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SOME PHYSICAL, CHEMICAL, SENSORY PROPERTIES, MINERAL SUBSTANCES, AND HEAVY METAL CONTENTS OF MOLDY CHEESE PRODUCED IN BAYBURT AND THE SURROUNDING AREA

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Abstract: Moldy cheese produced in Bayburt and its surroundings is a mature cheese with a distinctive flavor that can be prepared in three ways. It is made from only Civil cheese, only cottage cheese (çökelek) or mixing the shredded Civil cheese with cottage cheese made from moderately fatty, or non-fat milk, pressing it into appropriate containers, draining the water, and allowing the cheese to organically mold. It is produced traditionally, and there are no production standards. This study was carried out to identify some of the physical, chemical, and sensory properties, mineral substances, and heavy metal contents of moldy cheeses produced and consumed in the region. In the cheese samples (24 pieces), the average dry matter (DM) rate was 51.26%, ash rate was 5.68%, salt rate was 6.21%, fat rate was 4.81%, acidity level was 0.96% and pH value was 5.79, L color value was 74.94, a color value was 0.94, b color value was 8.24. In sensory analyses, the samples scored an average of 5.94 points for color and appearance, 6.10 points in moldiness, 6.11 points for texture, 5.72 points for odor, 6.03 points for taste, 6.30 points for saltiness, and 6.01 points for general acceptability. 29 elements were examined to determine mineral substances and heavy metal concentrations. These findings are important in terms of revealing some general characteristics and heavy metal content of moldy cheese produced in the region.

Keywords: Moldy cheese, Chemical properties, Color values, Mineral substances, Heavy metal content

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1. Introduction

Moldy cheese produced in Bayburt and its region is also produced and consumed in many provinces of Türkiye (Arslaner and Salık, 2020). Moldy Civil Cheese, also known as Göğermiş Cheese, produced in Erzurum, was granted Geographical Indication registration (origin) in 2010, and its production area is limited to the territory defined by the province of Erzurum and its districts (Anonymous, 2010). This cheese is a sort of mature cheese with a unique flavor, obtained by shredding Civil cheese plainly or with curd cheese (Lor), pressing it into plastic bins suitable for food packaging, draining the water, and letting the cheese to molding naturally (Anonymous, 2010).

In the production of moldy cheese produced in Bayburt and its districts, curd cheese is not used, it is made with only Civil cheese or only cottage cheese or by mixing Civil cheese and cottage cheese made from fat and skim milk. The raw materials used in production, production methods, and storage conditions differ by region, and this affects the physical, chemical, microbiological, and sensory properties of the cheese (Arslaner and Salık, 2020).

While milk and dairy products are sources of a variety of minerals, they may occasionally contain pollution-causing chemicals such as heavy metals in varying amounts. In parallel with technological advancements, environmental pollution has significantly increased as a result of numerous industrial activities and increasing road traffic. These heavy metals, which are ingested by animals grazing or feeding in enclosed spaces, pose a risk to the animal's health and can also pass into milk as a result of excretion of the mammary gland (Capcarova et al., 2017). Due to the aforementioned issue or contamination from the metal surfaces of the tools and equipment used during processing, cheese may contain various heavy metals (Tarakci and Kucukoner, 2008; Moreno-Rojas et al., 2010). The risk of metals in the composition of the tools and equipment used in the production of acidic foods such as cheese to dissolve and pass into the product may be easier when compared to other foods (Özlü et al., 2012). Small concentrations of heavy metals are necessary for maintaining health, but larger quantities can be toxic or dangerous (Jaishankar et al., 2014). Because heavy metal levels in cheese have a direct impact on public health, it is desirable to both

control and collect data on these levels.

In this study, the aim was to determine some physical and chemical properties, mineral composition, and heavy metal contents of moldy cheese samples, which are traditionally produced and widely consumed in Bayburt Province.

2. Materials and Methods

2.1. Supply of Cheese Samples

24 moldy cheese samples used in the study were obtained from different sales points operating in Bayburt and its districts. Cheese samples were put into 500 g sterile sample bags and taken to the laboratory through cold chain and kept in the refrigerator at 4 °C until analysis.

2.2. Physical, Chemical, and Sensory Analyses

Total dry matter, ash, acidity (lactic acid%), salt, and fat analyses in moldy cheese samples were performed according to Kurt et al. (1996). pH values were determined by using a combined electrode digital pH-meter (WTW 340-1 brand), while color determination was carried out using a Minolta Colorimeter (CR-200 Minolta Colorimeter, Osaka, Japan) according to Sert et al. (2010). Color measurements of cheese samples were performed on three different sites directly on the sample surface. Sensory analyses were carried out by 10 panelists. In the sensory analysis scorecard, 9-8 means very good, 7-6 refers to good; 5-4-3 refers to average, and 2-1 means bad.

2.3. Determining Mineral Concentrations and Heavy Metal Contents

The mineral composition of cheese samples was determined as per the method suggested by Ataro et al. (2008) with a slight modification. First, the samples were dried in a microwave oven at 70 °C until their dry matter contents reached a stable weight. A sample of approximately 0.5 g of the dried samples was weighed into Teflon containers, and 10 ml of nitric acid (65%)-perchloric acid (70-72%) solution mixed in the ratio of 8:2 by volume was added. After the samples were heated in a microwave oven (Milestone, Ethos Easy) at 200 °C, they were washed with ultrapure water and then put in volumetric containers, and the volume was completed to 25 ml. Following this process, the samples were filtered using a 0.45 µm filter. Then, the mineral matter content of the samples was determined using an Inductively Coupled Plasma Mass Spectrometry (Agilent 7800 ICP-MS).

2.4. Statistical Analyses

The data obtained were analyzed statistically via the SPSS 22.0 package program (SPSS Inc., Chicago, IL, USA).

3. Results and Discussion

3.1. Physical, Chemical and Sensory Analyses

The results of physical and chemical analyses performed on moldy cheese samples are given in Table 1. According to the Geographical Indication Registration Certificate for Moldy Civil Cheese (Göğermiş Cheese), this cheese has dry matter content between 45.00 and 65.00%, a milk fat content between 1.00 and 4.00%, a salt content between 3.00 and 7.00%, a lactic acid acidity percentage between 0.55 and 1.70, and a pH range between 5.1 and 5.6. It can be noted that, excluding fat values, the average values of moldy cheeses produced in Bayburt are compatible with these values. The fat values in our samples are higher, and the reason for the higher fat content in our samples is likely the use of full-fat milk cottage cheese in addition to Civil cheese during production.

Arslan (2020) reported the average salt, pH and acidity values in 27 Moldy Civil Cheese samples collected from Erzurum and its vicinity as 7.34%, 5.25, and 0.48%, respectively. The average salt values of these cheese samples are higher than the values found in our study, and the reason for this difference is thought to be the lack of a standard production technique. Although the pH values were comparable to our findings, the acidity values were determined to be lower. The high salt content of the Moldy Civil Cheeses produced in Erzurum may have prevented the increase in acidity by slowing down the activities of the microbial flora.

Table 1. Results of some physical and chemical analyses performed on moldy cheese samples

	n	Min.	Max.	Mean (x ± Sx)
DM (%)	24	43.68	59.89	51.26±4.87
Ash (%)	24	3.15	8.57	5.68±1.37
Salt (%)	24	3.79	10.29	6.21±1.53
Fat (%)	24	0.80	19.00	4.81±4.68
Acidity	24	0.55	1.43	0.96±0.22
pH	24	4.76	7.38	5.79±0.51
L	24	49.17	87.99	74.94±8.53
a	24	-1.24	3.13	0.94±1.27
b	24	2.00	14.06	8.24±2.86

Cakmakci et al. (2014) produced four different types of Moldy Civil Cheese and allowed them to ripen for 180 days. Throughout the ripening process, chemical and microbiological parameters were measured periodically, and the changes were noted. At the end of the storage period, the total dry matter ratio of the cheese samples was found as 46.97%, fat content as 1.72%, acidity as 0.72%, pH as 6.48, salt content as 7.21%, and ash content as 7.41%. When these results were compared to the average values we obtained, it was seen that the DM, fat and acidity values were lower, while the pH, salt, and ash rates were higher. It is thought that the high salt content of the moldy cheeses produced in Erzurum, the use of curd in production, the different ripening periods of the cheeses or the use of different animal milk are the sources of these differences in composition.

L values found in the color analyses performed on the cheese samples ranged from 49.17 to 87.99; a values from -1.24 to 3.13, and b values from 2.00 to 14.06. There is no study in the literature that has examined and

reported the color values of the moldy cheese produced in Bayburt and the nearby regions.

Table 2 showed the results of sensory analyses conducted on moldy cheese samples. Cheese samples were rated between 3.10-7.10 for color and appearance; 2.80-7.90 for moldiness; 3.60-7.10 for texture; 2.80-7.40 for odor; 3.40-7.40 for taste; and 3.70-7.30 for general acceptability. When sensory analysis results are evaluated along with the relevant physical, chemical, and color analysis results, the sample with 77.88; -0.28; 8.01 L, a, b color values respectively was the most favored sample by the panelists in terms of color and appearance, while the sample with 5.61% salt content was the most favored by the panelists in terms of salt content.

Table 2. Results of sensory analyses performed on moldy cheese samples

	n	Min.	Max.	Mean (x ± Sx)
Color and Appearance	24	3.10	7.10	5.94±0.91
Moldiness	24	2.80	7.90	6.10±1.30
Texture	24	3.60	7.10	6.11±0.90
Odor	24	2.80	7.40	5.72±1.01
Taste	24	3.40	7.40	6.03±0.96
Saltiness	24	5.30	8.00	6.30±0.65
General Acceptability	24	3.70	7.30	6.01±0.90

3.2. Mineral Concentration and Heavy Metal Contents Analysis

Table 3 shows the mineral and heavy metal analysis results of cheese samples. Accordingly, the average Na content of moldy cheese samples is 42094.84±13905.46 mg/kg dry weight. This value is similar to the Na values (14225.25±127.39-91688.18±46.01mg/kg dry weight) determined by Arslaner and Salık (2020) in Civil cheese samples obtained from Bayburt. Many researchers reported that the high Na levels detected in cheese samples are caused by salt content, and the Na level rises as the salt level increases (Demirci, 1988; Sağun et al., 2005; Öksüztepe et al., 2013). Özlü et al. (2012) reported that the amount of Na in ripened Kashar cheese was higher than that of fresh Kashar cheese and stated that this may be due to a proportional increase in moisture loss as the cheese ripens.

K and P were the second and third most often found elements in cheese samples, with average concentrations of 7624.34±1245.68 and 1825.81±657.93 mg/kg dry weight, respectively. These values are within the range of the values determined by Arslaner and Salık (2020) (6403.39±13.04-11397.51±196.79, 755.38±9.05-2056.00±52.36 mg/kg dry weight). P is one of the elements that can be found in the structure of proteins, and thus protein-rich milk and dairy products such as cheese are among the foods rich in phosphorus (Uribarri and Calvo, 2003). Milk and dairy products are an important source of K. In a study conducted in Poland, milk and dairy products were reported to come in fourth place (11.9%) as a source of potassium. This value was 9.6% in the USA, 11.3% in France, and 14.1%–15.5% in Australia (Górska-Warsewicz et al., 2019).

The average Ca and Mg concentrations in cheese samples were determined as 1654.96±560.21, and 296.55±75.60 mg/kg dry weight, respectively. Arslaner and Salık (2020) calculated the amounts of Ca as 772.89±4.24 - 2146.25±11.21 and Mg as 332.56±2.15-1919.05±22.53 µg/kg dry weight. In the cheese-making process, paracasein micelles combine in the presence of Ca ions to generate cheese curd (Metin, 2005). Therefore, cheese is a good source of (especially bioavailable) calcium (Walther et al., 2008; Fox et al, 2017). Calcium content in hard or semi-hard cheeses is 6-11 $g.kg^{-1}$. In softer varieties of cheese, this rate is lower. Hard or semi-hard cheese delivers half or third of the daily necessary calcium intake of 1200 mg in one serving (50 g) (Walther et al., 2008). Compared to cheeses curdled with acid, cheeses curdled with rennin have increased calcium content (Demirci, 1990). In addition to calcium, milk is a rich source of Mg (Walther et al., 2008).

The average Si and Zn contents of the cheese samples were determined as 72.92±27.69 and 46.98±16.08 mg/kg dry weight, respectively. When compared to the values found by Arslaner and Salık (2020), the amount of Si was found to be within the range reported by them (TE-132243.58±88.68 mg/kg dry weight), while the amount of Zn was found to be lower (49949.43±84.82-94558.05±80.33 µg/kg dry weight). Zn is one of the most important essential trace minerals in human nutrition, and its deficiency is a worldwide nutritional problem. The Recommended Dietary Allowance for Zn in the US is 15 mg/day (Gascho, 2001; Gulbas and Saldamli, 2005; Snyder, Matichenkov and Datnoff, 2016).

The average concentrations of Al, Fe, and Sr were found to be 22.54±19.85, 15.66±8.05, and 8.11±3.37 mg/kg dry weight, respectively, in the cheese samples. These values were found to be similar to the values determined by Arslaner and Salık (2020) (TE-35487.79±45.51, TE-31113.0±86.56, 4810.50±10.79-36405.24±280.34 µg/kg dry weight). Al is a non-essential metal that humans are frequently exposed to (Soni et al., 2001). The majority of Al in the diet results from the use of food additives (such as baking soda, coloring agents, anti-caking agents, acidifying agents, stabilizers, thickening agents, bleaching agents, and emulsifiers) during processing, in particular. Al levels in processed cheese wrapped in aluminum foil have been found to be significantly higher than in cheese packaged in glass containers (AI-Ashmawy, 2011).

Table 3. Mineral substance and heavy metal contents of moldy cheese samples (mg/kg dry weight)

Minerals and heavy metals		n	Min.	Max.	Mean (x ± Sx)
Na	Sodium	24	18794.61	73068.09	42094.84±13905.46
P	Phosphorus	24	5627.27	10220.34	7624.34±1245.68
K	Potassium	24	1119.54	3989.18	1825.81±657.93
Ca	Calcium	24	910.93	3000.17	1654.96±560.21
Mg	Magnesium	24	206.90	452.18	296.55±75.60
Si	Silicium	24	31.82	133.45	72.92±27.69
Zn	Zinc	24	28.50	91.01	46.98±16.08
Al	Aluminum	24	ND	71.55	22.54±19.85
Fe	Iron	24	4.17	35.62	15.66±8.05
Sr	Strontium	24	3.61	14.70	8.11±3.37
Ti	Titanium	24	0.55	114.63	8.03±25.31
Sn	Stannum	24	2.80	30.96	7.18±6.28
Cu	Copper	24	0.80	12.27	2.16±2.59
Ba	Barium	24	0.67	4.43	1.69±0.88
B	Boron	24	ND	8.88	0.86±2.03
Mn	Manganese	24	0.35	1.45	0.72±0.25
Se	Selenium	24	0.09	0.44	0.23±0.10
Pb	Lead	24	0.05	1.66	0.22±0.34
Mo	Molybdenum	24	0.04	0.29	0.15±0.06
Ni	Nickel	24	ND	0.46	0.12±0.13
Cr	Chromium	24	0.03	0.27	0.09±0.05
V	Vanadium	24	ND	0.04	0.01±0.01
In	Indium	24	ND	0.28	0.06±0.09
Ag	Silver	24	ND	0.06	0.01±0.01
Co	Cobalt	24	ND	0.03	0.01±0.01
Ga	Gallium	24	ND	0.02	0.01±0.01
Cd	Cadmium	24	ND	0.01	ND
As	Arsenic	24	ND	0.01	ND
Hg	Mercury	24	ND	ND	ND

ND= not detected

Dairy products are a great source of calcium and protein, but they are poor in iron (Zhang and Mahoney, 1989; Jalili, 2016). As a result, numerous studies have been carried out on iron fortification in dairy products, and it has been found that enriching cheese with 80 $mg.kg^{-1}$ microencapsulated iron and 150 $mg.kg^{-1}$ L-ascorbic acid is possible without causing any unpleasant flavors (Jalili, 2016). According to the most recent research, Sr, one of the trace elements frequently found in the earth's crust, is harmful to humans, plants, and animals (Anke et al., 2008).

In cheese samples, the average concentrations of Ti, Sn, and Cu were found to be 8.03±25.31, 7.18±6.28, and 2.16±2.59 mg/kg dry weight, respectively. In Codex (1998), the Temporary Tolerable Intake amount is expressed as 14 mg/kg/week for Sn and 0.5 mg/kg/day for Cu. İşleyici et al. (2017) found the average amount of Sn in Divle Tulum Cheese samples as 0.01 mg/kg, and Öztürk, Kaptan and Şimşek (2012) determined it as 0.0366 ppm in Kashar cheese. Arslaner and Salık (2020) determined the Cu rate in Civil cheese as TE-891.60±3.01 µg/kg dry weight. It is thought that the differences in the results are due to the equipment used in cheese making being made of different materials or the mineral composition of the milk (Yüzbaşı et al., 2003; Lucas et al., 2006; Stergiadiset al., 2021).

The average concentrations of Ba, B, and Mn in cheese samples were determined as 1.69±0.88, 0.86±2.03, 0.72±0.25 mg/kg dry weight, respectively. Arslaner and Salık (2020) determined Ba and Mn rates as 1226.05±2.32-4951.59±37.55 and 34.15±0.42-1077.14±38.41 µg/kg dry weight, respectively. The results we obtained are similar to the current study.

Simsek et al. (2003) determined the average B ratios of White Cheese, Tulum Cheese and Urfa cheese as 0.61, 1.84 and 1.12 mg/kg, respectively. Our results are similar to these values. B is a dynamic trace element that can affect the metabolism or utilization of many other substances involved in life processes, and the lowest value given for the safe intake range is 1.0 mg B/day (Berger and Truog, 1939).

Kodrik et al. (2011) examined the impact of road traffic on the heavy metal content of cow milk and cheese and they found that there was no significant difference in the Mn concentrations between cheese samples made from milk obtained from locations near and far from highways. Se, Pb, Mo ratios of cheese samples was determined as 0.23±0.10, 0.22±0.34, 0.15±0.06 mg/kg dry weight, respectively. Arslaner and Salık (2020) determined Se and Pb values as TE-723.57±7.00 and TE-181.81±5.19

µg/kg dry weight. Our findings appear to be consistent with this study. Selenium is a trace mineral essential for human life. The Recommended Dietary Allowance for Se in the US is 50 µg/day (Gulbas and Saldamli, 2005).

The Temporary Tolerable Intake amount for Pb was listed as 25 mcg/kg bw per week in Codex (1998). Pb has reportedly been linked to numerous child fatalities in Zambia and Nigeria. Additionally, Pb is associated with a decline in intellectual performance and cognitive development (Dai, et al., 2023). Molybdenum is a cofactor (molybdopterin) that stimulates oxidation and reduction reactions for some enzymes and is an essential trace element. The US Institute of Medicine (IOM, 2001) reported the average daily molybdenum intake for adults as 22 µg/day (EFSA, 2013).

The concentrations of Ni, Cr, and V in cheese samples were determined as 0.12±0.13, 0.09±0.05, and 0.09±0.01 mg/kg dry weight. Arslaner and Salık (2020) determined Cr values as TE-1203.44±62.83 µg/kg dry weight. In the study by Orak, Altun, and Ercag (2005), the Ni concentration of White Cheese samples was found to be 1.057±0.209 (0.654-1.518) µg/g, and it was noted that this value was greater than the values in the literature. Different equipment made from nickel alloy is used in the dairy industry. According to Orak, Altun, and Ercag (2005), the low quality of these alloys and the salt used in brine and other pollution sources may cause an increase in the Ni content in cheese.

As a metal present everywhere in nature, Cr influences the insulin function of the body, which in turn impacts how carbohydrates and proteins are metabolized. The typical daily consumption of Cr ranges from 30 to 200 g, and small amounts of Cr are present in milk and dairy products. The Turkish Food Codex Contaminants Regulation does not place any restrictions on the quantity of Cr that can be found in foods (Kahvecioğlu et al., 2003; Orak, Altun and Ercag, 2005).

According to Kodrik et al. (2011), the quantity of V in milk increased in locations with heavy traffic compared to rural areas, but the amount of V in cheese remained the same. There is no significant evidence to establish that V is an essential component of the human diet (Imtiaz et al., 2015).

The average concentrations of In, Ag, and Co were found to be 0.06±0.09, 8.51±0.01, and 7.00±0.01 mg/kg dry weight, respectively, in cheese samples. These rates were calculated by Arslaner and Salık (2020) to be TE-7040.92±10.30, TE-376.63±2.80 and TE-28.64±0.35 µg/kg, respectively.

The maximum Ga, Cd and As rates in cheese samples were determined as 0.02, 0.01, and 0.01 mg/kg dry weight, respectively. It was observed that Hg levels were below the detectable limit in all cheese samples. Arslaner and Salık (2020) determined the Cd rate as TE-979.69±1.41 µg/kg dry weight and the As rate as TE-TE. Heavy metals such as Cd, As and Hg have no physiological function for living organisms. These metals are characterized by bioaccumulation and biomagnification properties and reach the human body through the ingestion of contaminated food and water, leading to various toxicological consequences (Dai, et al., 2023).

5. Conclusion

Moldy cheese is one of the most produced and consumed cheese types in Bayburt and its region. It is produced traditionally, and there are no production standards. Production techniques may differ from similar cheeses produced in the region. This study is important in terms of providing information about various physical, chemical and sensory properties, heavy metal and mineral composition of moldy cheeses produced in Bayburt and its region, and can serve as a source for future studies. The results we obtained can contribute to the development of a standard production with a quality appreciated by consumers.

Author Contributions

The percentage of the author contributions is presented below. The author reviewed and approved the final version of the manuscript.

	E.M.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans

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