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Preliminary research on garlic peel powder as a source of essential mineral elements

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Abstract
Garlic peel, by-product obtained from peeling garlic bulbs (*Alium sativum* L.) contains important amounts of proteins, fibers, minerals, carbohydrates and a number of biologically active compounds. The purpose of this paper was to determine the content of mineral elements in the garlic peel obtained by peeling the local white garlic bulbs sold in local markets and to evaluate their mineral intake. The average values obtained when determining the mineral content: 30.23 mg/100g Na, 1786 mg/100g K, 6074 mg/100g Ca, 542 mg/100g Mg, 5.74 mg/100g Fe, 0.382 mg/100g Mn, 2.51 mg/100g Zn, and 0.816 mg/100g Cu, shows that the analyzed garlic peel samples contain increased amounts of macro and microelements essential for the proper functioning of the body. The results obtained from the evaluation of the mineral intake show that, under the conditions of the present experiment, a quantity of 50 g of garlic peel covers different percentages of the daily requirement of some mineral elements: 1.01% Na, 26.3% K, 304% Ca, 64.5% Mg, 35.9% Fe, 8.30% Mn, 11.41% Zn, 45.33% Cu – for men aged between 19-50 and 1.01% Na, 34.5% K, 304% Ca, 87.4% Mg, 15.9% Fe, 10.6% Mn, 15.7% Zn, 45.33% Cu – for women aged between 19-50 years. These values suggest that the investigated garlic peel could be taken into consideration for obtaining products with added mineral content, especially in the case of calcium, potassium, copper and iron. The superior utilization of garlic peels can provide an ecological method of reducing the waste resulting from peeling garlic bulbs.
Key words: garlic peel powder, essential elements, mineral intake

1. Introduction

Garlic (*Allium sativum L.*) is a common culinary spice grown and used all over the world. It is often used in the preparation of traditional products such as stews, mayonnaise, sausages, ketchup and salads, but also it can be used for health purposes in order to reduce blood pressure, cholesterol and triglyceride levels, to control platelet aggregation, to inhibit cancer cells proliferation or as an antimicrobial agent [1, 2, 3]. Several studies have shown that garlic has antioxidant, antiviral, antimicrobial, antifungal, antihypertensive, antianemic, antihyperlipidemic, anticarcinogenic, antiaggregatory and immunomodulatory properties [4]. Consumption of garlic and its supplements reduces the risk of diabetes and cardiovascular disease and strengthens the immune system with antibacterial, antifungal, anti-aging and anti-cancer properties [4, 5].

Dried garlic contains 4.55% moisture, 4.08% crude ash, 15.33% crude protein, 0.72% crude fat, 2.10% crude fibre, 73.22% carbohydrates. It also contains 10.19 mg/100g K, 26.30 mg/100g Ca, 0.001 mg/100g Mg, 10.19 mg/100g P, 5.29 mg/100g Fe, 0.34 mg/100g

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Zn, 0.001 mg/100g Mn [6]. Garlic is also acidic (pH=3.91) and contains 4.21, 3.54, 0.64, 0.80, 5.56, 0.04 and 0.02 mg/100g alkaloids, tannins, carotenoids, saponin, flavonoids, steroids and cardenolides [6]. The chemical composition and content of bioactive compounds in garlic varies depending on a number of factors such as genotype, cultivation techniques, soil and climatic conditions, etc. [7].

The health benefits of garlic may be due to the presence of both volatile (involved in flavour) and non-volatile compounds (proteins, minerals, amino acids, amino acids, antioxidants, organo-sulphur compounds and other phytochemicals) [1,2]. Garlic contains about 200 chemical compounds, including sulphur-containing compounds (such as allicin, ajoene, vinyl-dithiin), volatile oils, enzymes, carbohydrates, minerals, amino acids and vitamins (vitamin C, B vitamins) [4, 5, 8].To use garlic in the form of peeled cloves in food production, it is necessary to remove the skin covering the bulb and cloves.100 g of garlic bulbs yield about 0.76 g of cloves and 0.24 g of outer and inner skin [9]. The obtained skins, which make up about 25% of the total garlic, are considered a by-product and also contain significant amounts of nutrients and phytochemicals [10]. Garlic peel, the discarded part of garlic after processing, has metabolically active components similar to garlic bulbs [11]. Garlic peel waste is rich in cellulose and functional ingredients and can be used as a functional material for the production of high value-added products [12, 13].

Previous studies have shown that garlic peel contains significant amounts of nutritional and bioactive compounds that make it possible to use it as an additive to improve the quality of food products or to obtain pharmaceutical products with potential applications in the prevention and treatment of various diseases and also in animal feed. [3, 12, 14, 15, 16, 17]. According to Zhivkova, washed garlic peels were characterized by the highest content of total fibre (62.10%), total sugars (6.51%), dry matter (80.8%), total ash (7.37%), B (18.0 mg/kg), Al (826 mg/kg), S (1635 mg/kg), K (9081 mg/kg), Ca (20610 mg/kg), Cr (18. 40 mg/kg), Mn (35.4 mg/kg), Fe (682 mg/kg), Zn (12.9 mg/kg), Se (0.058 mg/kg) and Mo (1480 mg/kg) as well as 8.5% digestible carbohydrates, 1.36% reducing sugars, 2.61% crude protein and 0.22% free fat [15]. Lyngdoh and Ray's experimental studies showed that garlic peel is a rich source of total phenolics (108.79 µg/ml GAE), total flavonoids (33.27 mg quercetin/ml) and has significant antioxidant activity (33.38 mg/ml) [16]. According to Min *et al*, garlic peel contains 10.97g/100g moisture, 3.39g/100g crude protein, 0.56g/100g crude fat, 5.83/100g crude ash, 79.25g/100g carbohydrate, 6.25% total pyruvate, 57.77mg/100g total polyphenols, 3.68mg/100g total flavonoids, 57.45% DPPH radical scavenging capacity [17]. The non-nutritional and bioactive compounds of garlic skin give this by-product several biological properties, such as antioxidant, anticancer, antidiabetic, antimicrobial, antiviral, antiinflammatory, cardioprotective, neuroprotective, hepato-protective, which have allowed its use in the treatment and prevention of various diseases [3].

The nutritional quality and health benefits of garlic are determined by the quality of the compounds in their composition and therefore the mineral content. Previous studies have shown that garlic peels contain high levels of minerals [3], which depends on the variety, cultivation practices, growing conditions, soil type, fertilizer application rates and garlic bulb peeling method [14]. Since in most references the mineral composition of garlic peel is expressed as a percentage of ash, we considered the percentage of ash to represent the total mineral content. In fact, we prefer to give information on the number of mineral elements that are part of the product [18].

Data on the mineral (ash) content of garlic peels were reported by Pathak *et al.* in a characterization of fruit and vegetable peels as bioadsorbents, they showed that garlic peels contained 8.47% ash [19]. Caglar and Aydinli, in a study on the characterization of pyrolysis products from the pyrolysis of industrial-related vegetable waste, reported that garlic inner and outer peels (with moisture contents of 15.03 and 12.85%, respectively) had ash contents of 6.30 and 9.76%, respectively [20]. Investigating the use of garlic peel powder as a sorbent for the removal of phenol from aqueous systems, Muthamilselvi et al. showed that the GPP used in these experimental studies had a moisture content of 2.69% and an ash content of 7.67% [21]. In a study of the effect of processing methods on the quality characteristics of garlic peels, Min *et al.* showed that garlic peels with a moisture content of 10.97% contained 5.83% crude ash [17]. De Lima Bezerra *et al.* reported an ash content of 8.42% for natural garlic peels with a moisture content of 8.50% and an ash content of 6.50% for black garlic peels with a moisture content of 9.61% [22].

In a study on the valorization of garlic peel as a potential ingredient for the development of a value-added feed, Lyngdoh et al. showed that garlic peel contains 16.34% ash [16]. Ding et al. showed that garlic peels contain 5.60-7.95% total minerals in a study on the use of garlic products in ruminant diets [14]. According to Prakash et al., raw garlic peel powder has an ash content of 5.41% [12].

It should be noted that there is little concrete information on the distribution of macro- and microelements in garlic peel. Information on the mineral composition of garlic peel has also been presented by Odilovna et al. they reported that garlic peel contains a rich set of macro- and microelements, which can vary greatly depending on growing conditions, climatic zone and diversity: 5134.817 mg/kg Ca, 5031.959 mg/kg K, 1103.573 mg/kg Mg, 790.391 mg/kg P, 790.943 mg/kg Na, 393.163 mg/kg Si, 203.658 mg/kg S, 178.245 mg/kg Al, 22.314 mg/kg Ti, 10.042 mg/kg B, 4.298 mg/kg Mn, 0.496 mg/kg Cr, 0.10 mg/kg Be, 0.099 mg/kg V [23]. Proceeding to the determination of nutritional and mineral composition of wasted peels of garlic, onion and potato, Zhivkova, showed that the wasted peels were characterized by increased macroelements and significant contents of microelements: 20610 mg/kg Ca, 9081 mg/kg K, 1635 mg/kg S, 826 mg/kg Al, 682 mg/kg Fe, 35.4 mg/kg Mn, 12.9 mg/kg Zn, 18.0 mg/kg B, 18.40 mg/kg Cr, 0.058 mg/kg Se, 1480 mg/kg Mo [15]. For the synthesis of activated charcoal from garlic peel, Ji et al. reported that the used garlic peel contains 46.48% C, 42.69% N, 2.2% Mg, 1.75% Al, 2.69% K and 4.19% Ca [24]. In a study on biochemical characterization of vegetable waste, Hashmi et al. found that garlic peel waste (5.23% moisture) contains 174 mg/kg Ca, 26 mg/kg Na, 478 mg/kg K, 3.75 mg/kg Fe, 0.27 mg/kg Zn [25].

It can be observed that garlic peel, considered as a by-product of garlic processing, contains increased amounts of essential mineral elements, especially Ca, K, Mg, P, S, but also Na, Fe, Mn, Zn, Cr. Therefore, the waste garlic peel, after a preliminary processing, could be used as an additive for enrichment the mineral content of some food products. The aim of this work was to determine the mineral element content of garlic peel obtained by peeling local white garlic bulbs sold in local markets and to evaluate their mineral contribution.

2. Material and methods

2.1. Material

To perform the experiment, white garlic bulbs of different sizes commercialized by three producers in the flying agri-food market in Timisoara – Romania, were taken from the fall harvest of 2023 (Figure 1 a). About 2 kg of randomly chosen bulbs were used to obtain the peels.

a **b**

Figure 1. The bulbs (a) and peels of white garlic (b)

The bulbs were peeled by hand and the obtained peels were washed first in running tap water, then in distilled water to remove adhering debris and dried in an oven at 60°C for 10 h. The dried garlic peels (Figure 1b) were then ground using a coffee grinder (Figure 2) and used as samples to determine the mineral element content. The powder samples from the garlic peels were stored in polyethylene bottles in a refrigerator at 4°C until analysis.

Figure 2. Powder of white garlic peels

2.2. Methods

The essential mineral elements determination from garlic peel powder (GPP) were carried by flame absorption spectrometry using the calcination method (550°C), followed by solubilizing the ash in HNO_3 of 0.5 N concentration and measuring the absorbance of mineral elements using the FS Varian AA - 240 FF Spectrometer [26]. Calcination of the samples (1.0000 g) was done at 500^0 C, in two steps of 4 hours each. After cooling, the ashes were treated with 25 mL of HNO_3 0.5 N concentration in solution, and then evaporated until almost dry; the last operation was repeated two more times. After the complete solubilisation the sample solution was filtered and made up to 50 ml with bidistilled water and submitted for the carried-out measurements.

The analysis performed in order to determine the concentrations of essential mineral elements was carried out in the accredited laboratory "Physico-chemical analysis laboratory of the Office for Pedological and Agrochemical Studies Timisoara," using the "Varian AA-240 FF" absorption spectrometer.

3. Results and Discussion

Preliminary results of the determination of Na, K, Ca, Mg, Fe, Mn, Zn and Cu in GPPs obtained from the peeling of white garlic bulbs commercialized by local producers in the markets of Timisoara (Romania) are presented in Table 1.

Table 1. The mineral content in garlic peel

Specification	Mineral elements, mg/100g dry weight							
	Na	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**
Limit values	27.5-32.3	1714-1857	5652-6386	485-586	4.94-6.41	0.332-0.433	2.43-2.61	0.753-0.889
Mean values	30.2±2.00	1786±58.46	6074±309	542±42.36	5.74±0.61	0.382±0.04	2.51±0.07	0.816±0.06

The limit values represent the minimum and maximum values obtained for three determinations for each element analyzed, and the mean value is the average of the values of the three determinations.

The data presented in Table 1 show that the GPP analyzed contain high amounts of macroelements and important amounts of essential microelements, unevenly distributed depending on the garlic producer and the type of mineral element: 5652-6386 mg/100g Ca, 1714-1857 mg/100g K, 485-586 mg/100g Mg, 27.5-32.3 mg/100g Na, 4.94-6.41 mg/100g Fe, 2.43-2.61 mg/100g Zn, 0.753-0.889 mg/100g Cu and 0.332-0.433 mg/100g Mn. Among the analyzed mineral elements, the best represented are macro elements. They were found in the following average concentrations: 6074±309 mg/100g Ca, 1786±58.46 mg/100g K, 542±42.36 mg/100g Mg and 30.2±2.00 mg/100g Na. Microelements were found in much lower concentrations than macroelements, their average concentrations being as follows: 5.74 mg/100g Fe, 0.382 mg/100g Mn, 2.51 mg/100g Zn and 0.816 mg/100g Cu. The average concentrations of the main mineral elements in the GPP analyzed show the following decreasing trend Ca> K> Mg> Na> Fe> Zn> Cu> Mn.

Comparing the obtained values with those reported by other authors [15, 23, 24, 25] when analyzing similar products, it can be seen that they are higher. However, they are generally of the same order of magnitude. The differences are justified by the fact that the chemical composition of GPs varies depending on genotype, cultivation techniques, pedoclimatic conditions, etc. [7].

Calcium, an essential macroelement required for the health of the heart, muscles and digestive system, building bones and supporting the synthesis and function of blood cells [27], was found in the highest concentrations of the essential elements determined (5652-6386 mg/100g). The very high average concentration of calcium in the analyzed sample of GPP (6074 mg/1100g) indicates that GPP contains increased amounts of Ca, and recommends its use as a source of Ca to obtain foods with added calcium.

Potassium is an essential macroelement that plays an important role in all metabolic processes, in neuromuscular regulation, in muscle protein synthesis, in the normalization of heart rate, in the synthesis of insulin and adrenaline, and in the stabilization of intracellular osmotic pressure [27]. It was determined in concentrations lower than calcium, but much higher than magnesium and sodium (1714-1857 mg/100g). These values, together with the average concentration of this element (1786±58.46/100g), show that the GPP analyzed contains increased amounts of potassium and can be used to supplement with potassium foods low in this essential element.

Magnesium is an essential macroelement for ATP processing and for bones, and its deficiency increases the risks of cardiovascular diseases, favors memory loss, the occurrence of osteoporosis, diabetes, arterial hypertension, etc. [27]. The analyzed GPPs contain high amounts of Mg (5424±2.36 mg/100g), but much lower than Ca and K and much higher than Na. However, the concentration limits of magnesium (485-586 mg/100g) show that the analysed GPP can be used as an additive to increase the Mg content in food. Sodium, an essential macroelement that controls cellular osmotic pressure and body water volume, stimulates muscle tone and maintains blood pressure [27], was found in much lower concentrations than Ca, K and Mg (30.2± 2.00mg/100g, average), but higher than the microelements: Fe, Zn, Cu, Mn. The sodium concentration limits (27.5-32.3 mg/100g) show that the analysed GPPs contain moderate amounts of Na.

The highest concentration (4.94-6.41 mg/100g) of the microelements analyzed was found for iron, an essential element for almost all living organisms because it is involved in a wide range of metabolic processes, including oxygen transport, deoxyribonucleic acid (DNA) synthesis and electron transport [27]. The average concentration of this essential element in analyzed GPPs samples (5.74 ±0.61 mg/100g) indicates that GPPs contain important amounts of Fe, so that they can be used as a mineral supplement.

Zinc was found in a lower concentration than iron (2.51±0.07 mg/100g), but higher than Cu and Mn. Zinc is an essential trace element that performs a variety of functions in the human body, such as the maintenance of physiological processes, metabolism, signaling, transduction, cell growth and differentiation [28]. The analyzed GPPs contain sufficient Zn, the concentration limits of this essential micro-element being between 2.43-2.61 mg/kg. These values show that the analyzed GPP can be considered as a source of Zn.

Copper, an essential trace element, is involved in a wide range of biological processes, from immune and neural functions to the health of the bones and blood or the antioxidant defense system [28]. The analyzed GPPs contain sufficient amounts of copper (0.753-0.889 mg/100 g) to cover the daily requirement as a source of copper. The average content of copper in the analyzed GPP (0.816±0.06 mg/100 g) suggests that it can be used as a source of that element.

Manganese is essential for bone formation and the metabolism of amino acids, lipids, proteins and carbohydrates [28]. This microelement was found in the lowest concentrations of all the elements analyzed (0.332-0.433 mg/100g). The average Mn concentration (0.382±0.04 mg/100g) shows that the analyzed GPP contains much lower amounts, especially compared to the macroelements (Ca, K, Mg, Na) and lower compared to Fe, Zn and Cu. The use of the analyzed GPP as a Mn supplement would therefore be of little interest.

The increased content of essential elements in the garlic peels collected in the experiment suggested the evaluation of the analyzed GPP. The content of essential elements in 50 g of GPP was taken into account in the evaluation of Mn: 30.2 mg Na, 1786 mg K, 6074 mg Ca, 542 mg Mg, 5.74 mg Fe, 0.382 mg Mn, 2.51 mg Zn, 0.816 mg Cu and from the recommended daily mineral intake of Na, K, Ca, Mg, Fe, Mn, Zn and Cu for men and women aged 19-50 years (Table 2).

The MI is calculated according to the following formula:

$$MI\ (\%) = \frac{c}{a} \cdot 100$$

where: MI – mineral supply, c – amount of element (mg) eaten/day, a – amount of element (mg) recommended/day.

Table 2. Dietary Reference Intakes (DRIs): Recommended Dietary Allowance and Adequate Intakes, Elements Food and Nutrition Board, National Academies [29]

Specification	People	Mineral element, mg/day Na	K	Ca	Mg	Mn	Fe	Zn	Cu
Recommended values	Man	1500	3400	1000	420	2.3	8	11	0.9
	Women	1500	2600	1000	310	1.8	18	8	0.9

The mineral supply of the analyzed GPP, i.e. the degree of coverage of the daily-recommended mineral diet with Na, K, Ca, Mg, Fe, Mn, Zn, and Cu for 50 g of dried GPP is shown in Table 3.

Table 3. Mineral intake, in the recommended daily diet, for a consumption of 50 g of GPP

People	Mineral supply (%) Na	K	Ca	Mg	Mn	Fe	Zn	Cu
Man	1.01	26.26	304	64.52	35.88	8.30	11.41	45.33
Women	1.01	34.35	304	87.42	15.94	10.61	15.69	45.33

As shown above, the value of the mineral supply of the GPP has different values depending on the essential mineral contents in the 50 g of GPP, the essential mineral requirement recommended by the gender and age of the consumer. The obtained results show that, under the conditions of the present experiment, a quantity of 50 g of garlic peel covers different percentages of the daily requirement of some mineral elements: 1.01% Na, 26.3% K, 304% Ca, 64.5% Mg, 35.9% Fe, 8.30% Mn, 11.41% Zn, 45.33% Cu – for men 19-50 aged and 1.01% Na, 34.5% K, 304% Ca, 87.4% Mg, 15.9% Fe, 10.6% Mn, 10.6% Zn, 45.33% Cu – for women 19-50 aged. These values show that a consumption of 50 g of GPP can cover high percentages of the required for Ca, Mg, Cu, Cu, Mn, and significant percentages of Zn and Fe. Under these conditions, 50 g of GPP ensures an amount of Ca three times higher than the recommended requirement. Because the "Dietary Reference Intakes (DRIs): Tolerable Upper Intake Levels, Elements" does not specify a maximum limit of Ca requirement, a 50 g of GPP does not present a risk of toxicity with Ca [30]. GPP is not of interest from the point of sodium daily intake.

4. Conclusion

Garlic peel, by-product obtained from peeling garlic bulbs (*Allium sativum L.*) also contains important amounts of minerals essential in the proper functioning of the body.

The obtained results in the analysis of garlic peel powder, obtained from the peeling of garlic bulbs sold in agrifood markets, show that this by-product contains increased amounts of mineral elements, especially Ca, K, and Mg (6074, 1786, respectively 542 mg/100g), and important amounts of Na, Fe, Zn, Cu and Mn (30.23, 5.74, 2.51, 0.816, and respectively 0.382 mg/100g Mn), essential for the proper functioning of the body.

The preliminary results obtained from the evaluation of the mineral intake show that, under the conditions of the present experiment, a quantity of 50 g of garlic peel covers can cover high percentages of the need for Ca, Mg, Cu, Cu, Mn, and significant percentages of Zn and Fe.

We consider that further studies are needed to characterize other nutritional and biologically active constituents responsible for the health-promoting uses of garlic peels.

These results suggest that the investigated garlic peel could be considered for obtaining products with added mineral content, especially in the case of calcium, potassium, zinc, copper and iron. Furthermore, the superior utilization of garlic peels can provide an ecological method of reducing the waste resulting from peeling garlic bulbs.

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