

Chemical composition and mineral profile of different white brined cheeses from cow's milk produced in Kosovo

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Abstract

White brined cheese (WBC) from cow's milk is a staple in the diet of, all age groups in Kosovo. This study examined the chemical composition and mineral profile of WBC from ten industrial dairies in Kosovo which use similar processing technologies, analyzing 18 parameters (moisture, dry matter, acidity, fat, NaCl, proteins, pH, ash, P, Zn, Ca, Fe, Cu, K, Mg, Mn, Na) using national and international standards. A one-sample t-test compared the means of assessed parameters to known standards, and Spearman's rank correlation coefficients (rS) explored relationships between individual mineral contents. The study found substantial variations in chemical and mineral content ($p < 0.05$). Cheese samples had 26.8-56.4% moisture, 43.5-73.2% dry matter, 3.9-18.6% fat, 17.9-30.1% proteins, 11.8-31.5% NaCl, 4.0-8.2% ash, 3.7-6.7°SH acidity, and 4.3-5.3 mS/cm EC. Mineral content also varied widely: 1849.1-5606.9 mg/kg P, 0.53-13.89 mg/kg Zn, 1217.9-5458.2 mg/kg Ca, 2.0-4.3 mg/kg Fe, 0.9-2.1 mg/kg Cu, 273.4-2220.4 mg/kg K, 46.9-143.7 mg/kg Mg, 0.2-0.5 mg/kg Mn, and 10622.9-26145.9 mg/kg Na. Positive correlations ($p < 0.05$ or $p < 0.01$) were observed among minerals, including P and Zn, P and Ca, Zn and Ca, Zn and Mg, and K and Mg. Discrepancies were found between manufacturer-declared values and study results, particularly concerning salt content, averaging $17.6 \pm 5.7\%$, with a range of 11.8-31.5%. These variations and discrepancies may stem from production non-standardization and weak regulatory oversight. Further assessments are needed to ensure WBC quality and consumer safety due to high salt levels.

1. Introduction

Cheeses are diverse dairy products whose structure and composition vary significantly depending on factors such as the type of milk used, processing methods, and maturation conditions (Feeney *et al.*, 2021). According to international data, the global cheese market is currently valued at approximately \$100 billion, with a projected growth rate of about 13.8% from 2019 to 2029 (OECD/FAO, 2020).

Milk and dairy products are crucial sources of nutrients, providing a rich supply of both macronutrients and micronutrients with high bioavailability (Rizzoli, 2014; Black *et al.*, 2014; Pfeuffer and Watzl, 2017). The proteins, minerals, and vitamins found in milk and dairy products play a vital role in promoting healthy human nutrition and development throughout life (Bonjour, 2007; Park, 2009; Muehlhoff *et al.*, 2013). Various studies suggest that milk and dairy products, including white brined cheeses (WBC), are significant sources of bioactive peptides, which are increasingly recognized as

important components of functional foods (Gantner *et al.*, 2015; Vargas-Bello-Pérez *et al.*, 2019)

Macro-minerals such as sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and phosphorus (P), along with micro-minerals like iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn), are essential for numerous metabolic functions in the human body. Therefore, assessing the mineral content of cheeses is crucial (Gharibzahedi and Jafari, 2017; Morris and Mohiuddin, 2023).

White brined cheeses, traditionally produced in Mediterranean countries, Southeastern Europe, and the Middle East, are stored in brine (a sodium chloride solution), which acts as a preservative, allowing the cheese to be stored at room temperature (Hayaloglu *et al.*, 2002; McSweeney, 2007). Most white brined cheeses are coagulated with rennet and salted in brine. They remain highly popular in the Balkans, including Kosovo, which produces various types and also imports these

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cheeses predominantly from the Balkan region. Despite the significant production, import, and consumption of white cheese in Kosovo, there is a lack of detailed data on the chemical and mineral content of these products. While reviewing the literature, we found data on the chemical parameter profile of one of the ten types analyzed in this study—industrial Rugova cheese variety (Sulejmani and Selimi, 2022). However, no data were found on the mineral profile of these types of cheeses.

Given that these cheeses are a staple in the diet across all age groups in Kosovo, it is essential to have accurate information on their composition. This study aims to evaluate the chemical composition and mineral profile of ten industrial white brined cheeses made from cow's milk in Kosovo, analyzing 18 parameters (moisture, dry matter, acidity, fat, sodium chloride, proteins, pH, ash, phosphorus, zinc, calcium, iron, copper, potassium, magnesium, manganese, sodium). Additionally, this study will assess the nutritional labeling of the evaluated cheeses for accuracy.

2. Materials and methods

2.1 Sample collection

A total of ten types of white brined cheese (WBC) made from cow's milk, produced by ten different industrial dairies, were assessed. These cheeses were purchased from three major supermarket chains in Kosovo: Interex, ETC, and Viva Fresh Store. For each cheese type, three samples were collected, placed in sterile containers, labeled with the brand name, and transported to the laboratory. The samples were then stored in refrigeration ($4\pm 2^\circ\text{C}$) until analysis. The chemical composition and mineral profile analyses were carried out at the Faculty of Agrobusiness Laboratory and the Kosovo Agricultural Institute in Pejë.

2.2 Sample analyses

2.2.1 Determination of moisture and dry matter

Moisture content and dry matter were determined using a moisture analyzer (Model MB 90, Ohaus). First, the cheese was ground in a porcelain mortar, and then an appropriate plate was placed inside the device to which 5 - 10 g of the sample was added. The temperature was adjusted to 105°C for 20 min until a signal was given that the analysis had completed.

2.2.2 Determination of pH and conductivity

These measurements were performed using the 'Meters-table top' pH meter (S213 Mettler Toledo Seven Compact Duo pH/Conductivity Meters), calibrated beforehand with buffer solutions at pH 4, 7, and 12. For the test, 10 g of the sample and 100 mL of distilled water were mixed in a 150 mL Erlenmeyer flask using a

horizontal mixer for 30 min. The values of two parameters were measured by immersing the electrode in the mixture and reading the value directly from the device.

2.2.3 Determination of acidity

The acidity was determined by the titrimetric method. This method involved the titration of a sample (10 g with 100 mL of distilled water) with a 0.1 N NaOH solution using 1% phenolphthalein as an indicator.

2.2.4 Determination of ash

Ash content was determined by incinerating 3-5 grams of samples in an electrical furnace (Drying Oven SLW 115) at 550°C until complete ashing. Calculation: $\text{Ash \%} = \frac{A_1 - A_2}{A_1 - A_0} \times 100$ (A_0 : Weight of empty porcelain cup (g); A_1 : Weight of porcelain cup with sample (g); A_2 : Weight of porcelain cup after ashing (g))

2.2.5 Determination of proteins

Protein content was measured using the Kjeldahl method, which determines total nitrogen in a sample, assuming it originates from protein. The method involved digestion (420°C for 1 hour 27 min), converting organic nitrogen to ammonium sulfate using concentrated sulfuric acid and a catalyst at high temperature. After digestion, the ammonium is released as ammonia and is distilled in a distiller (Kjeltec 3100), and titrated with 0.1 N HCl as outlined by AOAC Official Method 991.20.

2.2.6 Determination of fat

Fat content was determined by extracting the homogenized sample with cyclohexane using a Soxhlet apparatus. The solvent is distilled off, and the extracted fat is weighed. Calculation: $\text{Fat \%} = \frac{A_1 - A_0}{m} \times 100$ (A_0 : Weight of empty beaker (g); A_1 : Weight of beaker with fat (g); m : Sample weight (g). Results are expressed as a percentage to one decimal place (AOAC Official Method 925.12).

2.2.7 Determination of NaCl

Salt content was determined using a Mohr's method that involves the titration of chloride ions (Cl^-) with a silver nitrate (AgNO_3) solution in the presence of potassium chromate (K_2CrO_4) as an indicator (Mohr's method, AOAC Official Method 920.124, 1990). Calculation formula: $\% \text{NaCl} = \frac{4 \times A \times 0.00585 \times 100}{m}$ (A = volume of AgNO_3 used (mL); 0.00585g = mass of NaCl equivalent to 1 mL of 0.1 M AgNO_3 and m = mass of sample (g))

2.2.8 Determination of minerals

Mineral analysis was conducted using a Microwave Plasma–Atomic Emission Spectrometer (MP-AES 4200, Agilent Technologies). Approximately 0.5 g of each sample was weighed into a Teflon microwave vessel. Samples were digested using microwave-assisted mineralization with concentrated nitric acid (HNO₃, 65%), hydrogen peroxide (H₂O₂, 30%), and distilled water. The digestion process lasted 55 min, including cooling. Afterwards, vessels were opened under a fume hood, rinsed, and the contents transferred into 50.0 mL Teflon tubes. Standard solutions were placed in the calibration rack, followed by distilled water, a blank, and the test sample in the sample rack. Samples were then homogenized and transferred to 10.0 ml tubes for analysis with the MP-AES 4200. Results were reported directly in ppm (mg/kg).

Each analysis was performed in triplicate, with results presented as mean±standard deviation (SD), along with ranges. A one-sample t-test compared sample means to reference values, and Spearman's rank correlation (r_s) was used to assess relationships between mineral contents. Statistical significance was set at $p \leq 0.05$.

3. Results

3.1 Chemical parameters

Table 1 presents the chemical composition of the assessed cheese samples, including moisture, dry matter, acidity, fat, sodium chloride (NaCl), proteins, pH, and ash.

The moisture content in the assessed cheese samples varied significantly, ranging from 26.8% to 56.4% (mean±SD = 43.6±8.2%). Significant differences ($p < 0.05$) were observed when comparing these values to the

foreign standards.

The dry matter content of the WBC samples ranged from 43.55% to 73.16% (mean±SD = 56.4±8.2%). Significant differences ($p < 0.05$) were found when comparing the dry matter values of the samples with the foreign standards. Most samples had dry matter content between 50% and 60%, except for sample number 3, which deviated notably.

The acidity of the cheese samples ranged from 3.7 to 6.7 °SH (mean±SD = 5.1±1.2%), while the pH values ranged from 3.9 to 5.6 (mean±SD = 4.7±0.6%). No significant differences were observed when comparing acidity and pH values with the foreign standards.

The average fat content in the white brined cheese samples was 12.3%, ranging from 3.9% to 18.6%. In contrast, the protein content ranged from 17.9% to 30.1% (mean±SD = 23.8±3.7%). Highly significant differences ($p < 0.01$) were found when comparing fat and protein values to the reference standards. The fat content was below the minimum required value, while the protein content exceeded the standard requirements. In addition to discrepancies with the standards, there were also inconsistencies with the declared values for these parameters

Regarding salt content, this study found very high levels in all analyzed samples. The average salt content ranged from 11.8% to 31.5% (mean±SD = 17.6±5.7%). Highly significant differences ($p < 0.01$) were observed when comparing these values to the reference standards.

The ash content in the cheese samples ranged from 4.0% to 8.2%, with an average of 6.3% (mean±SD = 6.3±1.6%). Significant differences ($p < 0.05$) were observed when comparing these values to reference standards. Sample 6 had the highest ash content (8.25%), while sample 3 had the lowest (4.02%).

Table 1. Chemical composition of the cheese samples.

Sample	Moisture (%)	Dry matter (%)	Acidity (°SH)	Fat (%)	NaCl (%)	Proteins (%)	pH	EC (mS/cm)	Ash (%)
1	41.64	58.36	4.30	11.36	17.16	24.56	4.01	4.28	4.98
2	43.82	56.18	4.00	6.13	31.52	30.14	4.18	5.08	7.13
3	26.84	73.16	6.60	12.18	12.06	17.86	4.43	4.28	4.02
4	42.98	57.02	4.80	18.62	16.88	24.56	4.53	5.04	5.29
5	42.81	57.19	5.90	17.11	11.83	23.44	4.37	4.01	5.50
6	50.88	49.12	3.90	15.64	17.16	24.56	5.19	5.34	8.25
7	41.07	58.93	6.70	14.87	16.50	24.56	5.25	4.35	8.15
8	51.56	48.44	4.40	15.09	13.26	26.79	5.62	4.28	4.68
9	38.08	61.92	3.70	3.94	17.80	23.44	5.28	5.06	6.91
10	56.45	43.55	6.30	7.81	21.66	17.86	3.87	5.06	7.93
Mean±SD	43.6±8.2	56.4±8.2	5.1±1.2	12.3±4.9	17.6±5.7	23.8±3.7	4.7±0.6	4.7±0.5	6.3±1.6
(min-max)	(26.8-56.4)	(43.5-73.2)	(3.7-6.7)	(3.9-18.6)	(11.8-31.5)	(17.9-30.1)	(3.9-5.6)	(4.3-5.3)	(4.0-8.2)
p-value	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p > 0.05$	$p < 0.05$	$p < 0.05$

3.2 Minerals

Table 2 presents the content of selected macro-minerals (P, Ca, K, Mg, Na) and trace elements (Zn, Fe, Cu, Mn). This study revealed wide variations in mineral content among the cheese samples and significant differences ($p < 0.05$) when compared to reference values. Sodium (Na) was the most abundant mineral, averaging 18,451.3 mg/kg, followed by phosphorus (P) at 3,922.1 mg/kg, calcium (Ca) at 3,326.2 mg/kg, potassium (K) at 651.1 mg/kg, and magnesium (Mg) at 91.6 mg/kg. Among the trace elements, zinc (Zn) was found to be below the recommended value, averaging 5.5 mg/kg, followed by iron (Fe), copper (Cu), and manganese (Mn), with averages of 3.0 mg/kg, 1.3 mg/kg, and 0.3 mg/kg, respectively. To explore the relationships between the concentrations of macro-minerals (P, Ca, K, Mg, Na) and trace elements (Zn, Fe, Cu, Mn) in the different types of white brined cheeses produced in Kosovo, Spearman's rank correlation coefficients were calculated. Table 3 summarizes these correlations, highlighting the interrelationships between various mineral contents. Positive correlation coefficients were

observed in several mineral pairs in the cheese samples, including Phosphorus (P) and Zinc (Zn) ($rS = 0.867$, $p < 0.01$), Phosphorus (P) and Calcium (Ca) ($rS = 0.952$, $p < 0.01$), Zinc (Zn) and Calcium (Ca) ($rS = 0.794$, $p < 0.01$), Zinc (Zn) and Magnesium (Mg) ($rS = 0.648$, $p < 0.05$) and Potassium (K) and Magnesium (Mg) ($rS = 0.685$, $p < 0.05$).

3.3 Adequacy of nutritional labeling for white brined cheeses

A comparison of the chemical composition data from this study with the nutritional information declared on the labels of the assessed cheeses revealed several discrepancies. All ten brands provided information on energy value, protein, and fat content, while seven included carbohydrate data. Only two brands declared salt content, and only three listed calcium and sodium concentrations. Five brands declared calcium content, while two brands did not provide any information on salt, calcium, or sodium. Significant differences were noted between the declared and actual values for fat and protein content. Specifically, the fat content reported on labels was higher than the experimental results. In

Table 2. Content of selected minerals in cheese samples.

Sample	P (mg/kg)	Zn (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	K (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Na (mg/kg)
1	2920.1	0.96	2161.2	3.16	2.14	285.9	53.8	0.38	14422.3
2	4414.2	7.45	3269.3	4.32	1.64	632.8	111	0.32	23463.7
3	3005.5	3.5	2241.6	3.38	1.32	2220.4	110.7	0.18	10622.9
4	3769.3	4.43	3333.6	2.53	1.3	349.9	77.3	0.28	18164.5
5	2867.8	0.53	2466.3	2.02	1.17	613.5	100.2	0.17	16788.1
6	4519.2	7.77	3922.3	3.01	1.13	504.7	79.2	0.17	20077.0
7	5410.9	6.16	5101.6	2.44	1.04	496.7	73.7	0.2	16596.1
8	4857.7	13.89	4090.2	2.76	0.88	473.5	143.7	0.31	18773.5
9	5606.9	9.12	5458.2	3.94	1.29	660.5	119.7	0.51	19458.5
10	1849.1	1.5	1217.9	2.86	1.08	273.4	46.9	0.21	26145.9
Mean±SD	3922.1±1238.5	5.5±4.2	3326.22±1348.15	3.0±0.7	1.3±0.4	651.1±568.4	91.6±30.6	0.3±0.1	18451.3±4370.3
(min-max)	(1849.1-5606.9)	(0.53-13.89)	(1217.9-5458.2)	(2.0-4.3)	(0.9-2.1)	(273.4-2220.4)	(46.9-143.7)	(0.2-0.5)	(10622.9-26145.9)
p-value	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$

Table 3. Spearman's Rank Correlation Coefficients (rS) between the concentrations of macro-minerals and trace elements in white brined cheese.

Mineral	P	Zn	Ca	Fe	Cu	K	Mg	Mn	Na
P	1	0.867**	0.952**	0.176	-0.297	0.37	0.539	0.304	0.067
Zn	0.867**	1	0.794**	0.309	-0.37	0.261	0.648*	0.316	0.394
Ca	0.952**	0.794**	1	-0.067	-0.418	0.333	0.527	0.17	0.079
Fe	0.176	0.309	-0.067	1	0.588	0.43	0.333	0.535	0.236
Cu	-0.297	-0.37	-0.418	0.588	1	0.248	-0.042	0.353	-0.273
K	0.37	0.261	0.333	0.43	0.248	1	0.685*	-0.122	-0.164
Mg	0.539	0.648*	0.527	0.333	-0.042	0.685*	1	0.219	0.079
Mn	0.304	0.316	0.17	0.535	0.353	-0.122	0.219	1	0.152
Na	0.067	0.394	0.079	0.236	-0.273	-0.164	0.079	0.152	1

* $P < 0.05$, ** $P < 0.01$

contrast, the protein content in all samples was higher than the values stated on the labels. The calcium content declared on labels was lower compared to the experimental results. For salt and sodium, the values declared on the labels were generally lower than those found in this study.

4. Discussion

Due to the absence of established standards for white brined cheeses in Kosovo, the results of this study were compared with the Codex Alimentarius standard for cheeses (CXS 283-1978), as well as with standards from the USA, Bulgaria, and Turkey. Comparison with Turkish and Bulgarian standards (Turkish Standards Institution, TS 591; Bulgarian Institute for Standardization) were particularly relevant, given that white brined cheeses are traditionally produced in Mediterranean and Southeastern European countries. According to the Codex Alimentarius, the moisture content on a fat-free basis (MFFB%) for soft cheeses should exceed 67%. The U.S. Department of Agriculture (USDA) specifies a moisture content range of 46.7% to 56% for white cheese. The Bulgarian standard sets this range at 54-55%, while the Turkish standard requires a minimum of 49% moisture content. In this study, the observed moisture content in all samples was lower than the values prescribed by the Codex Alimentarius and several Balkan standards. The moisture values were also lower than those reported by other researchers (Pappa and Sotirakoglou, 2009; Ivanova *et al.*, 2015). Conversely, the dry matter content in most samples exceeded the 49% threshold set by the Bulgarian standard and was slightly above the USDA's range of 44% to 53.3%. Overall, the values obtained in this study were slightly higher than those reported in previous studies (Sulejmani *et al.*, 2020; Buhalova *et al.*, 2023).

Dry matter content typically depends on the protein, mineral, and fat content in cheese. The pH levels are crucial for controlling spoilage and pathogenic organisms. The average pH values in this study are consistent with those reported in other studies (Massouras *et al.*, 2023). The declared values for fat content in the cheese samples were around 20%, while the declared protein content was approximately 16%. In contrast, the average results from this study revealed lower fat content and higher protein content compared to those reported in other studies (Dabevska-Kosotoska *et al.*, 2015; Ivanov *et al.*, 2016; Sulejmani *et al.*, 2020; Massouras *et al.*, 2023). The salt content in these samples was notably higher than in 'Sharri cheese,' a hard cheese from Kosovo stored in brine, which contains about 6.6% salt (Rysha and Delaš, 2014). Excessive salt intake is a global health concern, with high salt

consumption linked to various health issues such as hypertension, cardiovascular diseases, kidney diseases, osteoporosis, and cancer (Massey, 2005; Cook *et al.*, 2016; Song *et al.*, 2017; Hong *et al.*, 2022). White brined cheese is known for its high salt content, and some studies suggest that it can contain up to 7% NaCl (Lisak Jakopović *et al.*, 2023). Organizations like the World Health Organization (WHO) recommend reducing sodium chloride intake, with a goal of a 30% reduction in salt consumption by 2025 (Cirila *et al.*, 2021). While salt plays a crucial role in cheese preservation, taste, and spoilage prevention, its high content contributes significantly to dietary sodium intake (Guinee, 2004). Variations in ash content may be related to differences in salt content. Similar ash content was found in Turkish white brined cheese (Kirdar *et al.*, 2013), while other studies reported lower ash content compared to this study (Messias *et al.*, 2022; Massouras *et al.*, 2023). The mineral content in white cheeses can vary due to factors such as salt concentration, which influences mineral levels, and the maturation process, during which moisture loss can alter mineral concentration. Only three out of the nine minerals (Ca, P, and K) were within the limits determined by the reference standards. The average Na, Ca, and P content in the cheese samples were higher than reported values, particularly Na, while Mg and K content were lower (Borys *et al.*, 2006; Levkov *et al.*, 2017; Massouras *et al.*, 2023; Visentin *et al.*, 2023). The high sodium content is likely due to extensive salting. Elevated calcium and phosphorus levels may result from the production process and the retention of these minerals in casein, leading to higher concentrations in the cheese. The low zinc content in nearly all samples may be attributed to its availability in the soil from which animal feed is sourced. The zinc content in these samples is lower compared to results reported by other researchers (Borys *et al.*, 2006; Özlü *et al.*, 2012; Kirdar *et al.*, 2013; Levkov *et al.*, 2017). While sodium (Na) content was high, the levels of copper (Cu), iron (Fe), and manganese (Mn) were higher than the standards. However, lower levels of Cu, Mn, and Fe have been reported in some studies, while others have found higher concentrations of these trace elements compared to the results of this study (Kirdar *et al.*, 2013; Levkov *et al.*, 2017). Spearman's rank correlation coefficients of this study align with previous research that also reported positive correlations between calcium and phosphorus, as well as zinc (Gambelli *et al.*, 1999; González-Martín *et al.*, 2009).

5. Conclusion

This research revealed significant variations in the chemical and mineral composition of white brined cheeses made from cow's milk, despite being produced

using similar technologies. Key findings include: lower water content (mean value = 43.6%) and higher dry matter content (mean value = 56.4%) in the assessed cheeses. No significant differences in acidity and pH values were observed. Significant deviations from standard requirements were noted for fat content (mean value = 12.3%) and protein content (mean value = 23.8%). Extremely high salt content was found in all samples (mean value = 17.6%). Wide variations were observed in the content of selected macro-minerals and trace elements, with only three of the nine minerals (Ca, P, and K) meeting the reference standards. Positive correlations were found between several mineral pairs. The study also highlighted discrepancies between the nutritional labels and laboratory findings, particularly in fat, protein, calcium, and salt content. Given the widespread consumption of white brined cheeses in Kosovo, the high salt content may significantly contribute to the dietary salt intake of Kosovars. These findings underscore the need for standardization in the production of white brined cheese, rigorous oversight to ensure product composition aligns with label declarations and regulatory measures to address high salt content, including public health campaigns encouraging reduced salt consumption. Further research is recommended to evaluate the quality and nutritional labeling adequacy of white brined cheeses produced in Kosovo.

Conflict of interest

The authors declare no conflict of interest.

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