Evaluation of Mineral Compositions of Selected Commercial Yogurts Consumed in North Macedonia

Hyseni, A.[1], Kalevska, T.[2], Nikolovska-Nedelkoska, D.[2], Knights, V.[2] and Hyseni, V.[2]*

[1]*Faculty of Food Technology, University "Isa Boletini" Mitrovicë, Mitrovicë, Republic of Kosovo*
[2]*Faculty of Technology and Technical Sciences – Veles, University "St. Kliment Ohridski" – Bitola, Republic of North Macedonia*

*__Corresponding author:__ vlora.huseni@uklo.edu.mk **Phone number:** +38349588834

ABSTRACT

Background: *Yogurt is obtained by lactic fermentation of milk and plays an important role in the human diet due to its nutritional and health properties. Although it is consumed regularly by different age groups in North Macedonia, the mineral content of commercial yogurt has not been widely studied.*
Objective: *The objective of this study was to determine the concentrations of essential minerals in selected commercially available plain and fruit yogurts from the North Macedonia market.*
Methodology: *The elements were analysed using inductively coupled plasma–optical emission spectroscopy (ICP-OES) after microwave digestion. The labelled nutrient content and the analysed mineral contents were evaluated to determine their contribution to the recommended daily intake (RDI), providing insights into the nutritional composition of different yogurt types. The nutrient data were analysed using three-dimensional principal component analysis (3D-PCA) to identify similar nutrient profiles.*
Results: *Protein and fat contents were similar among yogurt types ($P > 0.05$), while fruit yogurts had significantly higher carbohydrate content due to added sugars ($P < 0.05$). Calcium and phosphorus were the main contributors to the recommended daily intake (RDI). PCA revealed positive associations among Ca, Mg, P, and Zn, particularly in fruit-containing yogurts.*
Conclusion: *Fruit yogurts showed a more favourable mineral profile but contained higher levels of sugars. These findings provide insight into the nutritional quality of commercially available yogurts in North Macedonia.*

Keywords: Commercial yogurt, Nutrient content, Essential minerals, RDI, Dietary intake

Doi: https://dx.doi.org/10.4314/njns.v47i2.10

INTRODUCTION

Yogurt is the most popular and widely consumed fermented milk product worldwide (1). Its popularity is mainly due to its healthy and nutritious properties, providing protein and essential fatty acids with high biological value (2, 3). In addition to increasing awareness about the health benefits of yogurt, the availability of various flavours and varieties has significantly contributed to the increase in yogurt consumption over the past few decades (2). Yogurt is commercially produced using a variety of ingredients, flavours, and additives (4). A wide range of yogurts with various flavours (unsweetened, flavoured, sweetened, fruit, juice, and other natural products), as well as diverse textures and consistencies (firm, liquid, shaken, smooth, frozen), has been developed to satisfy consumer preferences and provide beneficial effects (5). Fruits are rich in fibre, antioxidants, vitamin C, and potential prebiotics that increase the nutritional value of yogurt (6). Although the micronutrient composition of yogurt and milk is similar, yogurt contains higher amounts of micronutrients, including calcium, magnesium, potassium, and other minerals (7, 8). A study supported the role of yogurt and dairy products as foods that help children increase their absorption of important micronutrients, including potassium and calcium (9). In particular, dietary calcium and potassium intake are associated with the health of children of all ages in the United States (10). The variety of fruits added to the yogurt has a significant impact on the mineral content of retail products. For example, iron, manganese, magnesium, and zinc show the most pronounced variation (11). It is possible to improve nutrient intake and adequacy, as well as adopt a healthier diet, by encouraging yogurt consumption (12). Yogurt consumption offers several benefits to the host, including improved bone health, enhanced nutritional quality, and a reduced risk of chronic diseases such as obesity and cardiovascular disease (13). In general, the available literature suggests that yogurt consumption is positively associated with overall diet quality (8). Studies have reported substantial variation in the mineral composition of commercial dairy products, including yogurts (14–18). Considerable differences in mineral profiles have also been reported among commercial delactosed dairy products, indicating variability in the nutritional composition of dairy products (14). An evaluation of flavored dairy products marketed in Europe reported marked differences in calcium, potassium, magnesium, and other essential minerals among products, emphasizing the importance of product-specific nutritional assessment (15). Likewise, studies comparing dairy and plant-based yogurts have shown considerable variation in mineral composition and bioaccessibility, further supporting the need for detailed compositional characterization of commercially available yogurt products (16,17). Investigations of commercially available Greek yogurts have also revealed significant differences in physicochemical characteristics among products, reflecting variations in formulation and manufacturing practices that may influence their nutritional profiles (18). In the regional context, recent research conducted in North Macedonia on yogurts produced from milk–whey mixtures supplemented with fruits demonstrated the growing interest in evaluating the nutritional quality of fermented dairy products and highlighted their potential contribution to dietary nutrient intake (19). Despite the nutritional importance of yogurt as a source of essential minerals, information regarding the mineral composition of commercial yogurts available on the North Macedonian market remains limited. Studies have reported on the presence of heavy metal content in cow milk (20, 21) and essential minerals (macro and trace elements) in raw sheep milk in North Macedonia (22). Additionally, studies have been conducted on the heavy metal content in milk in the neighbouring country of Kosovo (23-26) and commercial yogurts sold in this region (27). Multivariate analyses of cow's milk and animal feed across different regions of Kosovo have revealed marked spatial differences in mineral composition, highlighting the importance of feed characteristics and regional production conditions in determining the mineral profile of dairy systems (28). However, to date, no studies have reported on the mineral composition of commercial yogurts in North Macedonia. The objective of the present study was to determine the mineral composition of eleven commercial yogurts, evaluate their contribution to the recommended daily intake (RDI) for adults, and assess how mineral content and labelled nutrient information contribute to the nutritional characterization of different yogurt varieties.

MATERIALS AND METHODS

Sample Collection

A total of eleven (11) yogurt samples were purchased in September 2021 at different supermarkets in Skopje, Republic of North Macedonia. Two types of yogurts were analysed, including five plain yogurts and six fruit yogurts (four strawberry and two blueberry). Following collection, samples were placed into sterile polypropylene bottles and labelled. The products were transported and subsequently stored at 4°C in the laboratory until before analyses.

Analysis of Dietary Minerals

Samples of yogurts (500 mg) were weighed into the digestion vessel, and 5 mL of H_2O, 5 mL of HNO_3 (65% v/v), and 2 mL of HCl (32% v/v) were added. The mixture was thoroughly shaken with a clean Teflon bar. The sample was pre-digested for 48 hours in a digestion vessel before being sealed and heated in the microwave. A microwave oven, MWS-3 (Begerhof, Germany), was employed to perform the acid digestion of the sample at the Agrovet laboratory, Fushë Kosovë, Republic of Kosovo. An iCAP 7000 Series (Thermo Scientific, USA) inductively coupled plasma-optical emission spectrometer (ICP-OES) was used for essential mineral determination (Ca, K, Mg, Na, P, Fe, and Zn) according to EPA method 6010C at the University of Belgrade, Serbia (29).

Percentage Contribution of Nutrients in Yogurts with Reference to RDI Values

Nutritional composition data were obtained from the information provided on yogurt labels, including energy, fat, protein, carbohydrates, and salt content. Dietary fiber and ash were not declared on the product labels of the analyzed yogurts and were therefore excluded from the proximate composition analysis. In addition, following ICP-OES analysis, the contribution of the mineral and macronutrient content of the yogurt samples to the Recommended Daily Intake (RDI) values for adult human nutrition was evaluated. Nutrient contribution values were calculated based on a serving size of 100 g of yogurt. The percentage contribution of each nutrient to the RDI was calculated using Eq. (1), adapted from (24), to assess the extent to which the consumption of 100 g of yogurt contributes to the daily requirements of essential minerals and macronutrients in adult human nutrition.

$$\%\,nutrient\ contribution = \frac{Nutrient\ content\ in\ yogurt\ (mg/100)}{(RDI/DRV)value\ (mg/d)} \times 100$$

Statistical Analysis

Statistical analyses were performed using the SPSS 25.0 software (SPSS, Chicago, IL, USA), and the obtained values were presented as the mean ± SE. The normality of the data was evaluated using Shapiro-Wilk's test. Data following a normal distribution were analysed using one-way ANOVA, followed by Fisher's post hoc test. Data that did not meet normality requirements were analysed using the non-parametric Kruskal-Wallis test with Dunn's multiple comparisons. The differences between means were considered significant at $P \leq 0.05$. The relationships between individual commercial yogurts and the studied variables were evaluated using three-dimensional Principal Component Analysis (3D-PCA) in OriginPro 2021b trial version (OriginLab Corporation, Northampton, MA).

RESULTS

Chemical Composition of Different Types of Commercial Yogurt

Protein and fat contents did not differ significantly among plain, strawberry, and blueberry yogurts ($P > 0.05$), with mean protein contents of 3.26%, 3.37%, and 3.15%, respectively, and mean fat contents of 2.96%, 4.05%, and 2.75%, respectively. Carbohydrate contents were significantly lower in plain yogurts (3.1–4.6 g/100 g) than in strawberry (12.0–14.0 g/100 g) and blueberry yogurts (11.3–14.3 g/100 g) ($P < 0.01$). Salt contents ranged from 0 to 0.3 g/100 g in plain yogurts, and no significant differences were observed among yogurt types ($P > 0.05$). The results of the mineral composition analysis of commercial yogurts are presented in Table 1. Concentrations of Ca, K, Mg, Na, P, Fe, and Zn ranged from 680.91 to 1200.12 mg/kg, 661.39 to 1061.58 mg/kg, 74.50 to 119.05 mg/kg, 186.94 to 341.33 mg/kg, 646.48 to 1020.56 mg/kg, 2.80 to 88.47 mg/kg, and 2.11 to 3.78 mg/kg, respectively. In plain and strawberry yogurts, the minerals followed the concentration order Ca ≈ K > P > Na > Fe > Zn, whereas a similar pattern was observed in blueberry yogurts (Ca > K ≈ P > Na > Fe > Zn).

Table 1: Chemical Composition of Different Types of Commercial Yogurt

Proximate composition (g) [1]	Plain yogurt	Strawberry yogurt	Blueberry yogurt
Protein	3.26 ± 0.07^a	3.37 ± 0.09^a	3.15 ± 0.35^a
Fat	2.96 ± 0.09^a	4.05 ± 1.39^a	2.75 ± 0.05^a
Carbohydrates	3.98 ± 0.29^b	13.1 ± 0.43^a	12.8 ± 1.5^a
Salt	0.10 ± 0.05^a	0.13 ± 0.009^a	0.12 ± 0.01^a
Mineral composition (mg/kg)[2]			
Ca	913.8 ± 49.7^a	1004 ± 114^a	908.7 ± 83.9^a
K	945.2 ± 22.6^a	904.6 ± 90.6^{ab}	702.84 ± 7.03^b
Mg	83.79 ± 5.65^b	93.9 ± 11.2^{ab}	92.97 ± 2.06^a
Na	258 ± 22.1^a	255.3 ± 16.6^a	272.9 ± 68.4^a
P	766 ± 27^a	895.7 ± 87.4^a	807.9 ± 36.5^a
Fe	6.73 ± 2.03^b	6.52 ± 1.6^b	53.5 ± 35^a
Zn	2.76 ± 0.25^b	3.12 ± 0.34^{ab}	3.06 ± 0.31^a

[1]Source: Product`s label; [2]Results are the mean ± SE: Plain yogurt (n=5); Strawberry yogurt (n=4); Blueberry yogurt (n=2). Within a row, different letters (a, b) denote significant differences (P≤ 0.05) between yogurt types

Percentage Contribution of Different Commercial Yogurt Types to the Recommended Daily Intake (RDI)

Table 2 presents the percentage contributions of the yogurt varieties to the Recommended Daily Intake (RDI) of essential minerals and macronutrients for adult human nutrition, expressed per 100 g of yogurt. The nutritional contribution of yogurts ranged from 1% to 38.2% of RDI values. Energy content was 103 kcal/ 100 g in strawberry yogurt, 88 kcal/ 100 g in blueberry yogurt, and 57 kcal/ 100 g in plain yogurt.

Commercial yogurts contributed 4.1–6.0% of the recommended daily intake (RDI) for fat. Carbohydrates contributed 1.3% of the RDI in plain yogurt and approximately 4.3–4.4% in strawberry and blueberry yogurts. Protein contributed 6.3–6.7% of the RDI across all yogurt samples. Sodium contribution was approximately 1.3% of the RDI across all yogurt types.

Table 2: Percentage Contribution (%) of Different Commercial Yogurt Types to the Recommended Daily Intake (RDI) of Minerals and Macronutrients for Adults, per 100 G

Nutrient	RDI (g)[1]	Plain yogurt	Strawberry yogurt	Blueberry yogurt
Total carbohydrate	300	1.3	4.4	4.3
Fat	67	4.4	6	4.1
Protein	50	6.5	6.7	6.3
Sodium (Na)	2	1.3	1.3	1.4
Potassium (K)	3,51	2.7	2.6	2.0
Calcium (Ca)	1	9.1	10	9.1
Phosphorus (P)	0,7	10.9	12.8	11.5
Magnesium (Mg)	0,375	2.2	2.5	2.5
Iron (Fe)	0,014	4.8	4.7	38.2
Zinc (Zn)	0,01	2.8	3.1	3.1

[1]*RDI: Recommended daily intakes by the World Health Organization (WHO).*

3D-PCA: Nutrients (Vectors) and Commercial Yogurts (Circles)

Figure 1 shows the 3D principal component analysis (PCA) of the nutritional composition of commercial yogurts. The first three principal components explained 73.97% of the total variance, with PC1 accounting for 41.35%, PC2 for 18.75%, and PC3 for 13.87%. Principal Component 1 was associated with Ca, Mg, P, and Zn; PC2 with energy and carbohydrate content; and PC3 with K and protein (positive loadings) and Na (negative loading). The PCA score plot showed separation of samples along the first three components. Dimension 1 reflected variation in mineral content, Dimension 2 reflected energy and carbohydrate content, and Dimension 3 reflected protein, potassium, and sodium content. Plain and fruit yogurts were positioned in different regions of the PCA space.

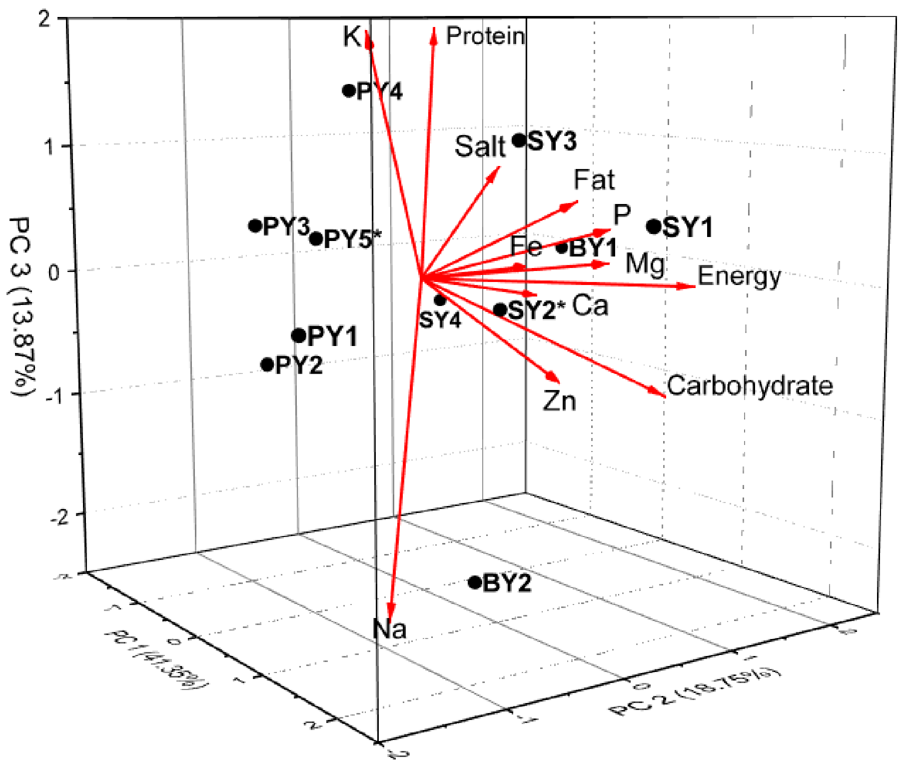

Figure 1: 3D-PCA: Nutrients (Vectors) and Commercial Yogurts (Circles). Samples: PY1–PY5 = Plain Yogurt; SY1–SY4 – Strawberry Yogurt; BY1 and BY2 – Blueberry Yogurt

DISCUSSION

The protein and fat contents did not differ significantly among plain, strawberry, and blueberry yogurts, indicating that fruit addition had little influence on these macronutrients. This is likely because milk solids remain the primary source of protein and fat in yogurt. The protein and fat contents obtained in the present study were within the ranges reported for commercial drinking and fruit yogurts available in UK supermarkets (32). In contrast, fruit yogurts contained significantly higher carbohydrate levels than plain yogurt, reflecting the addition of fruit preparations and sugars during manufacturing. Consequently, fruit yogurts also provided higher energy values than plain yogurt (32). The mineral composition of the analysed yogurts was characteristic of fermented dairy products, with calcium, potassium, and phosphorus representing the predominant minerals. Similar mineral profiles have been reported in yogurt products, where calcium, phosphorus, magnesium, and zinc represent important mineral constituents, although variations among products have been observed (33–36). The absence of significant differences in calcium concentrations among yogurt types suggests that fruit addition had little influence on calcium levels because milk remained the principal source of calcium in the analysed products. Differences among yogurt types were more evident for potassium, magnesium, iron, and zinc. Similar variability in mineral composition has also been reported among commercial flavoured dairy products, reflecting differences in product composition and formulation practices (37). The lower potassium concentrations observed in blueberry yogurts and the slightly higher magnesium concentrations observed in fruit yogurts may reflect differences in fruit composition, ingredient sourcing, or manufacturing formulations. Likewise, the slightly higher zinc concentrations observed in fruit yogurts may indicate a modest contribution from fruit ingredients or formulation-related factors. Previous research has shown that the incorporation of different fruit types can significantly modify the mineral composition of yogurts, with the magnitude and direction of these changes depending on the specific fruit used (38). Sodium and phosphorus concentrations were comparable among yogurt types, indicating that these minerals were less affected by fruit incorporation. Iron exhibited the greatest variation among the analysed minerals. The substantially higher iron concentrations observed in blueberry yogurts may be associated with the composition of blueberry preparations, differences in ingredient sourcing, or potential fortification practices. The large variability observed among blueberry yogurt samples further suggests that manufacturing formulations may contribute significantly to differences in iron content among products. Comparison with previous studies revealed considerable variability in mineral concentrations among commercial yogurts produced in different countries. Calcium concentrations in the present study were lower than those reported for goat milk and fermented goat milk products (33) and Romanian dairy products (39), but were comparable to commercial fermented cow- and goat-milk products (34). Potassium concentrations were similar to those reported for commercial dairy and soy yogurts (35), although lower than values reported in other studies (33). Magnesium concentrations were close to the lower limits of previously published ranges (34,35), whereas sodium concentrations tended to be lower than those reported in trace element surveys of yogurt products (40). Iron concentrations in plain and strawberry yogurts were consistent with values previously reported in the literature (35,40), whereas the elevated iron concentrations observed in blueberry yogurts exceeded most published values for commercial yogurts and fermented dairy products (33–40). Zinc concentrations were comparable to those reported for commercial fermented milk products and yogurt samples analysed by ICP-MS (34–36). Overall, differences among studies likely reflect variation in raw milk composition, fruit content, geographical origin, production practices, fortification, and analytical methodologies. The higher energy contribution of fruit yogurts was primarily associated with their increased carbohydrate content. In terms of recommended daily intake (RDI), fruit yogurts generally provided higher contributions of certain minerals than plain yogurts, although this pattern was element-dependent. Calcium, sodium, and phosphorus contributed similarly across yogurt types, while potassium, magnesium, iron, and zinc showed greater variability. In particular, blueberry yogurts provided a markedly higher contribution of iron to the RDI, which may be nutritionally relevant for populations with increased iron requirements. Principal component analysis confirmed that nutritional composition differed according to yogurt type. Mineral composition, carbohydrate content, and the Na/K ratio were the primary factors contributing to variability among samples. The clear separation between plain and fruit yogurts reflects differences in formulation and nutrient composition associated with fruit addition. Although fruit yogurts generally exhibited higher carbohydrate contents and, in some cases, greater contributions to mineral intake, these products also contained higher levels of sugars. Therefore, future product reformulation strategies should aim to preserve the nutritional benefits of fruit-containing yogurts while reducing added sugar content.

CONCLUSION

This study demonstrated that commercial yogurts in North Macedonia provide essential dietary minerals (Ca, K, Mg, Na, P, Fe, and Zn). Protein content did not differ among yogurt types, while fruit yogurts provided higher energy values due to their increased carbohydrate content. RDI evaluation demonstrated that the nutritional contribution of the analyzed yogurts varied among minerals, with calcium and phosphorus showing the highest contributions to daily intake requirements. In particular, fruit yogurts showed higher contributions for some minerals, especially iron in blueberry yogurt. The 3D-PCA analysis indicated associations between yogurt samples and their mineral profiles, with PC1 positively correlated with Ca, Mg, P, and Zn, suggesting distinct clustering based on mineral composition. Overall, these findings provide useful information on the nutritional composition of commercially available yogurts and may assist consumers in making informed dietary choices.

COMPETING INTERESTS

The authors declare no conflict of interest.

REFERENCES

1. Gahruie, H. H. (2018). Yogurt: The most suitable carrier for increasing bioavailability of minerals. *Progress in Nutrition, 20*(2), 294–296. https://doi.org/10.23751/pn.v20i2-S.5690
2. Chandan, R. C., Gandhi, A., & Shah, N. P. (2017). Yogurt: Historical background, health benefits, and global trade. In *Yogurt in health and disease prevention* (pp. 3–29). Academic Press. https://doi.org/10.1016/B978-0-12-805134-4.00001-8
3. Hadjimbei, E., Botsaris, G., & Chrysostomou, S. (2022). Beneficial effects of yoghurts and probiotic fermented milks and their functional food potential. *Foods, 11*(17), Article 2691. https://doi.org/10.3390/foods11172691
4. El-Abbadi, N. H., Dao, M. C., & Meydani, S. N. (2014). Yogurt: Role in healthy and active aging. *The American Journal of Clinical Nutrition, 99*(5), 1263S–1270S. https://doi.org/10.3945/ajcn.113.073957
5. Luis, G., Rubio, C., Revert, C., Espinosa, A., González-Weller, D., Gutiérrez, A. J., & Hardisson, A. (2015). Dietary intake of metals from yogurts analyzed by inductively coupled plasma optical emission spectrometry (ICP-OES). *Journal of Food Composition and Analysis, 39*, 48–54. https://doi.org/10.1016/j.jfca.2014.11.013
6. Okoniewski, A., Dobrzyńska, M., Kusyk, P., Dziedzic, K., Przysławski, J., & Drzymała-Czyż, S. (2023). The role of fermented dairy products on gut microbiota composition. *Fermentation, 9*(3), Article 231. https://doi.org/10.3390/fermentation9030231
7. Webb, D., Donovan, S. M., & Meydani, S. N. (2014). The role of yogurt in improving the quality of the American diet and meeting dietary guidelines. *Nutrition Reviews, 72*(3), 180–189. https://doi.org/10.1111/nure. 12098
8. Tremblay, A., & Panahi, S. (2017). Yogurt consumption as a signature of a healthy diet and lifestyle. *The Journal of Nutrition, 147*(7), 1476S–1480S. https://doi.org/10.3945/jn.116.245522
9. Keast, D. R., Hill Gallant, K. M., Albertson, A. M., Gugger, C. K., & Holschuh, N. M. (2015). Associations between yogurt, dairy, calcium, and vitamin D intake and obesity among US children aged 8–18 years: NHANES, 2005–2008. *Nutrients, 7*(3), 1577–1593. https://doi.org/10.3390/nu7031577
10. Freitas, M. (2017). The benefits of yogurt, cultures, and fermentation. In *The microbiota in gastrointestinal pathophysiology* (pp. 209–223). Academic Press. https://doi.org/10.1016/B978-0-12-804024-9.00024-0
11. Tamime, A. Y., & Robinson, R. K. (2007). Nutritional value of yoghurt. In *Tamime and Robinson's yoghurt: Science and technology* (3rd ed., pp. 646–684). CRC Press. https://doi.org/10.1533/9781845692612.646
12. Cifelli, C. J., Agarwal, S., & Fulgoni, V. L., III. (2020). Association of yogurt consumption with nutrient intakes, nutrient adequacy, and diet quality in American children and adults. *Nutrients, 12*(11), Article 3435. https://doi.org/10.3390/nu12113435
13. Kaur, R., Kaur, G., Mishra, S. K., Panwar, H., Mishra, K. K., & Brar, G. S. (2017). Yogurt: A nature's wonder for mankind. *International Journal of Fermented Foods, 6*(1), 57–69. https://doi.org/10.5958/2321-712X.2017.00006.0
14. Crupi, R., Lo Turco, V., Gugliandolo, E., Nava, V., Potortì, A. G., Cuzzocrea, S., Di Bella, G., & Licata, P. (2022). Mineral composition in delactosed dairy products: Quality and safety status. *Foods*, 11(2), 139. https://doi.org/10.3390/foods11020139
15. Gliszczyńska-Świgło, A., & Rybicka, I. (2023). Minerals and vitamin B2 in flavoured dairy

products. *Journal of Food Composition and Analysis*, 124, 105695. https://doi.org/10.1016/j.jfca.2023.105695
16. Rebellato, A. P., Fioravanti, M. I. A., Milani, R. F., & Morgano, M. A. (2023). Composition and bioaccessibility of inorganic elements in plant-based yogurts. *Journal of Food Composition and Analysis, 123*, 105639. https://doi.org/10.1016/j.jfca.2023.105639
17. Marlapati, L., Basha, R. F. S., Navarre, A., Kinchla, A. J., & Nolden, A. A. (2024). Comparison of physical and compositional attributes between commercial plant-based and dairy yogurts. *Foods*, *13*(7), 984. https://doi.org/10.3390/foods13070984
18. Pappa, E. C., Kondyli, E., Pappas, A. C., Kyriakaki, P., Zoidis, E., Papalamprou, L., Karageorgou, A., Simitzis, P., Goliomytis, M., Tsiplakou, E., & Georgiou, C. A. (2024). Physicochemical characteristics of commercially available Greek yoghurts. *Dairy, 5*(3), 436–450. https://doi.org/10.3390/dairy503 0034
19. Hyseni, A., Kalevska, T., Nikolovska-Nedelkoska, D., Dimitrovska, G., Knights, V., Stamatovska, V., & Hyseni, V. (2025). Proximate composition and microbiological safety of yogurts produced by fermentation of a milk-whey mixture and supplemented with fruits. *Asian Journal of Dairy and Food Research*. https://doi.org/10.18805/ajdfr.DRF-525
20. Limani, B., Karapetkovska-Hristova, V., Blazhekovikj-Dimovska, D., & Hristovski, S. (2020). Assessment of heavy metals concentrations in cow's milk collected from Polog Region, Republic North Macedonia. *International Journal of Advanced Science and Technology, 29*(2), 1815–1821. http://sersc.org/ journals/index.php/IJAST/article/view/3432
21. Limani, B., & Karapetkovska-Hristova, V. (2022). Concentration of toxic heavy metals in raw milk from dairy farms in RN Macedonia. *International Journal of Biolife Sciences, 1*(2), 81–88. https://doi.org/10.22034/jbs.2022.160708
22. Levkov, V., Stafilov, T., Pacinovski, N., Bačeva, K., Mateva, N., Gjorgovska, N., Eftimova, E., & Kostadinov, T. (2017). Content of major and trace elements in raw ewes' milk used for production of traditional white brined cheese. *Slovak Journal of Animal Science, 50*(1), 7–14. https://office.sjas-journal.org/index.php/sjas/article/view/133/121
23. Hyseni, B., & Musaj, A. (2014). Heavy metals in the raw milk in Mitrovica. *Albanian Journal of Agricultural Sciences (Special edition)*, 495–498. https://media.proquest.com/media/hms/ORIG/1/FSGgC?_s=lferKLl14PdTRDFchQ1zT5wqjwc%3D
24. Dragusha, B., Aliu, H., & Dizman, S. (2021). Concentrations of metal residues in domestically produced and imported milk in Kosovo. *South African Journal of Animal Science, 51*(5), 622–627. https://doi.org/10.4314/sajas.v51i5.8
25. Durguti, V., Bytyqi, X., Laha, F., Feka, F., & Zeqiri, M. (2023). Determination by FAAS of some of the heavy metals and trace elements in raw cow's milk produced in Kosovo. *Journal of Hygienic Engineering and Design, 42*, 82. https://keypublishing.org/jhed/wp-content/uploads/2023/04/10.-Abstract-Valon-Durguti.pdf
26. Osmani, I., Mula, V., Hashani, Z., Bajraktari, D., & Zeneli, L. (2023). Heavy metal levels in raw cow's milk and health risk implications from thermal power plant emissions in Obilic, Kosovo. *Poljoprivreda i Šumarstvo, 69*(4), 233–244. https://doi.org/10.17707/ AgricultForest.69.4.15
27. Hyseni, A., Sadiku, M., Salihu, D., Mulliqi, I., & Salihu, L. (2017). Research of Pb and Zn in yogurt brands in the Republic of Kosovo. *Naučni trudove na Săjuza na učenite–Plovdiv. Serija V: Tehnika i tehnologii, 14*, 63–65. https://cyberleninka.ru/article/n/research-of-pb-and-zn-in-yogurt-brands-in-republic-of-kosovo/pdf
28. Loshi, I., Knights, V., Elshani, A., Muriqi, Sh., Sadiku, V., Hyseni, A., & Gajdoš Kljusurić, J. (2026). Multivariate statistical assessment of regional differences in mineral composition of cow's milk and feed in Kosovo. *Mljekarstvo – Dairy Experts Journal, 76*(3), 185–198. https://doi.org/10.15567/mljekarstvo.2026.0306
29. Hiseni, A. (2023). *Formulacii i proizvodstvo na funkcionalen jogurt, mikrobiološka, reološka, senzorna i nutritivna karakterizacija pri skladiranje,* doctoral thesis, Faculty of Technology and Technical Sciences–Veles, University St. Kliment Ohridski, Republic of North Macedonia.
30. Subpart A. (2024). *Part 101—Food labeling*. Electronic Code of Federal Regulations. https://www.ecfr.gov/current/title-21/chapter-I/subchapter-B/part-101
31. Gülfen, M., & Özdemir, A. (2016). Analysis of dietary minerals in selected seeds and nuts by using ICP-OES and assessment based on the recommended daily intakes. *Nutrition & Food*

Science, 46(2), 282–292. https://doi.org/10.1108/NFS-11-2015-0138
32. Moore, J. B., Horti, A., & Fielding, B. A. (2018). *Evaluation of the nutrient content of yogurts: A comprehensive survey of yogurt products in the major UK supermarkets.* BMJ Open, 8(8), e021387. https://doi.org/10.1136/bmjopen-2017-021387
33. Güler, Z. (2007). *Levels of 24 minerals in local goat milk, its strained yoghurt and salted yoghurt (tuzlu yogurt).* Small Ruminant Research, 71(1), 130–137. https://doi.org/10.1016/j.smallrumres.2006.05.011
34. Navarro-Alarcón, M., Cabrera-Vique, C., Ruiz-López, M. D., Olalla, M., Artacho, R., Giménez, R., Quintana, V., & Bergillos, T. (2011). *Levels of Se, Zn, Mg and Ca in commercial goat and cow milk fermented products: Relationship with their chemical composition and probiotic starter culture.* Food Chemistry, 129(3), 1126–1131. https://doi.org/10.1016/j.foodchem.2011.05.090
35. Llorent-Martínez, E. J., De Córdova, M. F., Ruiz-Medina, A., & Ortega-Barrales, P. (2012). *Analysis of 20 trace and minor elements in soy and dairy yogurts by ICP-MS.* Microchemical Journal, 102, 23–27. https://doi.org/10.1016/j.microc.2011.11.004
36. Souza, T. S., Luna, A. S., Barros, D. B., Pimentel, T. C., Pereira, E. P., Guimaraes, J. T., & Cruz, A. G. (2019). *Yogurt and whey beverages available in Brazilian market: Mineral and trace contents, daily intake and statistical differentiation.* Food Research International, 119, 709–714. https://doi.org/10.1016/j.foodres.2018.10.050
37. Gliszczyńska-Świgło, A., & Rybicka, I. (2023). *Minerals and vitamin B2 in flavoured dairy products.* Journal of Food Composition and Analysis, 124, 105695. https://doi.org/10.1016/j.jfca.2023.105695
38. Sánchez-Segarra, P. J., García-Martínez, M., Gordillo-Otero, M. J., Díaz-Valverde, A., Amaro-López, M. A., & Moreno-Rojas, R. (2000). *Influence of the addition of fruit on the mineral content of yoghurts: Nutritional assessment.* Food Chemistry, 71(1), 85–89. https://doi.org/10.1016/S0308-8146(00)00146-1
39. Crivineanu, V., Goran, G. V., Tudoreanu, L., Bianu, E., & Dumitrean, L. (2009). *Mineral content and heavy metals contamination of some Romanian dairy products.* Bulletin UASVM Veterinary Medicine, 66(2), 325–332. https://doi.org/10.15835/buasvmcn-vm:66:2:4234
40. Capcarova, M., Harangozo, L., Toth, T., Schwarczova, L., Bobkova, A., Stawarz, R., Guidi, A., & Massanyi, P. (2017). *Detection of selected trace elements in yogurt components.* Journal of Environmental Science and Health, Part B, 52(12), 858–863. https://doi.org/10.1080/03601234.2017.1359029