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DETERMINATION OF THE MINERAL PROFILE OF POTATOES PEEL, BY-PRODUCT FROM POTATO PROCESSING - A PRELIMINARY STUDY

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Abstract

Potatoes play an important role in ensuring global food security. The potato peel, resulting as a by-product from the processing of potatoes, still contains available quantities of nutrient compounds, among which the mineral elements are counted. The purpose of this study is to determine the mineral profile of the potato peel obtained by peeling some local potatoes, in order to use them to enrich the mineral intake of some food products. The total concentrations of Na, K, Ca, Mg, Fe, Mn, Zn and Cu potato peel from potatoes sold in agro-food markets from Timișoara city (Romania) were determined. Preliminary results revealed that 100g of dried potato peel contain appreciable amounts of essential elements: 38.60-82.30 mg/100 g Na, 1856-2531 mg/100 g K, 155-201 mg/100 g Ca, 122-193 mg/100 g Mg, 4.62-10.88 mg/100 g Fe, 0.64-1.22 mg/100 g Mn, 1.61-2.53 mg/100 g Zn, 0.78-1.60 mg/100 g Cu. These values suggest that these by-products, after proper processing, could be introduced into the diet as a source of essential minerals.

Key words: *potato, potatoes peel, essential minerals.*

INTRODUCTION

Potatoes are one of the main food sources in the world, being a valuable source of starch, proteins, ascorbic acid, carbohydrates, minerals, vitamins and fibers, alkaloids, flavonoids, phenolic compounds and low fat content (Priedniece et al., 2017; Taiyeba et al., 2020). The potato tubers have high concentrations of promoting substances, like ascorbate, carotenoid, and various organic acids and amino acids which enhance the absorption of essential micronutrients. The potato fibers, the potassium, the C and B6 vitamins, together with the lack of cholesterol, all sustain the health of the heart (Nischala, 2019). According to Frida fooddata dk., the proximate composition and mineral content of raw potato (*Solanum tuberosum* L.), shows the following values: 2.00% protein, 17.30% carbohydrate, 1.40% dietary fibre, 0.30% fat, 0.90% ash, 20.50 % dry matter, 7.00 mg/100 g Na, 414 mg/100 g K, 6.76 mg/100 g Ca, 20.40 mg/100 g Mg, 1.03 mg/100 g Fe, 0.05 mg/100 g Cu, 0.30 mg/100 g Zn, 0.23 mg/100 g Mn, 0.60 µg/100 g Cr, 0.27 µg/100 g Se, 55.20 mg/100 g P, 1.20µg/100 g I, 5.75µg/100 g Ni, 0.28µg/100 g Hg, 1.39 µg/100 g As, 2.07 µg/100 g Cd , 0.81 µg/100 g Pb. The proximate and mineral composition depends on potato tissue and cultivar (Vaitkevičienė, 2019). Potato peels, considered waste in many households, as well as in the potato processing industry (Khattak and Rahman, 2017; Nischala, 2019), still contain a series of useful compounds from nutritional and pharmacological point of view, which by different procedures, like extraction or other processes, may be used to produce biofuels, dietary fiber, biofertilizers, biogase and food additives (Verma et al., 2021; Nischala, 2019**;** Zhivkova, 2021). Potatoes peel contains various polyphenols and phenolic acids (responsible for its antioxidant activities), fatty acids and lipids (showed antibacterial activities); potato peel also contains starch (25%), non-starch polysaccharide (30%), protein (18%), acid soluble and acid insoluble lignin (20%), lipids (1%) and ash (6%) on dry basis (Abebaw, 2020; Eshak and Mousa, 2015). Potato peel waste, processed by various procedures, has numerous practical uses, these being food preservation (as a promising source of natural antioxidant), obtaining antimicrobial ingredients (that could serve as food preservative in food processing industries) and pharmaceutical ingredient, as a source of dietary fiber, ingredient in the baking industry, in the production of a starch hydrolyzing enzyme, thermostable alpha-amylase under controlled solid-state growth conditions (which is widely employed in food industry), is used for the synthesis of biofertilizers, and in animal feed, for production of lactic acid, for biogas productions and as a source of renewable energy (Verma et al., 2021; Abebaw, 2020; Taiyeba, 2020; Thakur et al. 2020; Lau et al., 2021). The data presented in the literature of this field reveal that potato peels contain important quantities of mineral elements, essential for the normal functioning of the human body. The concentrations of some minerals are larger in the skin than in the flesh of the tuber (Verma et al., 2021; Nischala, 2019**)**. Miles et al. (2009) investigated the impact effect of the Zebra Chip disease on the mineral composition of 'Atlantic' potato tubers, for both tuber flesh and peel tissues, from potatoes grown at two separate and geographically distant locations, under controlled cage conditions. The results of this study show that the non-infected potato peels with Zebra Chip disease contain important amounts of mineral elements: 0.11 - 0.14% P, 3.20 - 3.32% K; 0.12 - 0.15% S; 0.38 - 0.93% Ca, 0.22 - 0.23% Mg, 0.03 - 0.07% Na. In a study regarding the variation of the mineral composition within the potato tuber (*Solanum tuberosum* - 'Stirling' variety) planted at Balruddery Farm (Dundee, UK), Subramanian et al. (2011) have observed that the concentrations of most minerals were higher in the skin than in the flesh of tubers; the potato skin contained about 17% of total tuber zinc, 34% of calcium and 55% of iron. The authors of the study show that the mineral concentration in the tuber surface layer shows the following values: 1.90 mg/g Mg, 39.30 mg/g K, 2.20 mg/g Ca, 32.80 mg/g Zn, 17.50 mg/g, 308 mg/g Fe, 10.20 mg/g Cu. Studying the hepato protective effect of potato and apple peels as antioxidant on intoxicated rats with CCl_4, Sello (2011) discovered that potato peels contain 18.90% protein, 0.99% fat, 5.30% ash, 4.84% moisture, 69.97% carbohydrate and: 0.83 ppm Cu, 39.20 ppm Ca, 0.52 ppm Zn, 18.6 ppm Fe. Analyzing the feasibility of utilizing peelings from sweet melon, banana and potato in methane production through anaerobic digestion, Jekayinfa (2015) found out that the waste of potato peels used in the production of biogas contain also important quantities of macro and micro essential elements: 24.80 ppm Cu, 22.80 ppm Zn, 178 ppm Fe, 0.05% Mg, 0.04% Na, 0.16% Ca, 3.09% K, 1.80% P (in dry weight). Zoair et al., 2016 have studied the use of orange, banana and potato peels for preparing functional cupcakes and crackers with high fiber content. The authors of this study showed that, in addition to some bioactive components such as dietary fiber and antioxidants, potato peels also contain important amounts of: 59.92 mg/100 g Na, 88.25 mg/100 g K, 161.21 mg/100 g Ca, 9.12 mg/100 g Mg, 1.19 mg/100 g Fe, 0.71 mg/100 g Mn, 1.09 mg/100 g Cu, bioelements with an important role in the functioning of the human body. The peels of vegetables and fruits contain significant amounts of mineral elements demonstrated by, Khattak and Rahman (2017), who in the analysis of potato peels *(Solanum tuberosum)* obtained by peeling potatoes from the local market of Peshawardi (Pakistan), they found the following values: 206±9 mg/100 g Na, 1895±43 mg/100 g K, 73±3 mg/100 g Ca, 142±7 mg/100 g Mg, 11.00±0.00 mg/100 g Fe, 3.00±0.00 mg/100 g Mn, 9.00±0.00 mg/100 g Zn. Various quantities of K, Fe, riboflavin, folic acid and vitamins can be found mainly in the thick periderm of the potato peel. The concentrations of some minerals are larger in the skin than in the flesh of the tuber (Nischala, 2019). Thakur et al. (2020) reported that potato peel contained the highest concentration of K (1823 to 3342 mg/kg DW) followed by Fe (43 to 56 mg/kg DW) and Zn (20 to 29 mg/kg DW). Analyzing the nutritional and mineral composition of wasted potato peels coming from potatoes collected from the local market (Bulgaria), Zhivkova, (2021) has reported that these contained the highest amount of crude protein (2.67%), digestible carbohydrates (9.50%) and water content (84.30%) and important quantities of mineral elements which decreased in the following order: K(59 mg/kg) > S(390 mg/kg) > P(378 mg/kg) > Mg(325 mg/kg) > Ca(130 mg/kg) > Al(62.70 mg/kg)> Fe(41.60 mg/kg) > Na(17.60 mg/kg) > Zn(4.32 mg/kg) >Mn(2.03 mg/kg) > Cu(1.67 mg/kg) > B(1.21 mg/kg). 'Irish' potato peel, a waste by-product of potato processing, is a good source of phytochemicals (flavonoids and terpenes) nutritional components such as starch, dietary fiber, proteins, amino acids, vitamins (B6, B3, C) and mineral elements, particularly K, P, Ca, Na, Mg, Mn, Fe and Zn (Akinsulie et al., 2021). According to Akinsulie et al., (2021) the peels of 'Irish' potato contain: 4.54% crude protein, 1.65% crude fat, 4.81% crude fibre, 3.67% ash, 9.90% moisture, 67.89% dry matter, 0.16% Mg, 0.10% Ca, 0.05% Na, 0.26% K, 0.21% P, 0.87% Cl, 8.50 mg/kg Mn, 12.40 mg/kg Fe. The objective of the present work is the determination of the mineral profile of potato peels resulting as household waste after food preparation and the evaluation of their mineral intake. The total concentrations of Na, K, Ca, Mg, Fe, Mn, Zn and Cu potato peel from potatoes sold in agro-food markets from the city of Timișoara (Romania) were determined.

MATERIALS AND METHODS

To carry out the experiment, three batches of potatoes, *Solanum tuberosum* (approximately 1 kg of potato tubers) were taken from local agrofood markets in Timișoara city (Romania). Five potatoes have been chosen, from each batch, which, after washing thoroughly with a jet of tap water and drying by blotting with filter paper, were peeled using a stainless steel knife. The potato peels obtained were washed again with distilled water, to remove possible impurities, then cut into small pieces and dried in an oven at 60 °C until constant mass. The dried samples were ground in a kitchen grinder and stored in brown jars (at a temperature not exceeding 5°C) until further analysis. The determination of the mineral elements in dried potato peels was carried out by the atomic absorption spectroscopy in the flame method, the calcination variant and the solubilization of the ash in 0.5 N nitric acid (Rada et al., 2018). Practically, 1.0 g dried potato peel was calcined at 550 °C in two rounds of 4 hours each, then the ash obtained was treated with 20 mL of 0.5 N HNO_3 solution, then evaporated until almost dry. This operation was repeated two more times, after which it was added quantitatively with small portions of 0.5 N nitric acid and distilled water to level of 50 mL. Determination of the element concentrations the clear solution brought to the level of 50 mL was carried out using the Varian 280 FS Spectrometer, in the air - acetylene flame. Working parameters of the spectrometer: wavelength, air flow and acetylene, etc. were those recommended by the device supplier. Simultaneously with the measurement of the analyzed samples and under the same working conditions, the solutions used to calibrate the device were also measured. All the mineral composition analyses were performed in triplicate.

RESULTS AND DISCUSSIONS

The results obtained at the determination of the mineral elements for the three batches of investigated potato peels (marked in the text with B1, B2 and B3) are presented in Table 1.

Table 1. Mineral profile of some potato peels (*Solanum tuberosum*)

Specification	Mineral content, mg/100 g on dry weight basis							
	Na	K	Ca	Mg	Fe	Mn	Zn	Cu
Batch 1 (B1)	38.60± 1.07	1856± 13.77	158± 7.79	122± 6.53	4.62± 0.31	0.64± 0.08	1.61± 0.18	1.07 ±0.17
Batch 2 (B2)	82.30± 2.61	2531± 17.56	201± 8.96	193± 7.36	10.88± 0.89	1.22± 0.89	2.53± 0.10	1.60± 0.12
Batch 3 (B3)	44.50± 3.19	2241± 16.32	155± 6.13	148± 7.35	8.22± 0.68	0.71± 0.08	1.88± 0.16	0.78 ±0.06
Mean value	*55.13± 19.36*	*2209± 276*	*181± 28.90*	*154± 29.30*	*7.91± 2.57*	*0.97± 0.26*	*2.01± 0.39*	*1.34± 0.27*

As can be seen from Table 1, the analyzed potato peels, contains important amounts of essential mineral elements unevenly distributed, their concentration being included in wide concentration limits, depending on the origin of the potato peels and also on the nature of the essential element analyzed: 38.60 ÷ 82.30 mg/100 g Na, 1856 ÷ 2531mg/100 g K, 155 ÷ 201 mg/100 g Ca, 122 ÷ 193 mg/100 g Mg, 4.62 ÷ 10.88 mg/100 g Fe, 0.64 ÷ 1.22 mg/100 g Mn, 1.61 ÷ 2.53 mg/100 g Zn and 0.78 ÷ 1.60 mg/100 g Cu (mean values). This is also confirmed by the literature references which show that the chemical composition of potato peels is influenced by a series of factors such as: the variety of potato, pedoclimatic conditions, cultivation techniques, etc. (Vaitkevičienė, 2019). **Potassium** is the main cation in intracellular fluid and functions in the acid-base balance and in the regulation of osmotic pressure (Soetan et al., 2010). This essential microelement is the best represented among all the analyzed elements, its concentration presenting average values between 1856 ÷ 2531 mg/100 g DW. These values are of the same order of magnitude or close to those obtained by Khattak and Rahman, (2017), respectively Thakur et al., (2020) but lower than those reported by Subramanian, et al. (2011) and Jekayinfa (2015). The average concentration of this essential macroelement is 2209±276 mg/kg DW. **Calcium** is an important constituent of bones and teeth, helps regulate nerve and muscle function and is important in blood clotting, blood pressure regulation and immune system health (Soetan et al., 2010). Compared to potassium, calcium was determined in much lower concentrations, the concentration limits of this macroelement having values between 155 - 201 mg/100 g DW. The average concentration of this element in the three batches of potato peels (181±28.90 mg/100 g DW) is close to the average concentration of magnesium and much higher compared to the average concentrations of Na, Fe, Mn, Zn and Cu. Calcium concentrations, determined experimentally, are in agreement with those obtained by Jekayinfa (2015) and Zoair et al. (2016) but higher than those reported by Zhivkova (2021) and Akinsulie et al., 2021. **Magnesium** is an essential macroelement for ATP synthesis, oxidative phosphorylation, protein synthesis, muscular contraction, neuromuscular conduction, bone structure, blood sugar metabolism, membrane stabilization, and DNA transcription (Soetan et al., 2010). The magnesium concentration in the potato peels analyzed shows values between 122 - 193 mg/100 g DW. The average value of the magnesium concentration is lower (154±9.30 mg/100 g DW), but close to the average calcium concentration. Magnesium concentrations in the analyzed potato peels show values comparable to those reported by Subramanian, et al. (2011), Khattak. and Rahman (2017) and Akinsulie et al. (2021), but higher than those reported by Jekayinfa (2015), Zoair et al. (2016) and Zhivkova (2021). **Sodium**, a macroelement that contributes to the regulation of the osmotic balance of all solutions in the body and adjusts the volume of intra/intercellular solutions (Soetan et al., 2010), was determined in much lower concentrations than potassium and lower than calcium and magnesium (38.60 ÷ 82.30 mg/100 g DW). The average value of sodium concentrations in potato peels analyzed are in accordance with those obtained by Miles et al. (2009), Zoair et al. (2016) and Akinsulie et al. (2021), but lower than the value reported by Jekayinfa (2015) and higher than Zhivkova (2021). **Iron** is a component of myoglobin and hemoglobin, functions as a carrier of oxygen in the blood and muscles (Attar, 2020). The concentrations of this essential microelement in the samples of potato peels show average values between 4.62 - 10.88 mg/100g DW. Compared to the other analyzed microelements, iron was determined in the highest concentrations (7.91±2.57 mg/100 g DW). Comparable values of the concentration of some potato peels were also determined by Khattak and Rahman (2017), Thakur et al. (2020) and Zhivkova (2021). Lower values of iron concentration were reported by Zoair et al. (2016), Sello (2011) while Subramanian, et al., 2011 and Jekayinfa (2015) obtained higher values. **Manganese**, an essential microelement that helps the body to form connective tissue, bones, blood-clotting factors, and sex hormones (Attar, 2020). Compared to the rest of the microelements, manganese was determined in the lowest concentrations (0.97±0.26 mg/100 g DW). The Mn concentrations in the potato peels analyzed have values between 0.64 - 1.22 mg/100 g DW. These values are close to those obtained by Zoair et al. (2016) and Akinsulie et al. (2021), but smaller compared to the value reported by

Khattak. and Rahman (2017) and higher than those obtained by Subramanian et al. (2011) and Zhivkova (2021). **Zinc** has a fundamental relevance for many molecular, cellular, metabolic, and immunological processes, including anti-oxidative, anti-inflammatory, and anti-apoptotic responses (Attar, 2020). This essential microelement was identified in smaller amounts compared to iron (1.61 - 2.53 mg/100 g DW), but slightly higher than copper and manganese. The concentrations of zinc in the three batches of potato peels and the calculated average value is included in the range of the values obtained by Jekayinfa (2015) and Thakur et al. (2020). Much lower values, respectively higher values were reported by Subramanian et al. (2011), Sello (2011), Zhivkova (2021), respectively Khattak. and Rahman (2017). **Copper** is one of various fundamental trace metals that are necessary in supporting biological functions for the human organism, forming part of many copper dependent enzymes and proteins (Attar, 2020). This essential micronutrient that is associated in the formation of red blood cells (Attar, 2020) was determined in concentrations between 0.78 – 1.60 mg/100 g DW. The average value of the copper concentration, calculated for the three batches of potato peels (1.34± 0.27 mg/100 g DW) shows that this microelement is present in lower concentrations than Fe and Zn, but slightly higher than Mn. These values are comparable to the value determined by Zoair et al., (2016), but higher than those reported by Subramanian, et al. (2011), Sello (2011) and Zhivkova (2021).

From those presented previously it can be stated that the analyzed potato peels contain important amounts of essential macro and microelements. Taking into account the average concentrations calculated on the basis of the concentrations determined in the three batches of potato peels, it can be observed that the distribution of macroelements in potato peels follows the following decreasing trend: Fe> Zn > Cu≅Mn. The obtained results confirm that the peels have a rich source of minerals and can be used as food or as dietary ingredients after appropriate processing. The average values of the mineral concentration experimentally determined (Table 1) can be used to evaluate the mineral intake of dried potato peels in the recommended daily diet. For the evaluation of the mineral intake, the Recommended Dietary Allowances and Adequate Intakes, Elements Food and Nutrition Board, National Academies - Food and Nutrition Board, Institute of Medicine, for people aged between 31 and 70 years were taken into account (Table 2).

Table 2. Recommended dietary allowance intakes (man and women 31-70 years) and tolerable upper intake levels elements

Specification		Mineral elements, mg/day							
		Na	K	Ca	Mg	Fe	Mn	Zn	Cu
Recommended values	*Man*	1500	4700	1000	420	8	2.3	11	0.9
	Women	1500	4700	1000	320	18	1.8	8	0.9
Tolerable upper levels	*Man and women*	2.300	-	2000	350	45	11	40	10

The obtained results, for the evaluation of the mineral intake, shows that, under the conditions of the present experiment, 100 g of dried potato peel covers different percentages of the required mineral elements recommended (Table 3).

Table 3. Mineral intake in the recommended daily diet, for men and women between 30-70 years corresponding to 100 g of dried potato peels

Specification	Mineral intake, %							
	Na	K	Ca	Mg	Fe	Mn	Zn	Cu
Man	3.68	47.01	18.07	36.75	99.00	63.00	18.24	148.00
Women	3.68	47.01	7.13	48.23	43.93	80.28	25.00	148.00

From those presented in Table 3, it can be seen that a consumption of 100g potatoes peel powder covers 148% of the daily copper requirement - for men and women; 99% and 43.93% of the daily iron requirement - for men and women, respectively; 80.28% and 63.00% of the daily manganese requirement - for woman and men, respectively; 47% of the daily requirement of potassium - for men and women; 48.23% and 36.75% of the daily magnesium requirement - for woman and men, respectively; 25.00% and 18.24% of the daily requirement of zinc, respectively; 18.07% and 7.13% of the daily calcium requirement - for men and women; 3.68% of the daily sodium requirement - for men and women. In addition, we note that the amount of copper contained in 100 g of potatoes peel exceeds the recommended daily copper requirement for men and women between 30-70 years. Therefore, under the conditions of the present experiment, a consumption of 100 g of potato peel, would also bring a surplus of 148% of the Cu requirement. Taking into account the tolerable upper intake levels elements per day, for men and women between 31-70 years (Table 2) it can be said that the increased content of Cu in potato peel does not pose a health risk. The preliminary results obtained in the evaluation of the mineral intake show that the dried potatoes peel obtained under the conditions of the present experiment could be considered as a source of essential mineral elements, especially as a source of Cu, Fe, Mn as well as K and Mg. Potatoes peel powder cannot be considered as a source of Ca and Na. These values suggest that these by-products, after proper processing, could be introduced into the diet as a source of essential minerals (Cu, Fe, Mn as well as K and Mg). In addition, the superior valorisation of this by-product of potatoes can serve as a method of greening of waste potatoes.

CONCLUSIONS

The preliminary results obtained for determination of the mineral profile of the potato peels analysed under the conditions of this experiment show that it contains important amounts of essential macro and microelements. The average concentrations of the analysed macro and microelements show the following decreasing trend: K> Ca> Mg> Na, respectively: Fe> Zn > Cu≅Mn. Potatoes peel powder cannot be taken into account as a source of Ca and Na. Finally, it can be stated that these by-products, after proper processing, could be introduced into the diet as a source of Cu, Fe, Mn as well as K and Mg. In addition, the superior valorization of this by-product of potatoes can serve as a method of greening of waste potatoes.

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