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A survey of selected minerals in ready-to-eat pastırma types from different regions of Turkey using ICP/OES

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Abstract: The aim of this study was to assess the content of selected minerals (Ca, K, Na, Mg, S, P, Pb, Zn, Mn, Fe, and Ni) and moisture values in types of pastırma (sırt, kuşgömü, bohça, and şekerpare), a dry-cured meat product. Forty-four samples of pastırma were collected from Turkey and analyzed using inductively coupled plasma-optical emission spectrometry (ICP/OES) for quantitative determination. Na content was the highest out of all the other minerals in all the pastırma types (31.9–47.7 g kg^{-1} dry weight). The determined mean ranges of heavy metals were 2.6 ± 0.5 to 3.6 ± 0.8 Pb, 245.3 ± 102 to 323.4 ± 92 Zn, 2.8 ± 2.4 to 3.9 ± 1.8 Mn, 69.7 ± 25 to 81.6 ± 15 Fe, and 0.9 ± 0.3 to 1.2 ± 0.5 Ni mg kg^{-1} dry weight. Significant differences among the types of pastırma were observed in Ca ($P < 0.05$), K ($P < 0.05$), Mg ($P < 0.05$), Na ($P < 0.01$), Pb ($P < 0.01$), S ($P < 0.05$), and Zn ($P < 0.01$), while there was no difference in the amounts of Fe, Mn, Ni, and P among types of pastırma ($P > 0.05$). Moisture values of kuşgömü were lower than those of the other types of pastırma ($P < 0.05$).

Key words: Pastırma types, dry-cured meat, mineral, heavy metals, ICP/OES, moisture

1. Introduction

Pastırma, which is categorized as an intermediate-moisture meat product, is produced from whole muscles obtained from certain parts of beef and water buffalo carcasses. From a single carcass, 16 to 20 different types of pastırma can be produced. Muscles are cured, dried, pressed, redried, repressed, and coated with a paste containing garlic (çemen: garlic, red pepper, paprika, flour ground from *Trigonella foenum-graecum* seeds, and water), and dried again to achieve a maximum 40% moisture level. This period is complete after approximately 1 month. Pastırma is an increasingly important source of high-value animal protein and is low in fat (1–3).

Pastırma is produced in many parts of the world, such as the Middle East, central Asia, and some Mediterranean and European countries (4,5). A lot of dry-cured meat products are produced around the world, such as pastırma, bacon, Bündnerfleisch, ham, and so on, both with and without a heat process. Cured-meat products differ greatly in composition and intended eating quality, but the types of bacteria growing on and in them are similar, due to the fact that the main factors controlling their growth are the same in a wide range of products (6,7). Curing may be combined with other processes, including drying, heating, smoking, and fermentation, but the production of pastırma does not include heating or smoking processes (8).

Pastırma is produced from whole muscles that are obtained from certain parts of beef and buffalo carcasses. Pastırma quality is ranked according to the muscles that are used in pastırma production as first, second, and third class (9). Good-quality pastırma is produced from the fillet, shank, leg and shoulder cuts (10). "Sırt" and "kuşgömü" types of pastırma are defined as first class, while "şekerpare" and "bohça-eğrice" types of pastırma are defined as second class. Therefore, the production of sırt, kuşgömü, bohça-eğrice, and şekerpare types of pastırma is generally more widespread than other types of pastırma, due to their high quality.

Fresh meat is commonly used for pastırma production in Turkey. However, frozen/thawed meat can also be used. In fact, pastırma made from frozen/thawed meat has similar properties to pastırma made from fresh meat (11). Numerous studies have shown that frozen/thawed meats can be penetrated more rapidly, since the salt penetrates faster than in fresh meats (11,12). Inorganic substances in feed and food represent a severe risk due to their long-term toxicological effects. Some metals, especially heavy metals like Cu and Zn, are essential micronutrients and have a variety of biochemical functions in all living organisms (13). Heavy metals can enter the body of cattle and sheep as

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they eat food or drink water containing these heavy metals, and they can accumulate in the muscles (14). Additionally, additives of the pastırma or çemen paste used for pastırma production, such as salt, garlic, red pepper, paprika, flour ground from *Trigonella foenum-graecum* seeds, and water, can contain significant quantities of heavy metals.

The second stage of pastırma production is curing. The curing procedures and curing mixtures used in pastırma production have an extremely important effect on pastırma characteristics (4). Different curing methods, such as dry curing, brine curing, and injection + dry curing, can be used in the curing process, but the most commonly used is the method of dry curing alone (1,15). In the traditional dry curing method, the surface of the meat is completely coated with salt (NaCl) at a maximum of 10% of the total meat weight for 2–3 days, and then the remaining salt on the surface is removed with tap water or by plunging the meat into a solution of 2%–3% saline water (4,5). There has been some research about the amount of salt that is used for dry curing pastırma batches. Studies determined that for each 1 kg of pastırma, 50.0 g of curing mixture [NaCl 47.25 g, KNO_3 0.75 g (or $NaNO_2$ 0.25 g), glucose 1.0 g, sucrose 1.0 g, and a starter culture] could be used for dry curing (1,3). Ceylan and Aksu (8) reported that the amounts of free amino acids in the sırt, bohça, and şekerpare types of pastırma were generally different, and the most advantageous types of pastırma in terms of essential amino acids were bohça and sırt pastırma. Many studies have been conducted to determine the total amount of salt in pastırma. However, there are no detailed reports on the mineral content of types of pastırma. Therefore, the objective of this study was to investigate the amounts of selected minerals and moisture values of the ready-to-eat sırt, kuşgömü, bohça, and şekerpare types of pastırma.

2. Materials and methods

2.1. Materials

A total of 44 pastırma samples (18 sırt, 10 bohça, 7 kuşgömü, and 9 şekerpare) collected from Turkey during 2010 were analyzed. All samples were put into plastic bags and then transported to the laboratory. Samples were stored at 4 °C until the time of the analysis. For analysis, the samples were sliced and cut into small pieces with a steel knife (8). Sırt pastırma is 60–70 cm long, rectangular, 15–20 cm wide, and crispier and more easily digested than the other types of pastırma, and thus it is considered more delicious. Bohça pastırma is on average 60 cm long, triangular, 15 cm wide, and 1.5–2 kg in weight. Şekerpare pastırma is 10–12 cm wide, 55–60 cm long, and rectangular, and it weighs 1.2–1.5 kg. Kuşgömü pastırma is triangular, 60–70 cm long, and 8–10 cm wide, and it weighs 1.0–1.2 kg. Sırt pastırma is produced from the muscles found in the loin area of the carcass. Bohça and şekerpare types of pastırma are produced from the muscles obtained from the round section of the carcass. Kuşgömü pastırma is produced from the muscles obtained from the loin and round parts of the carcass (5,8).

2.2. Moisture analysis

The moisture content of the samples were determined as a weight loss of 10 g of sliced and cut small pieces of pastırma samples after drying at 100 ± 2 °C for 18 h.

2.3. Mineral composition analysis

In order to determine the mineral contents, pastırma samples were dried at 100 °C for 18–24 h. Macro- and microelements were determined after wet digestion of dried and ground subsamples using an HNO_3–H_2O_2 acid mixture (2:3 v/v) with 3 steps [first step: 145 °C, 75% radiofrequency (RF), 5 min; second step: 180 °C, 90% RF, 10 min; third step: 100 °C, 40% RF, 10 min] in a microwave oven (Berghof Speedwave Microwave Digestion Equipment MWS-2). The amounts of P, K, Ca, Mg, Na, Ni, Pb, S, Zn, Mn, and Fe were determined using an inductively coupled plasma spectrometer (ICP/OES, Optima 2100 DV, PerkinElmer,). The amounts of P, K, Ca, Mg, Na, Ni, Pb, S, Zn, Mn, and Fe were determined on a dry weight basis and reported as g kg^{-1} or mg kg^{-1} dry weight.

2.4. Statistical analysis

Statistical evaluations were performed with SPSS by using a completely randomized design procedure. One-way analysis of variance (ANOVA) via SPSS 10.01 was performed (16). The model included the effects of the types of the pastırma (sırt, kuşgömü, bohça, and şekerpare pastırma) as the main effect on mineral composition. The differences among means were tested using Duncan's multiple range test according to significance at $P < 0.05$. The results of the statistical analyses are shown as mean values and standard deviations (SDs) in the tables.

3. Results

The contents of the selected mineral and moisture of the kuşgömü pastırma samples are given in Table 1 as means and SDs. The moisture values ranged from 33.8% to 45.7%. The predominant mineral in the kuşgömü pastırma samples was determined to be Na, followed by S, K, P, and Ca. The mineral levels and moisture content of the şekerpare pastırma samples are also given in Table 1. The moisture content values for şekerpare pastırma samples ranged from 40.1% to 55.3%. The most abundant mineral in the şekerpare pastırma samples was Na, followed by K, S, P, and Ca.

The mineral and moisture values determined in sırt pastırma samples are presented in Table 2. The moisture content in the samples ranged from 31.6% to 56.7%.

Table 3 shows the moisture content and mineral values for bohça pastırma samples. The predominant mineral

Table 1. Moisture and mineral content in kuşgömü and şekerpare pastırma from Turkey.

No.	Moisture	Ca	K	Na	Mg	S	P	Zn	Pb	Mn	Fe	Ni
	%	g kg^{-1} dry wt.						mg kg^{-1} dry wt.				
Kuşgömü pastırma type												
1	35.4	1.7	10.7	43.8	1.3	17.9	8.5	391.5	3.2	2.5	77.5	1.1
2	45.7	1.6	9.9	35.6	1.1	12.7	6.4	240.0	3.8	3.3	71.9	0.4
3	41.4	2.0	12.3	39.1	1.2	11.2	6.6	219.0	3.4	7.7	107.4	0.7
4	36.2	1.5	12.4	26.6	1.1	13.4	7.1	301.5	5.5	2.5	65.7	2.2
5	33.8	1.6	8.9	20.6	1.0	12.3	6.1	337.0	2.9	3.1	73.5	1.0
6	39.8	1.2	8.0	25.8	0.7	10.7	5.0	211.0	3.0	2.6	75.1	0.8
7	37.7	1.7	11.3	31.8	1.0	12.3	6.0	180.0	3.5	5.4	100.0	1.7
Minimum	33.8	1.2	8.0	20.6	0.7	10.7	5.0	180.0	3,0	2.5	71.9	0.4
Maximum	45.7	2.0	12.4	43.8	1.3	17.9	8.5	391.5	5.5	7.7	107.4	2.2
Mean ± SD	38.6 ± 4.7	1.6 ± 0.3	10.5 ± 0.6	31.9 ± 7.9	1.1 ± 0.2	12.9 ± 2.3	6.5 ± 1.1	268.6 ± 7	3.6 ± 0.8	3.9 ± 1.8	81.6 ± 15	1.1 ± 0.6
Şekerpare pastirma type												
1	50.9	1.2	13.8	54.2	0.9	9.9	6.4	230.5	1.8	1.9	57.3	1.8
2	52.7	1.2	9.0	39.4	0.7	5.0	4.1	115.0	2.4	4.1	72.0	1.6
3	55.3	1.2	10.2	48.6	0.8	9.5	5.9	212.0	2.4	1.3	37.3	1.0
4	40.2	1.7	11.4	50.7	0.9	9.8	6.3	151.5	2.5	3.9	82.0	1.0
5	40.1	1.9	9.5	41.9	1.0	10.2	5.9	163.0	2.9	5.4	74.7	1.8
6	45.0	1.6	13.1	62.2	1.0	13.6	7.0	309.5	2.5	2.8	88.1	1.3
7	44.7	1.4	11.3	53.0	1.0	13.2	6.4	304.5	2.6	2.1	101.6	0.6
8	47.0	1.9	8.9	37.1	1.1	7.0	5.3	260.5	3.0	6.9	77.0	1.1
9	46.4	1.6	11.8	42.2	1.5	14.2	6.5	461.5	3.8	3.4	68.6	0.7
Minimum	40.1	1.2	8.9	37.1	0.7	5.0	4.1	115.0	1.8	1.3	37.3	0.6
Maximum	55.3	1.9	13.8	62.2	1.5	14.2	7.0	461.5	3.8	6.9	101.6	1.8
Mean ± SD	46.9 ± 5.3	1.5 ± 0.3	11.0 ± 0.5	47.7 ± 8.0	1.0 ± 0.2	10.3 ± 0.3	6.0 ± 0.8	245.3 ± 102	2.6 ± 0.5	3.5 ± 1.7	73.2 ± 18	1.2 ± 0.5

Ca: Calcium, K: potassium, Na: sodium, Mg: magnesium, S: sulfur, P: phosphorus, Pb: lead, Zn: zinc, Mn: magnesium, Fe: iron, Ni: nickel.
SD: Standard deviation.

Table 2. Moisture and mineral content in sırt pastırma from Turkey.

No.	Moisture	Ca	K	Na	Mg	S	P	Zn	Pb	Mn	Fe	Ni
	%	----------g kg^{-1} dry wt.----------						----------mg kg^{-1} dry wt.----------				
1	55.5	1.1	11.6	59.7	0.9	11.4	6.5	357.0	2.2	1.4	51.0	1.0
2	43.4	1.2	8.8	22.0	0.8	7.0	5.3	202.0	1.9	5.4	62.7	1.5
3	56.7	9.8	11.6	46.7	0.7	10.5	5.9	453.0	2.3	1.3	64.2	0.6
4	52.6	1.3	11.6	54.4	0.9	12.3	6.5	422.5	3.3	1.4	79.3	0.8
5	46.5	1.7	9.4	40.1	1.0	6.2	5.1	151.0	2.8	8.9	128.1	1.2
6	46.0	1.2	16.8	59.6	1.1	14.2	7.7	369.5	3.8	1.2	53.5	0.8
7	46.7	1.2	14.4	42.3	1.1	14.7	8.1	313.0	2.6	1.2	46.4	0.4
8	48.3	1.4	9.3	28.5	1.0	12.2	6.2	361.5	4.4	4.1	63.8	0.9
9	36.1	1.9	8.8	43.5	1.1	9.3	5.1	198.5	3.2	6.2	89.8	0.9
10	47.3	1.3	11.5	48.3	1.1	13.6	6.7	272.5	3.1	2.4	49.7	0.6
11	52.4	1.6	17.0	69.0	1.1	13.6	7.7	506.5	3.5	1.5	63.4	0.7
12	43.7	2.1	11.1	39.4	1.1	8.7	6.4	360.0	3.3	7.4	124.8	2.3
13	31.6	1.1	13.3	51.3	0.8	11.0	6.4	363.5	2.4	1.3	49.2	0.9
14	37.9	1.1	15.3	42.8	0.9	13.5	7.3	353.0	2.6	1.5	55.9	0.9
15	44.6	1.1	16.0	36.9	0.9	11.8	7.3	342.5	3.1	1.2	55.3	0.7
16	37.2	0.9	7.6	26.2	0.6	7.9	4.7	314.0	3.1	2.3	44.0	0.7
17	40.3	1.1	14.2	42.6	0.9	12.5	7.2	261.0	3.2	0.9	71.4	0.5
18	46.7	1.9	8.4	22.9	1.1	10.4	5.1	220.5	2.5	1.5	103.1	2.5
Minimum	31.6	0.9	7.6	22.0	0.6	6.2	4.7	151.0	1.9	0.9	44.0	0.4
Maximum	56.7	2.1	17.0	69.0	1.1	14.7	8.1	453.0	4.4	8. 9	128.1	2.5
Mean ± SD	45.2 ± 6.8	1.4 ± 0.4	12.0 ± 0.4	43.3 ± 12.8	1.0 ± 0.2	11.2 ± 2.5	6.4 ± 1.0	323.4 ± 9	3.0 ± 0.6	2.8 ± 2.4	69.7 ± 25	1.0 ± 0.6

Ca: Calcium, K: potassium, Na: sodium, Mg: magnesium, S: sulfur, P: phosphorus, Pb: lead, Zn: zinc, Mn: magnesium, Fe: iron, Ni: nickel.
SD: Standard deviation.

Table 3. Moisture and mineral content in bohça pastırma from Turkey.

No.	Moisture	Ca	K	Na	Mg	S	P	Zn	Pb	Mn	Fe	Ni
	%	----------g kg^{-1} dry wt.----------						----------mg kg^{-1} dry wt.----------				
1	46.5	1.4	10.2	38.9	1.1	16.2	7.1	394.5	2.1	2.5	99.2	0.7
2	42.7	1.4	9.8	41.7	1.0	12.1	7.5	335.5	2.8	1.5	66.2	0.5
3	54.6	1.1	11.2	50.2	0.8	9.4	5.9	184.0	2.6	1.5	44.9	0.9
4	57.9	0.9	9.7	47.1	0.8	10.4	5.5	197.5	2.1	1.5	35.4	0.7
5	45.6	1.7	8.9	41.1	1.0	9.0	5.4	217.5	3.0	6.3	106.6	1.3
6	48.7	1.3	10.7	48.7	1.0	11.3	6.3	233.5	3.0	3.2	75.0	1.2
7	49.5	1.3	12.8	54.1	1.1	11.8	7.1	371.5	2.7	1.3	73.0	0.7
8	48.9	2.0	9.4	42.0	1.0	6.0	5.1	151.0	2.9	8.1	96.5	1.3
9	44.8	1.1	11.9	45.7	0.8	12.1	6.3	277.5	3.2	2.8	68.3	0.6
10	45.3	1.2	11.3	58.4	0.6	10.9	5.5	270.5	3.4	0.9	57.4	0.8
Minimum	42.7	0.9	9.4	38.9	0.6	6.0	5.1	151.0	2.1	0.9	35.4	0.5
Maximum	57.9	2.0	12.8	58.4	1.1	16.2	7.5	394.5	3.4	8.1	106.6	1.3
Mean ± SD	48.4 ± 4.7	1.3 ± 0.3	10.6 ± 0.5	46.8 ± 6.1	0.9 ± 0.1	10.9 ± 2.5	6.2 ± 0.8	263.3 ± 80	2.8 ± 0.4	2.9 ± 2.3	72.3 ± 23	0.9 ± 0.3

Ca: Calcium, K: potassium, Na: sodium, Mg: magnesium, S: sulfur, P: phosphorus, Pb: lead, Zn: zinc, Mn: magnesium, Fe: iron, Ni: nickel.
SD: Standard deviation.

Table 4. Mean moisture and mineral content of kuşgömü, şekerpare, sırt, and bohça pastırma from Turkey.

Mineral	Pastırma types				Sig.
	Kuşgömü	Şekerpare	Sırt	Bohça	
Moisture (%)	38.6 ± 4.7 [b]	46.9 ± 5.3 [a]	45.2 ± 6.8 [a]	48.4 ± 4.7 [a]	**
Ca (g/kg dry wt. ± SD)	1.6 ± 0.3 [a]	1.5 ± 0.3 [ab]	1.3 ± 0.4 [b]	1.3 ± 0.3 [b]	*
K (g/kg dry wt. ± SD)	10.5 ± 0.6 [b]	11.0 ± 0.5 [ab]	12.0 ± 0.4 [a]	10.6 ± 0.5 [ab]	*
Na (g/kg dry wt. ± SD)	31.9 ± 7.6 [b]	47.7 ± 7.8 [a]	43.3 ± 12.8 [a]	46.8 ± 6.1 [a]	**
Mg (g/kg dry wt. ± SD)	1.1 ± 0.2 [a]	1.0 ± 0.2 [b]	1.0 ± 0.2 [b]	0.9 ± 0.1 [b]	*
S (g/kg dry wt. ± SD)	12.9 ± 2.3 [a]	10.3 ± 3.0 [b]	11.2 ± 2.5 [b]	10.9 ± 2.5 [b]	*
P (g/kg dry wt. ± SD)	6.5 ± 1.1 [a]	6.0 ± 0.8 [a]	6.4 ± 1.0 [a]	6.2 ± 0.80 [a]	ns
Pb (mg/kg dry wt. ± SD)	3.6 ± 0.8 [a]	2.6 ± 0.5 [b]	3.0 ± 0.6 [b]	2.8 ± 0.4 [b]	**
Zn (mg/kg dry wt. ± SD)	268.6 ± 74 [ab]	245.3 ± 102 [b]	323.4 ± 92 [a]	263.3 ± 80 [b]	**
Mn (mg/kg dry wt. ± SD)	3.9 ± 1.8 [a]	3.5 ± 1.7 [a]	2.8 ± 2.4 [a]	2.9 ± 2.3 [a]	ns
Fe (mg/kg dry wt. ± SD)	81.6 ± 15 [a]	73.2 ± 18 [a]	69.7 ± 25 [a]	72.3 ± 23 [a]	ns
Ni (mg/kg dry wt. ± SD)	1.1 ± 0.6 [a]	1.2 ± 0.5 [a]	1.0 ± 0.6 [a]	0.9 ± 0.3 [a]	ns

[a, b]: Values with different letters along rows are significantly different ($P < 0.05$), *: $P < 0.05$, **: $P < 0.01$, ns: not significant, SD: standard deviation.
Ca: calcium, K: potassium, Na: sodium, Mg: magnesium, S: sulfur, P: phosphorus, Pb: lead, Zn: zinc, Mn: magnesium, Fe: iron, Ni: nickel.

in the bohça pastırma samples was determined to be Na, followed by S, K, P, Ca, and Mg. The moisture values ranged from 42.7% to 57.9%.

The mean values of minerals and moisture determined in kuşgömü, şekerpare, sırt, and bohça pastırma types and their significance levels and Duncan's test results are shown in Table 4. Pastırma type had a significant effect ($P < 0.01$) on Na concentration and the highest average Na concentrations were determined from şekerpare, sırt, and bohça-eğrice types of pastırma, while the lowest value was obtained in kuşgömü pastırma (Table 4).

4. Discussion

The predominant mineral in the all of the pastırma samples was Na, while the amount of Na in raw beef was 69 mg/100 g (17). Ockerman (18) reported that the amount of Na in meat ranged from 0.044% to 0.168%. Karakök et al. (19) reported that the mean amount of Na in beef was 180.06 ± 2.89 ppm. In this study, the predominant mineral in all of the types of pastırma was Na. The main factors increasing Na in pastırma production were a loss of water in the drying process and usage of NaCl in a curing mixture. In the traditional dry curing method, the amount of sodium present in the pastırma increases because the surface of the meat is completely coated with salt (4,5). NaCl has some functional properties in meat products such as increasing water-holding capacity, binding fat, and providing color, flavor, and texture. Na, if used improperly or taken excessively, can be dangerous to human health. There is a positive relationship between high Na intake and the incidence of hypertension; therefore, there is a tendency to reduce the amount of NaCl in food (20). According to the Turkish Food Codex, Meat Products Communication, the maximum salt content of pastırma should be 7.0% of its dry mass. Aksu and Kaya (21) determined that the amount of salt in pastırma ranged from 4.87% to 6.07% and Doğruer et al. (22) reported that the mean amount of salt in pastırma was 6.15%. Similarly, Lawrie and Ledward (17) reported that, in cured meat, Na from the added salt predominates.

The amount of K was significantly ($P < 0.05$) affected by types of pastırma. The highest K concentration was found in sırt pastırma (12.0 ± 0.4 g kg^{-1} dry matter) and the lowest (10.5 ± 0.6 g kg^{-1} dry matter) in kuşgömü pastırma (Table 4). K is quantitatively the most important for raw beef, where the value of K has been reported as 334 mg/100 g (17). Similarly, Karakök et al. (19) reported that the amount of K in beef was 515.03 ± 15.39 ppm. The level of K in meat products depends on factors such as production conditions, the amount of K in raw meat, and the amount of water lost during the drying process.

The level of Ca in all of the pastırma samples ranged from 1.3 ± 0.3 to 1.6 ± 0.3 g kg^{-1} dry matter. Pastırma type had a significant effect ($P < 0.05$) on Ca concentration and

the highest values were determined in kuşgömü pastırma (Table 4). Lawrie and Ledward (17) reported that the amount of Ca as a mineral in raw beef was 5.4 mg/100 g, while Karakök et al. (19) determined that the amount of Ca in raw beef meat was 46.50 ± 1.64 ppm. Kan et al. (23) reported that the Ca in *Trigonella foenum-graecum L.* seeds used for the preparation of pastırma çemen ranged from 2030.706 to 2695.596 μg g^{-1}.

Pastırma type significantly affected S concentrations ($P < 0.05$). The highest amount of S ($P < 0.05$) was detected in kuşgömü pastırma (12.9 ± 2.3 g kg^{-1} dry weight), whereas there was no statistically significant difference among bohça (10.9 ± 2.5 g kg^{-1} dry weight), sırt (11.2 ± 2.5 g kg^{-1} dry weight), and şekerpare (10.3 ± 3.0 g kg^{-1} dry weight) pastırma (Table 4).

The level of P in all of the pastırma samples ranged from 6.5 ± 1.1 to 6.0 ± 0.8 g kg^{-1} dry weight. Pastırma type had no significant effect ($P > 0.05$) on P concentration and the highest value was determined in kuşgömü pastırma (Table 4). In raw beef, K content was followed by P at 276 mg/100 g and as 240.30 ± 3.43 ppm (17,19).

There was a significant difference ($P < 0.05$) in the Mg concentration of pastırma types. Among the types of pastırma, the highest Mg value was found in kuşgömü pastırma; there was no difference among the şekerpare, sırt, and bohça pastırma ($P < 0.05$) (Table 4). Karakök et al. (19) determined that the amount of Mg in meat was 48.54 ± 1.02 ppm. The Mg in *Trigonella foenum-graecum L.* seeds used for the preparation of pastırma çemen ranged from 1235.323 to 1521.036 μg g^{-1} (23).

Pastırma contains some trace elements in different concentrations (24). It has been previously reported that the highest average trace element concentrations were observed in pastırma, meat, and sausage made from different meat or meat and fish samples. In the present study, pastırma type was closely related to Pb concentrations ($P < 0.01$) (Table 4). The highest levels of Pb ($P < 0.05$) were detected in kuşgömü pastırma (3.6 ± 0.8 mg kg^{-1} dry weight), whereas there was no difference between bohça (2.8 ± 0.4 mg kg^{-1} dry weight), sırt (3.0 ± 0.6 mg kg^{-1} dry weight), and şekerpare (2.6 ± 0.5 mg kg^{-1} dry weight) pastırma. There was a significant difference ($P < 0.01$) in Zn concentration in various types of pastırma. Among the types of pastırma, the highest value was found in sırt pastırma (323.4 ± 92 mg kg^{-1} dry weight) ($P < 0.05$), and there was no difference between bohça (263.3 ± 80 mg kg^{-1} dry weight) and şekerpare (245.3 ± 102 mg kg^{-1} dry weight) pastırma (Table 4). Data in Table 4 show there were no significant differences ($P > 0.05$) in the Mn concentrations among pastırma types, and the concentration of Mn in all of the types of pastırma ranged from 2.8 ± 2.4 to 3.9 ± 1.8 mg kg^{-1} dry weight. Among the types of pastırma, the highest amount of Mn was found in sırt pastırma (3.9 ± 1.8 mg kg^{-1} dry weight). Ni levels in all of the pastırma types ranged from 0.9 ± 0.3 to 1.2 ± 0.5 mg kg^{-1} dry weight (Table 4), and there was no significant difference ($P > 0.05$) among types of pastırma. The level of Fe in all of the pastırma samples ranged from 69.7 ± 25 to 81.6 ± 15 mg kg^{-1} dry weight. There were no significant differences ($P > 0.05$) in Fe concentrations among pastırma types (Table 4). The amounts of Mn, Pb, Zn, Ni, and Fe in pastırma collected from the marketplace in Turkey were 6.6 ± 2.1 μg/100 g, 12.6 ± 2.1 μg/100 g, 159 ± 2.8 μg/100 g, 10.2 ± 0.7 μg/100 g, and 136.2 ± 1.8 μg/100g, respectively (24). In the present study, Ni values in all pastırma types were below these average values. The amounts of Pb, Zn, Ni, Mn, and Fe in *Trigonella foenum-graecum L.* seeds in pastırma çemen ranged from 0.010 to 1.078, from 43.947 to 70.267, from 1.475 to 3.386, from 13.171 to 17.575, and from 52.184 to 72.378 μg g^{-1}, respectively (23). Löker et al. (25) determined that the amount of Zn in Kayseri pastırma was 6.8 ± 0.2 mg/100 g.

Statistical analysis showed that there was a significant ($P < 0.01$) difference among moisture content in pastırma types. The lowest average moisture value was obtained from kuşgömü pastırma, while the highest value was in bohça, sırt, and şekerpare pastırma. Nevertheless, there were no significant differences ($P > 0.05$) in moisture levels among bohça, sırt, and şekerpare pastırma (Table 4). Ceylan and Aksu (8) determined that the average moisture values of sırt, bohça, and şekerpare pastırma were 47.17 ± 5.00, 46.61 ± 5.42, and 47.96 ± 3.21, respectively. They also reported that there was no statistically significant ($P > 0.05$) difference among types of pastırma for moisture values.

This study is the first one ever conducted to determine and to compare the mineral and heavy metal accumulation in the different types of pastırma. The highest amount of mineral in each of the 4 types of pastırma was Na, followed by K, S, P, Ca, Mg, Zn, Fe, Mn, Pb, and Ni. The amounts of Ca, K, Mg, Na, Pb, S, and Zn in sırt, kuşgömü, bohça, and şekerpare pastırma were significantly different, while no significant differences were determined among the types of pastırma regarding P, Mn, Fe, and Ni. The results of this study will help determine the changes that take place in the production stages of each type of pastırma with respect to minerals (Na, Pb, Ni, etc.) and the effects of different curing techniques on minerals. Although the results obtained in the present study demonstrated that the total mineral levels in all the analyzed pastırma types were acceptable according to the Turkish Food Codex, Meat Products Communication, Na levels may be reduced by using a different of type salt, such as $CaCl_2$ or KCl.

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