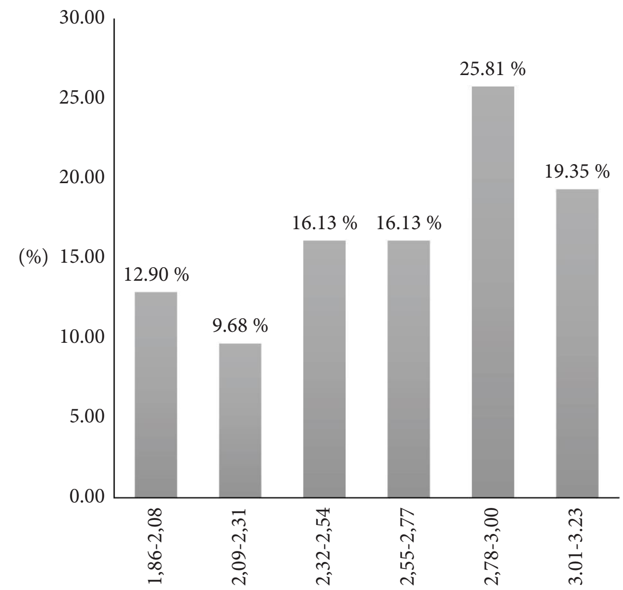

Figure 3: Frequencies of kajmak samples classified according to TQI.

production is often associated with uncontrolled hygienic conditions and nonstandardized production, which leads to expected variations in the quality properties of kajmak. However, the sensory panel gave the advantage to household produced kajmak (Tables 1 and 3). It should be emphasized that illegal adulteration of kajmak with vegetable fats (margarine) was found during sensory analysis even in samples produced in dairy plants. Therefore, further research could be conducted to determine the methods for combating adulteration of this valuable traditional dairy product. Some kajmak samples were found to have undesirable sensory characteristics, such as an unpleasant odor and/or taste, and an atypical texture.

A statistically significant positive correlation was found between sensory quality scores and pH, TP/DM, and TP content, while MNFS content was negatively correlated with sensory scores (Table 2).

This suggests that the protein profile of kajmak, as well as the biochemical changes leading to the changes in pH during ripening, is important for sensory quality. Bearing in mind that kajmak is considered a delicacy whose specificity is based on traditional production, by which a unique sensory quality is achieved, and the support of the authorities and investments in the dairy sector could be beneficial.

3.1.3. Textural Properties of Kajmak. The textural properties of artisanal dairy products are unique and depend on several parameters, such as rheological properties, maturity, processing, and chemical parameters [12, 32]. It has been reported that the texture of the product of different maturity levels differs and that fresh kajmak has a soft, creamy texture, good spreadability, a flat body, and a gelatinous structure. The mature product not only has a firmer granular texture but also has better spreadability due to the destruction of the protein structure during ripening [12, 22].

In this study, several textural characteristics were investigated. The peak load is represented as hardness/strength, defined as the maximum measured load during the test. Hardness as a mechanical property of a material is considered an intensive property of the same and is independent of the size of the object [57]. It is a maximum force required to compress food between teeth (molars) and maintain a certain deformation. Products with poor spreadability have high hardness values [58]. The results (Table 1) showed that the tested samples were very uneven with respect to hardness.

The influence of DM and MF on food hardness has been found in products such as kajmak and cottage cheese [12, 59]. Some studies have shown that higher content of saturated fatty acids leads to higher hardness values in butter [31]. A positive Pearson's correlation was determined for MF, MNFS, and FDM, while TP was negatively correlated with the kajmak peak load (Table 2). Biochemical changes that occur during ripening lead to the appearance of a firmer structure [12].

Adhesive force refers to the energy and force required to separate a probe from the sample during the return stroke being the work required to overcome the forces of attraction between the surface of the food and other surfaces that come into contact with the food during consumption, e.g., teeth, tongue, and palate [60]. It was positively correlated with MF content but not significantly, while there was a statistically significant positive correlation with MNFS. The proportion of protein in dry matter was negatively correlated with adhesive force. When compared to the studies on the adhesiveness of various dairy products, the present study was in line with those in which a positive correlation between fat content and adhesiveness was observed in various dairy products [31, 61], while other authors reported that cheeses with lower fat content had higher adhesive strength [62].

It is of note that at the level of statistical significance, no difference was found between kajmak produced in an industrial (dairy plants) and household environment (Table 3) in terms of texture profile characteristics.

Table 4: Quality characteristics of different groups of kajmak.

Groups	Group interval according to TQI	n	Sensory score	a_w	pH	DM (%)	MF (%)	Salt (%)	TP (%)	MNFS (%)	FDM (%)	TP/DM (%)	PL (g)	DP (mm)	AF (g)
I	1.86–2.08	4	4.13 $(\pm 0.44)^{a}$	0.93 (±0.00)	6.17 $(\pm 0.24)^{a}$	67.48 (±1.96)	53.75 $(\pm 4.92)^{b}$	0.88 (±0.38)	10.45 $(\pm 2.94)^{a}$	70.60 $(\pm 3.42)^{c}$	79.55 $(\pm 5.00)^{c}$	15.58 $(\pm 4.82)^{a}$	74.95 $(\pm 15.66)^{b}$	9.25 (±1.50)	23.96 (±3.24)
II	2.09–2.31	3	4.07 $(\pm 0.50)^{a}$	0.91 (±0.02)	5.77 $(\pm 0.72)^{bc}$	64.50 (±3.69)	54.67 $(\pm 1.15)^{ab}$	1.21 (±0.31)	7.20 $(\pm 1.28)^{b}$	78.20 $(\pm 6.23)^{abc}$	84.87 $(\pm 2.98)^{bc}$	11.12 $(\pm 4.82)^{ab}$	89.28 $(\pm 16.32)^{ab}$	9.93 (±0.12)	26.06 (±2.89)
III	2.32–2.54	5	3.97 $(\pm 1.15)^{ab}$	0.94 (±0.01)	5.94 $(\pm 0.47)^{b}$	68.52 (±5.33)	61.00 $(\pm 5.83)^{a}$	0.69 (±0.46)	4.99 $(\pm 0.66)^{bc}$	80.55 $(\pm 3.59)^{abc}$	88.93 $(\pm 2.44)^{ab}$	7.37 $(\pm 4.82)^{bc}$	92.73 $(\pm 39.00)^{ab}$	9.96 (±0.05)	25.15 (±5.67)
IV	2.55–2.77	5	3.18 $(\pm 0.83)^{bc}$	0.93 (±0.01)	6.03 $(\pm 0.67)^{b}$	69.39 (±6.35)	60.60 $(\pm 7.16)^{a}$	1.22 (±1.20)	5.11 $(\pm 1.39)^{bc}$	77.65 $(\pm 6.39)^{bc}$	87.23 $(\pm 4.26)^{b}$	7.43 $(\pm 4.82)^{bc}$	85.66 $(\pm 39.47)^{b}$	9.96 (±0.09)	24.20 (±7.61)
V	2.78–3.00	8	3.02 $(\pm 0.70)^{c}$	0.92 (±0.02)	5.06 $(\pm 0.50)^{c}$	68.51 (±5.73)	63.50 $(\pm 5.58)^{a}$	0.66 (±0.24)	3.06 $(\pm 0.33)^{c}$	85.83 $(\pm 3.47)^{a}$	92.67 $(\pm 0.51)^{a}$	4.48 $(\pm 4.82)^{c}$	108.05 $(\pm 31.20)^{ab}$	9.99 (±0.04)	28.98 (±6.40)
VI	3.01–3.23	6	2.79 $(\pm 0.77)^{c}$	0.92 (±0.02)	5.35 $(\pm 0.33)^{bc}$	67.49 (±2.07)	61.00 $(\pm 2.00)^{a}$	1.46 (±0.98)	3.05 $(\pm 0.48)^{c}$	83.42 $(\pm 4.19)^{ab}$	90.41 $(\pm 2.30)^{ab}$	4.52 $(\pm 4.82)^{c}$	162.14 $(\pm 54.37)^{a}$	9.95 (±0.12)	35.01 (±8.41)

Results are presented as the group mean ± standard deviation, $n = 31$. Means in the same column with different letters are significantly different ($p < 0.05$). a_w, water activity; DM, dry matter; MF, milk fat; TP, total protein; MNFS, moisture in nonfat substance; FDM, fat in dry matter; TP/DM, total protein in dry matter; PL, peak load; DP, deformation at peak; AF, adhesive force.

3.1.4. Total Quality Index of Kajmak. TQI scores were calculated to evaluate the overall quality of the tested samples. Kajmak samples were ranked and classified into six groups (Tables 1 and 2, Figure 3).

TQI ranged from 1.86 to 3.20 showing that the best TQIs were obtained for the following samples: 27 (1.86), 9 (1.88), 31 (1.90), and 29 (2.04). The worst scores were determined for samples 25 (3.20), 23 (3.18), 17 (3.15), 4 (3.11), 16 (3.07), and 19 (3.04). It is noteworthy that the best-scored samples were purchased in open markets as household produced kajmak, while this was the case for only one of the worst-scored samples (Table 1).

By analyzing the obtained values for each quality attribute of the samples, it can be concluded that the best-ranked samples had a higher TP and that it was significantly lower in the worst-ranked samples. The best-rated samples had lower values than the worst-rated samples for MF, which was also observed for FDM. When the results were analyzed after kajmak was classified into groups, statistically significant differences ($p < 0.05$) were found for both properties, TP and MF (Table 4).

The quality of kajmak is also determined by pH, which was higher in the best-ranked samples (5.99–6.44) than in the worst-ranked ones (4.84–5.75) (Table 1). For pH, a statistically significant difference was found between kajmak groups (Table 4).

For texture quality characteristics, the highest values for the peak load were observed for the worst-ranked samples, while no pattern was observed for other characteristics, although the highest values for adhesive force occurred for two out of the six worst-scored samples (Table 1). Differences between groups were found only for hardness at the level of statistical significance (Table 4).

For many years, the standardization and improvement of kajmak production were a unique challenge. Attempts to industrialize production did not have a positive effect, as resulting products differed significantly from traditional products in terms of sensory characteristics and/or quality [11, 21]. Therefore, it is necessary to define the key quality parameters and steps of the production process that would help obtain a product of uniform quality.

3.1.5. Principal Component Analysis. The quality characteristics that significantly distinguished the kajmak samples were subjected to principal component analysis. The results are shown in Figure 4 and Table 5. Four principal components were extracted, accounting for 86.1% of the total variance (Table 5). Loading values greater than 0.62 were considered large enough to be of significance for explanation of the correlation between PCs and kajmak quality attributes (Table 5) [63].

The first principal component (PC1) was strongly correlated with the sensory quality score, pH, TP, TP/DM, FDM, and MNFS, while DM and MF showed a strong correlation with PC2. The third principal component (PC3) will be referred to as the "salt" axis since it was strongly correlated only with the salt content. By analogy, the fourth principal component was named the "instrumental texture" axis due to a strong correlation with evaluated texture characteristics (Table 5).

Table 5: Overview of the extracted principal components: percentage of variance and attribute loadings.

Quality characteristics	PC1	PC2	PC3	PC4
% of variance	38.81	18.51	10.58	18.17
% of cumulative variance	38.81	57.32	67.89	86.06
Sensory score	**0.640**	0.219	−0.161	0.029
pH	**0.690**	0.106	0.057	−0.057
DM	0.001	**0.946**	0.031	−0.207
MF	−0.496	**0.851**	−0.134	−0.020
Salt	0.117	−0.054	**0.963**	−0.015
TP	**0.908**	−0.258	−0.013	−0.216
MNFS	**−0.827**	−0.186	−0.323	0.332
FDM	**−0.857**	0.326	−0.250	0.231
TP/DM	**0.884**	−0.353	−0.026	−0.198
PL	−0.257	−0.088	−0.121	**0.917**
AF	−0.183	−0.121	0.078	**0.927**

Extraction method: principal component analysis
Rotation method: varimax with Kaiser normalization (eigenvalue >1)
The variables with large loading values (≥|0.62|) marked with font style bold are considered large enough to be practically significant for explanation of the correlation between PCs and kajmak quality attributes

DM, dry matter; MF, milk fat; TP, total protein; MNFS, moisture in nonfat substance; FDM, fat in dry matter; TP/DM, total protein in dry matter; PL, peak load; AF, adhesive force.

Distribution of the kajmak samples along PC1 and PC2 is presented in Figure 4(a). The samples with the lowest TQIs (groups I and II) are positioned in the positive side of PC1, while the left quadrants of the biplot are occupied by the projections of samples with higher TQIs (the majority of the samples belonging to groups V and VI). In addition, it can be seen that the samples positioned in the first and fourth quadrant diverge from zero at PC2 in both directions, which indicates greater variability in terms of MF and DM, while the left half of the coordinate system is occupied by samples more uniform in terms of these characteristics (Figure 4(a)).

The second biplot (Figure 4(b)) shows that the harder texture and higher adhesiveness were pronounced in the worst quality samples (group VI and the majority of the samples within group V). Although the majority of the tested samples appeared in the negative side of PC3 indicating saltiness lower than the average values determined in the study, it can be concluded that the samples with a lower TQI had a salt content close to the mean value determined in the study and were less salty than the samples with the highest TQIs (group VI) (Figure 4(b)).

This multivariate approach showed that the better quality of kajmak is related to pH closer to neutral, higher total protein content, lower fat and moisture in dry matter content, smaller hardness and adhesiveness, as well as moderate salt content.

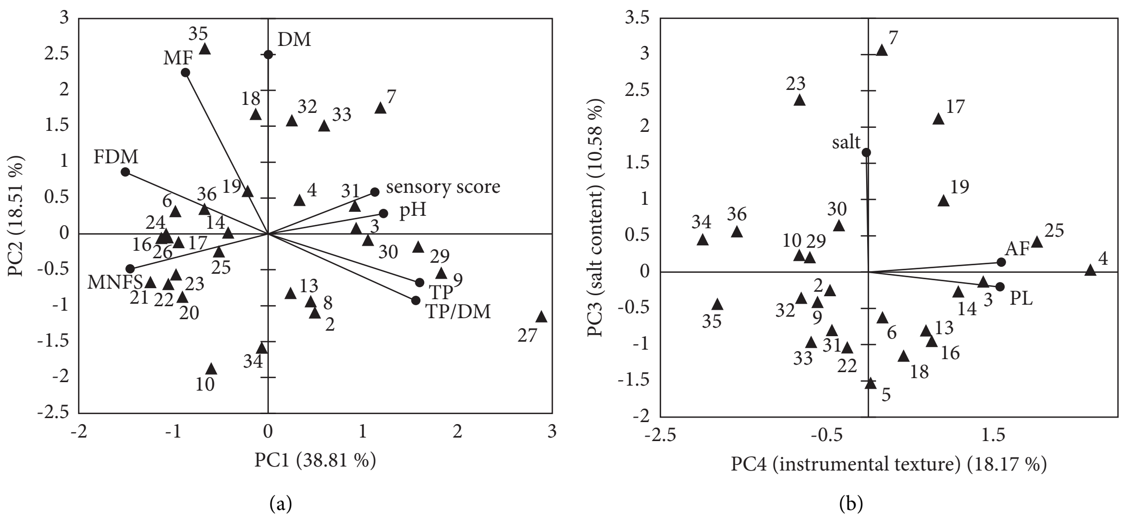

Figure 4: Biplots of the first four principal components obtained by applying principal component analysis on 11 physicochemical, texture, and sensory data of kajmak samples. The four extracted components explained 86.1% of total variance. The samples are marked with numbers. Attribute abbreviations are shown in Tables 1–5.

4. Conclusion

The objective of the study was to examine the quality parameters of kajmak in a short dairy supply chain, with the aim to determine the quality of this product, which would contribute to its better standardization. The kajmak samples studied showed very inconsistent quality for most of the examined parameters. The values for the mandatory quality parameters (DM and FDM) were lower than the legally prescribed values in 11.11% and 2.78% of the samples, respectively, most probably due to the nonstandardized production process at the household level.

In order to evaluate the overall quality of this product, a mathematical index of TQI was proposed in the study. On the basis of the calculated TQI, kajmak samples were divided into six groups, which significantly differ with respect to the following parameters: sensory evaluation, pH, total protein, moisture in nonfat substance, total protein in dry matter, and hardness.

The obtained results have shown that the samples with the best TQIs were produced in households and sold in open markets. The sensorial quality of kajmak produced in households was also evaluated with higher scores, indicating the uniqueness of traditional production methods. It was found that the protein profile of kajmak has great importance in the overall quality, and statistically significant differences were found for TP when the results were analyzed both, with respect to TQI classification and place of production. Hence, further research on the quality parameters of this specific dairy product could be required.

During the sensory evaluation, illegal adulteration of kajmak with vegetable fats was found even in samples produced in an industrial environment; therefore, further research could be carried out to determine methods for detecting the adulteration of kajmak. When it comes to the textural profile of kajmak, no statistically significant differences were found between the samples produced by traditional household procedures and those produced industrially.

Pearson's bivariate correlation analysis and PCA were used to determine the correlations between the studied quality parameters. The obtained results showed that the most important quality characteristics related to the overall quality of kajmak can be extracted by using PCA. Each of the quality attributes subjected to PCA had at least one loading value than could be considered to be of great significance, explaining the correlation between PCs and kajmak quality characteristics.

This study confirms the practical application of the TQI as a simple mathematical tool for calculating total quality without limitation on the number of quality attributes. One limitation of the study is that none of the quality attributes used to calculate TQI were assigned with a weighting factor.

The study contributes to the evaluation of the quality of kajmak but also to the determination of differences in quality that could be related to different production environments. Therefore, further research on the quality parameters of this specific dairy product could be beneficial.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Biljana Aleksic was responsible for conceptualization, investigation, methodology, visualization, statistical analysis, and writing of the original draft. Ilija Djekic was responsible for methodology, writing of the review, and editing. Nada Smigic was responsible for writing of the review and editing. Zorana Miloradovic was responsible for writing of the review and editing. Nikola Tomic was responsible for statistical analysis, writing of the review, and editing. Jelena Miocinovic was responsible for investigation, methodology, visualization, writing of the review, and editing.

References

[1] PBC, *Statistical Yearbook Of the Republic of Serbia*, PBC, Serbia, 2021.

[2] V. Tomić, D. Milić, and D. Janković, "Economic aspects of milk production and traditional dairy products on agricultural farms in the Republic of Serbia," *Ekonomika Poljoprivrede*, vol. 67, no. 3, pp. 881–893, 2020.

[3] B. Drašković, Z. Rajković, and D. Kostić, "Milk production in Serbia and the position of small farmers (in Serbian)," *Agricultural Economics*, vol. 4, 2010.

[4] B. Vlahovic, I. Mugosa, A. Puskraic, and D. Uzar, *Improvemnt of Cheese Production and Distribution (in Serbian)*, Faculty of Agriculture University of Novi Sad, Novi Sad, Serbia, 2018.

[5] M. Najib, M. W. Hallab, K. Hallab, and Z. Hallab, "Thermal processing of milk as a main tool in the production of Qishta, Khoa and Kajmak," *Jmaterenvironsci.Com*, vol. 11, no. 2, pp. 294–309, 2020.

[6] A. Popović Vranješ, S. Krstović, A. Kasalica et al., "Quality of milk for cheese production on registered agricultural holdings in vojvodina," *Contemporary Agriculture*, vol. 66, no. 3–4, pp. 32–37, 2017.

[7] M. Bugarčić and J. Bugarčić, "Influence of kajmak as a cultural asset on the growth of the tourist offer of western Serbia," *Tourism in Function of Development of the Republic of Serbia*, Tisc, Serbia,pp. 415–430, 2019.

[8] M. Jovanović, B. Bulatović, and A. Despotović, "Dairy farming integration into Europe," *Biotehnologija u stocarstvu*, vol. 21, no. 1-2, pp. 123–132, 2005.

[9] G. Petković and D. Užar, "Marketing channels in value creation and delivery of cheese in the Republic of Serbia," *Anali Ekonomskog Fakulteta u Subotici*, vol. 56, no. 43, pp. 101–115, 2020.

[10] P. Pudja, J. Djerovski, and M. Radovanović, "An autochthonous Serbian product kajmak Characteristics and production procedures Kajmak characteristics and production procedures," *Dairy Science and Technology*, vol. 88, no. 2, pp. 163–172, 2008.

[11] J. Djerovski, Z. Radulović, D. Radin, M. Radovanović, and P. Pudja, "The research of kajmak quality: chemical, microbiological and sensory aspect (in Serbian)," *Prehrambena industrija mleko i mlečni proizvodi*, vol. 1-2, pp. 25–28, 2006.

[12] J. Miocinovic, Z. Miloradovic, Z. Radulovic et al., "The composition and properties of kajmak from different producers," in *Proceedings of the 22nd International Scientific-Expert Conference of Agriculture and Food Industry*, vol. 28, pp. 329–331, Sarajevo, Bosnia and Herzegovina, October, 2011.

[13] Official Gazette of The Republic of Serbia, "Ordinance on the quality of milk products and starter cultures," Official Gazette of The Republic of Serbia, Belgrade, Serbia, No.33/2010, 2014.

[14] J. Djordjevic, "Kajmak the issue of classification and quality regulations (in Serbian)," *Mlekarstvo*, vol. 28, no. 6, pp. 137–140, 1978.

[15] D. Milićević, J. Pleadin, S. Janković et al., "Characterization and nutritional assessment of traditional dairy products from the Zlatibor region, Republic of Serbia," *Veterinarska Stanica*, vol. 53, no. 1, pp. 17–32, 2021.

[16] N. Jokovic, M. Nikolic, J. Begovic, B. Jovcic, D. Savic, and L. Topisirovic, "A survey of the lactic acid bacteria isolated from Serbian artisanal dairy product kajmak," *International Journal of Food Microbiology*, vol. 127, no. 3, pp. 305–311, 2008.

[17] Z. Mijačević and L. Babić, "Production technology of kajmak (cream)and some problems of quality standardization (in Serbian)," *Mljekarstvo*, vol. 40, no. 2, pp. 43–51, 1990.

[18] S. Bulajic, S. Colovic, D. Misic et al., "Enterotoxin production and antimicrobial susceptibility in Staphylococci isolated from traditional raw milk cheeses in Serbia," *Journal of Environmental Science and Health, Part B Part B Pesticides, Food Contaminants, and Agricultural Wastes*, vol. 52, no. 12, pp. 864–870, 2017.

[19] G. F. Fonseca, A. A. S. Helena, J. T. M. Oliveira et al., "Occurrence of *Escherichia coli* and *Staphylococcus aureus* in artisanal minas resh cheeses produced in the rural area of the Baixada Fluminense region, provinde of Rio de Janeiro, Brazil," *World Journal of Pharmacy and Pharmaceutical Sciences*, vol. 9, no. March, pp. 492–503, 2020.

[20] N. Joković, J. Rajković, K. Veljović, and M. Tolina, "Screening of lactic acid bacteria isolated from Serbian kajmak for use in starter cultures," *Biologica Nyssana*, vol. 5, no. September, pp. 37–46, 2014.

[21] D. Radin, J. Djerovski, Z. Radulovic, M. Radovanovic, and P. Pudja, *Maturation of Kajmak [under] Controlled Conditions*, Mleko i mlečni proizvodi, Novi Sad, Serbia, 2005.

[22] P. Pudja, M. Radovanovic, and J. Djerovski, "A study on classification and characteristics of kajmak (in Serbian)," *Food industry milk and milk products*, vol. 16, pp. 1-2, 2005.

[23] M. Radovanovic, P. Pudja, V. Pavlovic, J. Miocinovic, and A. Nedeljkovic, "Microstructure of kajmak skin layer made during kajmak production," *Mljekarstvo*, vol. 70, no. 3, pp. 150–161, 2020.

[24] M. Barać, T. Vučić, B. Špirović-Trifunović, N. Barać, and M. Smiljanić, "Protein and fatty acid profiles of Kajmak ripened at two different temperatures," *Food Science and Technology*, vol. 42, 2022.

[25] B. Milovanovic, V. Tomovic, I. Djekic et al., "Colour assessment of milk and milk products using computer vision system and colorimeter," *International Dairy Journal*, vol. 120, Article ID 105084, 2021.

[26] M. A. Drake, P. D. Gerard, V. D. Truong, and C. R. Daubert, "Relationship between instrumental and sensory measurements of cheese texture," *Journal of Texture Studies*, vol. 30, no. 4, pp. 451–476, 1999.

[27] E. Allen Foegeding, J. Brown, M. A. Drake, and C. R. Daubert, "Sensory and mechanical aspects of cheese texture," *International Dairy Journal*, vol. 13, no. 8, pp. 585–591, 2003.

[28] B. Milovanovic, I. Djekic, J. Miocinovic et al., "What is the color of milk and dairy products and how is it measured?" *Foods*, vol. 9, no. 11, pp. 1629–1717, 2020.

[29] J. Wang and L. Li, "Comparative study of chemical composition and texture profile analysis between camembert cheese and Chinese sufu," *Biotechnology Frontier*, vol. 1, no. 1, pp. 1–8, 2012.

[30] B. Sobti, A. O. A. A. Katheeri, S. Ghnimi, and A. K. Eldin, "Compositional analysis of Chami cheese made from bovine milk in UAE," *Emirates Journal of Food and Agriculture*, vol. 33, no. 1, pp. 87–92, 2021.

[31] S. Pădureţ, "The effect of fat content and fatty acids composition on color and textural properties of butter," *Molecules*, vol. 26, no. 15, p. 4565, 2021.

[32] Y. Zheng, Z. Liu, and B. Mo, "Texture profile analysis of sliced cheese in relation to chemical composition and storage temperature," *Journal of Chemistry*, vol. 2016, Article ID 8690380, 10 pages, 2016.

[33] W. S. C. Araújo, C. L. S. De Lima, M. R. S. Peixoto Joele, and L. D. F. H. Lourenço, "Development and application of the quality index method (QIM) for farmed tambaqui (*Colossoma macropomum*) stored under refrigeration," *Journal of Food Safety*, vol. 37, no. 1, Article ID e12288, 2017.

[34] I. Djekic, J. Vunduk, I. Tomasević et al., "Total quality index of Agaricus bisporus mushrooms packed inmodified atmosphere," *Journal of the Science of Food and Agriculture*, vol. 97, no. 9, pp. 3013–3021, 2016.

[35] I. Djekic, N. Tomic, S. Bourdoux et al., "Comparison of three types of drying (supercritical CO2, air and freeze) on the quality of dried apple quality index approach," *Lwt*, vol. 94, pp. 64–72, 2018.

[36] A. Doroški, A. Klaus, M. Kozarski et al., "The influence of grape pomace substrate on quality characterization of *Pleurotus ostreatus* total quality index approach," *Journal of Food Processing and Preservation*, vol. 45, no. 1, 2021.

[37] E. Finotti, A. M. Bersani, and E. Bersani, "Total quality indexes for extra-virgin olive oils," *Journal of Food Quality*, vol. 30, no. 6, pp. 911–931, 2007.

[38] P. J. Molnár, "A model for overall description of food quality," *Food Quality and Preference*, vol. 6, no. 3, pp. 185–190, 1995.

[39] E. Finotti, E. Bersani, V. Vivanti, and M. Friedman, "Application of a functional mathematical quality index to asparagine, free sugar and phenolic acid content of 20 commercial potato varieties," *Journal of Food Quality*, vol. 34, no. 1, pp. 74–79, 2011.

[40] A. Režek Jambrak, M. Šimunek, and I. Djekić, "Total quality index of ultrasound-treated blueberry and cranberry juices and nectars," *Food Science and Technology International*, vol. 24, no. 5, pp. 434–446, 2018.

[41] W. A. A. Q. I. Wan-Mohtar, A. Klaus, A. Cheng, S. A. Salis, and S. Abdul Halim-Lim, "Total quality index of commercial oyster mushroom Pleurotus sapidus in modified atmosphere packaging," *British Food Journal*, vol. 121, no. 8, pp. 1871–1883, 2019.

[42] Iso, *SRPS ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories III*, Institute for Standardization of Serbia, Belgrade, Serbia, 2018.

[43] Iso, *ISO 5534:2004 Cheese and Processed Cheese Determination of the Total Solids Content (Reference Method)*, International Organization for Standardization, Geneva, Switzerland, 2004.

[44] Iso, *ISO 3433:2008- Cheese Determination of Fat Content Van Gulik Method*, International Organization for Standardization, Geneva, Switzerland, 2008.

[45] Iso, *ISO 8968-1:2014 Milk and Milk Products Determination of Nitrogen Content Part 1: Kjeldahl Principle and Crude Protein Calculation*, International Organization for Standardization, Geneva, Switzerland, 2014.

[46] Idf, *IDF 1988- Standard 88A: Determination of Chloride Content (Cheese and Processed Cheese)*, International Dairy Federation, Brussels, Belgium, 1988.

[47] I. Djekic, J. M. Lorenzo, P. E. S. Munekata, M. Gagaoua, and I. Tomasevic, "Review on characteristics of trained sensory panels in food science," *Journal of Texture Studies*, vol. 52, no. 4, pp. 501–509, 2021.

[48] H. A. von der Gracht, "Consensus measurement in Delphi studies," *Technological Forecasting and Social Change*, vol. 79, no. 8, pp. 1525–1536, 2012.

[49] I. Djekic, N. Sanjuán, G. Clemente et al., "Review on environmental models in the food chain current status and future perspectives Current status and future perspectives," *Journal of Cleaner Production*, vol. 176, pp. 1012–1025, 2018.

[50] R. A. Horn and C. R. Johnson, *Matrix Analysis*, Cambridge University Press, Cambridge, UK, 1985.

[51] D. W. Scott, "Sturges' rule," *Wiley Interdisciplinary Reviews: Computational Statistics*, vol. 1, no. 3, pp. 303–306, 2009.

[52] N. Dozet, O. Maćej, and S. Jovanović, "Autohthonous milk products basis for specific, original milk products development in modern conditions," *Biotehnologija u stocarstvu*, vol. 20, no. 3-4, pp. 31–48, 2004.

[53] S. Mirecki, D. Tomić, S. Vučinić, M. Marković, and B. Marković, "Technology and quality of Skorup- traditional Montenegrin dairy product tradicionalnog crnogorskog mlijecnog proizvoda," *Mljekarstvo*, vol. 67, no. 3, pp. 197–207, 2017.

[54] A. Terzić-Vidojević, K. Veljović, M. Tolinački et al., "Diversity of non-starter lactic acid bacteria in autochthonous dairy products from Western Balkan Countries- technological and probiotic properties Technological and probiotic properties," *Food Research International*, vol. 136, Article ID 109494, 2020.

[55] B. Chen, M. J. Lewis, and A. S. Grandison, "Effect of seasonal variation on the composition and properties of raw milk destined for processing in the UK," *Food Chemistry*, vol. 158, pp. 216–223, 2014.

[56] M. Radovanović, "The Influence of Milk Composition and Heat Treatment on the Distribution of Proteins in Kajmak Production and Properties of the Formed Skin Layer (in Serbian)," doctoral dissertation, University of Belgrade, Faculty of Agriculture, Belgrade, Serbia, 2012.

[57] M. Peleg, "The instrumental texture profile analysis revisited," *Journal of Texture Studies*, vol. 50, no. 5, pp. 362–368, 2019.

[58] O. Radočaj, "Optimization of technology of hull-less pumpkin press- cake spread rich in omega fatty acids (in serbian)," doctoral dissertation, University of Novi Sad, Faculty of Technology, Novi Sad, Serbia, 2011.

[59] S. Jain, L. L. Rai, and S. S. Ahlawat, "Proximate compositional, texture profile and colour profile analysis of cottage cheeses prepared using milk clotting enzymes extracted from mustard and sunflower oilseed cakes," *The Pharma Innovation Journal*, vol. 9, no. 2, pp. 277–281, 2020.

[60] K. Nishinari, Y. Fang, and A. Rosenthal, "Human oral processing and texture profile analysis parameters: bridging the gap between the sensory evaluation and the instrumental measurements," *Journal of Texture Studies*, vol. 50, no. 5, pp. 369–380, 2019.

[61] S. Uprit and H. N. Mishra, "Instrumental textural profile analysis of soy fortified pressed chilled acid coagulated curd (paneer)," *International Journal of Food Properties*, vol. 7, no. 3, pp. 367–378, 2004.

[62] P. Chakraborty, U. S. Shivhare, and S. Basu, "Effect of milk composition on sensory attributes and instrumental properties of Indian Cottage Cheese (Chhana)," *NFS Journal*, vol. 23, no. September 2020, pp. 8–16, 2021.

[63] J. P. Stevens, *Applied Multivariate Statistics for the Social Sciences*, Taylor and Francis Group, LLC, New York, NY, USA, fifth edition, 2009.