

The effects of drying, roasting and germination processes on the macro and micro element quantities of pumpkin seeds

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Abstract

In this study, the effects of drying, roasting and germination processes on the macro and microelement amounts of pumpkin seeds were investigated. While the P contents of raw pumpkin seeds vary between 5688.86 (control) and 9810.9 mg/kg (Microwave), the P contents of germinated pumpkin seeds were found to be between 845.92 (Oven) and 10134.20 mg/kg (Microwave). The K contents of raw pumpkin and germinated pumpkin seeds depending on the drying types were determined to be between 4039.59 (Microwave) and 5048.27 mg/kg (control) and 1239.56 (control) and 2131.92 mg/kg (microwave), respectively. The P, K and Ca contents of microwave dried germinated pumpkin seeds were higher than those of roasted (raw) pumpkin seeds. While the Fe contents of roasted raw pumpkin seeds varied between 56.28 (Microwave) and 65.91 mg/kg (Control), the Fe contents of germinated-dried pumpkin seeds varied between 40.12 (Oven) and 42.75 mg/kg (Microwave). The Zn contents of roasted raw and germinated pumpkin seeds were established as 37.79 (Control) and 64.66 (Microwave) and 1.42 (Control) and 59.17 mg/kg (Microwave). As in macro elements, decreases were observed in microelement contents of seeds during germination. It was observed that raw and germinated seeds were rich in Fe and Zn content.

Key words: pumpkin seed, roasting, germination, elements, ICP-OES.

1. Introduction

Pumpkin belongs to the family Cucurbitaceae, which includes several species of economic and agricultural importance, and all parts contain edible and beneficial nutraceutical compounds. It is known that pumpkin seeds are an important source of nutritional supplements in terms of macro elements such as magnesium, phosphorus, potassium, sodium and calcium and micro minerals such as iron, copper, manganese, zinc and selenium, which help eliminate various deficiency disorders [1]. In recent years, it has been understood from various studies that pumpkin fruit and its parts such as seeds are a nutrient-rich and multifunctional food substance [2,3]. The main basic elements of pumpkin are flesh (78.69%), peel (17.95%) and seed (3.63%), and all parts of pumpkin can be used as food

because they have a rich hazelnut flavor and an easily chewy and edible texture [4]. Pumpkin seeds, which have approximately 6.37%-6.56% moisture content, 35%-50% lipid, 25%-37% protein, 18%-25% carbohydrate, 3%-6% fiber and 3%-5% ash content, are considered a functional food ingredient that makes a significant contribution to human nutrition [3]. The germination process involves not only functional changes in seeds but also structural, morphological and physicochemical changes. Since the water content of seeds increases during germination, this directly affects the processing, characterization and stability of the products. Therefore, germinated seeds to provide a longer shelf life are dried and converted into flour, thus reducing undesirable physicochemical changes and thus providing higher commercial value to the product [5,6].

In addition to increasing the nutritional quality of the seed, the germination process also causes significant changes in the biochemical and sensory properties of the seed [7]. With the drying and roasting process applied to the seeds, the moisture content in the environment is removed, increasing the shelf life and stability of the seeds, and the development of the desired color, taste and aroma is provided [8,9]. Minerals that are provided by regular food consumption and needed by the human body are found in pumpkins and play vital roles in various body processes [10]. Commercially produced pumpkin (*C. pepo*) due to its high nutritional content; when grown as a snack, its fleshy parts and otherwise its seed (kernel) parts are considered agricultural waste. Pumpkin seeds, which are considered waste products, can be evaluated as delicious snacks by being subjected to industrial processes [11]. The seeds of *C. pepo* are used commercially due to their beneficial nutritional content [12]. The aim of this study was to investigate the effects of drying, roasting and germination processes on the macro and micro element contents of pumpkin seeds.

2. Material and methods

2.1. Material

Pumpkin (T23 Variety) seeds were obtained from pumpkin fruits grown by the Soil Department of Selçuk University. After washing, the seeds were subjected to drying and germination processes. The control group represents untreated pumpkin seeds and germinated pumpkin seeds.

2.2. Methods

Drying process

Pumpkin seeds and germinated pumpkin seeds were roasted in the microwave at 720 W/ 9 minutes. The seeds were roasted in the oven at 180 °C for 20 minutes. The air drying process was carried out in 12 days.

Germination processing

In the study; pumpkin seeds were used and compared with ungerminated seeds as a control group. Pure water was added to the seeds in a way that it would be 3 times more and they were left to soak for 24 hours at room temperature (24 ± 1 °C) in a dark environment. At the end of the soaking period, the seeds were drained and placed between two layers consisting of filter paper and cotton. When

placing the seeds, care was taken to spread them in a thin layer and to prevent them from touching each other. The seeds were watered with pure water every 24 hours and the germination process was stopped at the end of the 5th day.

Macro and microelement contents of pumpkin seed samples

After 0.2 g seed samples were ingenerated in a microwave device at 210 °C and 200 PSI pressure in 5 ml of concentrated HNO₃ and 2 ml of H₂O₂ (30% w/v), the volumes of the dissolved samples were completed to 20 ml with deionized water. Then, the seeds were separated and dissolved separately in the microwave device, and the elements were determined in the ICP-OES device. Then, macro and microelement concentrations in seed samples were defined by ICP-OES [13].

2.3. Statistical analysis

The JMP statistical program was used for the statistical analysis of results obtained. Statistically changes were carried out by the analysis of variance (ANOVA) procedure in all data ($p < 0.05$) [14]. In order to examine the correlation between the nutrient content of non-germinated and germinated pumpkin samples dried in different ways (control, microwave and oven), a multivariate cluster analysis was performed using the PAST statistical program to perform Principal Component Analysis (PCA) [15].

3. Results and Discussion

Macroelement contents of raw and germinated pumpkin seeds dried in different drying systems are illustrated in Table 1. While the P amounts of raw pumpkin seeds varied between 5688.86 (control) and 9810.9 mg/kg (Microwave), the P contents of germinated pumpkin seeds were found to be between 845.92 (Oven) and 10134.20 mg/kg (Microwave). The K contents of raw pumpkin and germinated pumpkin seeds depending on the drying types were determined between 4039.59 (Microwave) and 5048.27 mg/kg (control) and 1239.56 (control) and 2131.92 mg/kg (microwave), respectively. In addition, the average P and K contents of pumpkin samples depending on the drying types were 3385.71 (control) and 9972.55 mg/kg (Microwave) and 3088.76 (Microwave) and 3327.60 mg/kg (Oven), respectively. The Ca contents of raw and germinated pumpkin seed

Table 1. Macroelement contents of raw, roasted and germinated pumpkin seeds

Samples	P		K		Ca		Mg													
	----- (mg/kg) -----																			
	Control	Air drying	Microwave	Oven	Mean	Control	Air drying	Microwave	Oven	Mean	Control	Air drying	Microwave	Oven	Mean					
Raw	5688.86 B*	9186.60 AB	9810.91 A	8422.19 AB	8277.14 A	5048.27 A	3892.20 B	4039.59 B	4814.94 A	4448.75 A	315.79 DE	323.26 DE	294.05 E	379.13 D	328.06 B	4384.39 B	4518.83 B	4959.51 A	4374.19 B	4572.70 A
Germinated pumpkin seeds	1082.56 C	10134.20 A	10134.20 A	845.92 C	5549.22 B	1239.56 D	2015.26 C	2131.92 C	1840.26 CD	1806.74 B	116.14 F	775.38 B	997.05 A	648.68 C	634.31 A	183.13 D	2042.66 C	2342.66 C	2041.60 C	1652.51 B
Mean	3385.71 B	9660.40 A	9972.55 A	4634.05 B	3143.92 ab	2953.73 b	3088.76 b	3327.60 a		215.97 C	549.32 B	645.55 A	549.32 B	2278.66 C	3312.99 B	3651.09 A	3212.99 B			

*p<0.05

samples were established between 294.05 (Microwave) and 379.13 mg/kg (Oven) and 116.14 (control) and 997.05 mg/kg (Microwave), respectively. In addition, the Mg contents of raw pumpkin seeds were determined between 4374.19 (control) and 4959.51 mg/kg (Microwave), while the Mg contents of germinated pumpkin seeds were defined to be between 183.13 (control) and 2342.66 mg/kg (Microwave). The average P, K and Mg quantities of pumpkin seeds were higher than those of germinated ones. The P, K and Ca contents of microwave dried germinated seeds were higher than those of roasted (raw)

pumpkin seeds. The macro element contents of pumpkin (raw) seeds compared to the control group decreased significantly with germination. In addition, the average macro element contents of germinated seeds (except Ca) were lower than those of unroasted pumpkin seeds. In addition, the K, Ca (except oven) and Mg amounts of germinated seeds were lower than those of roasted seeds. This decrease may be due to the physiological use of elements as plant nutrients by seeds during germination, shell particles separated from the seed during roasting and oxidation under the influence of heat.

Table 2. Microelement contents of raw, roasted and germinated pumpkin seeds

Samples	Fe		Zn		Cu		Mn		B																
	----- (mg/kg) -----																								
	Control	Air drying	Microwave	Oven	Mean	Control	Air drying	Microwave	Oven	Mean	Control	Air drying	Microwave	Oven	Mean										
Raw pumpkin	65.91 A*	53.88 B	56.28 B	62.57 A	59.66 A	37.79 BC	60.66 AB	64.66 A	51.45 AB	53.64 A	8.36 D	9.30 AB	10.03 A	9.62 AB	9.33 A	21.43	28.95	30.87	26.09	26.83 A	7.72 F	8.24 DE	8.13 EF	8.72 CD	8.20 B
Germinated pumpkin seeds	40.96 D	38.75 C	42.75 C	40.12 C	41.27 B	1.42 D	43.67 ABC	53.66 AB	22.19 CD	30.24 B	0.64 E	7.95 CD	9.28 B	7.45 D	6.33 B	0.67	5.95	6.95	4.14	4.43 B	9.00 C	9.94 B	10.94 A	9.21 C	9.77 A
Mean	53.44 C	46.21 B	49.51 AB	51.35 A	19.60 C	52.17 AB	59.17 A	36.82 BC	4.49 C	8.62 B	9.66 A	8.54 B	11.05 C	17.45 AB	18.91 A	18.12 B	8.36 C	9.09 B	9.53 A	8.97 B					

* p<0.05

Microelement amounts of raw and germinated pumpkin seeds roasted in microwave and oven are given in Table 2. While the Fe quantities of roasted raw pumpkin seeds varied between 56.28 (Microwave) and 65.91 mg/kg (Control), the Fe contents of germinated-dried pumpkin seeds varied between 40.12 (Oven) and 42.75 mg/kg (Microwave). The Zn contents of roasted raw and germinated pumpkin seeds were displayed as 37.79 (Control) and 64.66 (Microwave) and 1.42 (Control) and 59.17 mg/kg (Microwave). Depending on the pumpkin seed types, the average Zn contents were determined as 53.64 (Raw) and 30.24 mg/kg (germinated seeds). The average Cu amounts of the seed samples depending on the drying types ranged between 4.49 (control) and 9.66 mg/kg (Microwave). The Mn contents of the raw and germinated seed samples were determined between 21.43 (control) and 30.87 (Microwave) and 0.67 (Control) and 6.95 mg/kg (Microwave), respectively. In addition, B contents of raw and germinated-roasted seed samples were characterized as 7.72 (control) and 8.72 (Oven) and 9.00 (control) and 10.94 mg/kg (Microwave), respectively. As in macro elements, decreases were observed in microelement contents of seeds during germination. It was observed that raw and germinated seeds were rich in Fe and Zn content. The highest average microelements depending on the roasting types were detected in microwave roasted samples (except Fe). Differences in microelement contents of raw and germinated pumpkin samples roasted in microwave and oven compared to the control group of pumpkin seed samples may have been due to the applied heat treatment norms (temperature and time).

El-Adawy and Taha [16] determined 1.7 mg/100g Cu, 8.2 Zn, 10.9 Fe, 8.9 Mn, 483 Mg, 38 Na, 130 Ca Ca, 982 K and 1090 P in pumpkin seed flour. Raw, germinated and roasted pumpkin seed flour contained 102.4, 143.1 and 103.3 mg/100g K, 43.05, 51.20 and 42.85 Na, 4.59, 3.37 and 3.0 mg/100g Ca, 1.57, 2.50 and 1.15 Mg, 42.66, 61.01 and 51.34 mg/100g P, 0.27, 0.25 and 0.43 mg/100g Zn, 2.63, 3.65 and 1.47 mg/100g Fe, 0.53, 0.45 and 0.12 Cu, respectively [17]. All flours are sources of P, K, Mg and Ca. Dhiman *et al.* [18] and Badu *et al.* [19] found that pumpkin seeds contained 1676 mg/100 g and 33.14 mg/100 g Fe, respectively, and reported that this was due

to the difference in varieties. Rezig *et al.* [20] reported that pumpkin (*C. pepo*) seeds contained 89.84 mg/100 g Cu. It has been reported that Cucurbita sp seeds contain very little calcium and that manganese, selenium and copper contents in pumpkin seeds are in the range of 0.06-8.90, 0.13-2.57 and 1.38-1.91 mg/100 g [21]. The germinated pumpkin flours dried at 70°C contained 587.04-861.88 mg/100g K, 1302.20-1734.78 P, 878.06-1144.23 mg/100g Mg, 66.78-111.16 Ca, 12.68-17.62 Fe, 1.12-1.76 Cu and 3.96-8.19 mg/100g Mn [6]. It has been confirmed that the drying process in germinated pumpkin seed flours provides benefits in terms of mineral concentration [22]. There is a decrease in minerals in pumpkin seeds with the germination compared to seeds in nature due to the seeds absorbing water during germination [22]. Vieira *et al.* [23] observed that pumpkin flour dried in microwave and forced air ovens did not affect the concentration of micro and macro elements. When the macro and micro element amounts of raw and roasted pumpkin seeds and germinated seed samples were compared with the results of Lazos [24], El-Adawy and Taha [16], Dhiman *et al.* [18], Badu *et al.* [19], Rezig *et al.* [20] and Glew *et al.* [21], they showed similarities with high amounts of elements such as P, K, Mg, Fe, Zn, but they showed differences with their amounts. These differences probably vary according to whether the seeds are raw, roasted, germinated, and may also be affected by growing conditions, climatic factors, variety, genetic and analytical conditions.

Principal Component Analysis (PCA)

Pearson correlation (r) between macro (P, K, Ca and Mg) and micro (Fe, Zn, Cu, Mn and B) nutrient element contents of non-germinated and germinated zucchinis dried in different ways (control, microwave and oven) are given in Figure 1 and 2. When the macro and micro element quantities of the pumpkin samples dried in different ways were examined; it was determined that there were positive relationships between the macro and micro contents of the samples. In addition, it was determined that there were significant and strong positive relationships ($p < 0.05$, $r > 0.70$) between the Ca content and Mg content ($r = 0.999^{**}$) and between the Mn content and B content ($r = 0.998^{**}$). The Pearson correlation analysis was used to determine the strength

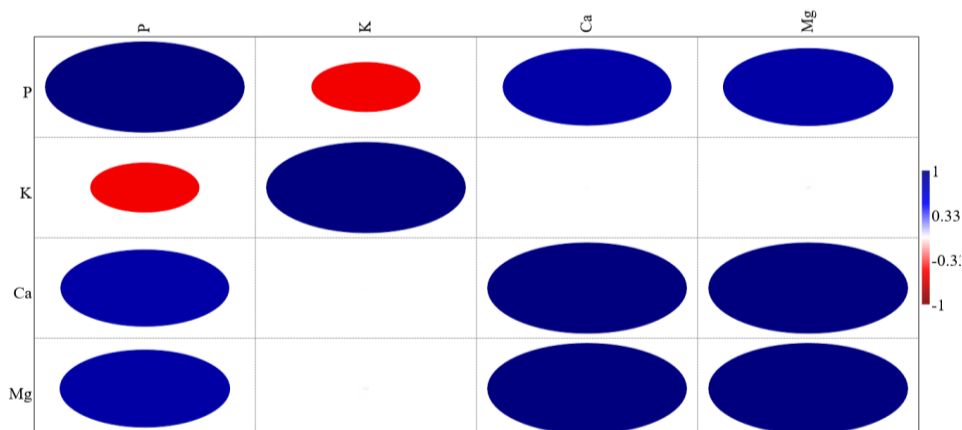


Figure 1. Pearson correlation (r) between macro (P, K, Ca and Mg) nutrient element contents of non-germinated and germinated zucchinis dried in different ways (control, microwave and oven).

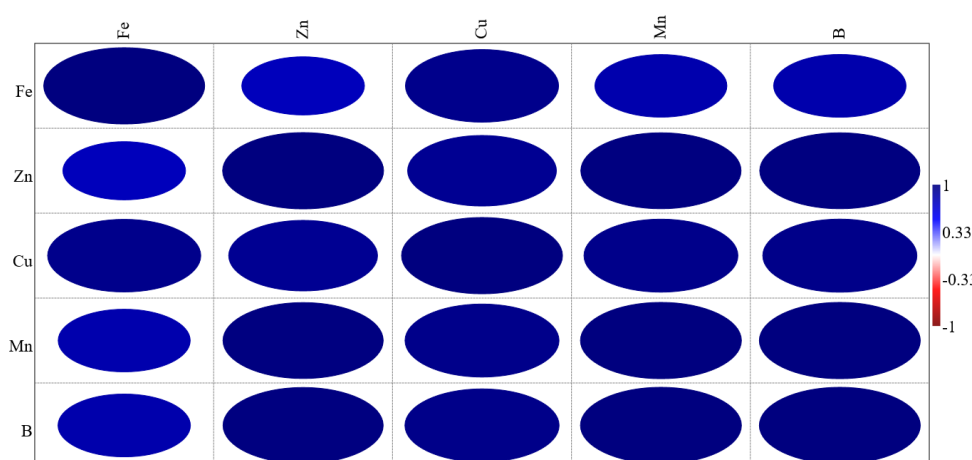


Figure 2. Pearson correlation (r) between micro (Fe, Zn, Cu, Mn and B) nutrient element contents of non-germinated and germinated zucchinis dried in different ways (control, microwave and oven)

and direction of the relationship between the nutrient content of the variable ungerminated and germinated squash samples, and with this Pearson correlation, the best fit line was tried to be drawn over the data on the nutrient content of the ungerminated and germinated squash samples. Thus, the Pearson correlation coefficient (r) revealed how far all these data points were from the best fit line [25].

4. Conclusions

The P, K and Ca contents of microwave dried germinated pumpkin seeds were higher than those of roasted (raw) pumpkin seeds. The macro element contents of pumpkin (raw) seeds compared to the control group decreased significantly with germination. In addition, the K, Ca (except oven) and Mg amounts of germinated pumpkin seeds were lower than those of roasted pumpkin seeds. It was observed that raw and germinated seeds were rich in Fe and Zn content. The highest average microelements

depending on the roasting types were established in microwave roasted samples (except Fe).

Conflicts of interest: No conflict of interest

Ethics declaration: not applicable

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