INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 4, No. 4, p. 169-178, 2014

RESEARCH PAPER | OPEN ACCESS

Nutrition value of the sweet potato (*Ipomoea batatas* (L.) Lam) cultivated in south – eastern Polish conditions

Barbara Krochmal-Marczak[1], Barbara Sawicka[2], Jacek Supski[3], Tomasz Cebulak[4], Katarzyna Paradowska[5*]

[1]*Departament of Agriculture and Rural Development, State Higher Vocational School names Stanislaw Pigonia in Krosno, Poland*

[2]*Department of Plant Production Technology and Commodity, University of Life Science Lublin, Poland*

[3]*Department of Raw Materials and Processing of Fruit and Vegetables, Department of Food Technology, University of Agriculture in Krakow, Poland*

[4]*Department of Technology and Quality Plant Products, Department of Biology and Agriculture, University in Rzeszow, Poland*

[5]*Department of Physical Chemistry, Faculty of Pharmacy, Medical University of Warsaw, Poland*

Article published on April 29, 2014

Key words: Chemical composition, macronutrients, sweet potato, variety.

Abstract

Studies were conducted in the years 2009–2011 on a brown soil, wheat faulty complex (Poland, Podkarpackie Voivodeship). The experiment was carried out using the randomized blocks method in 3 replications. Three cultivars of sweet potato were studied: Carmen Rubin, Goldstar and White Triumph with a different morphological and physiological type. Contents of dry matter, carbohydrates, protein, vitamin C, ascorbic acid and macronutrients in tubers were determined using standard methods. White Triumph cultivar with white skin and flesh is characterized by a significantly higher content of starch, sugars, proteins, vitamin C, ascorbic acid as well as phosphorus, calcium and magnesium in comparison with cultivars (Goldstar and Carmen Rubin) with coloured skin and flesh. The biological value of sweet potato tubers is high. The content of nutrients in sweet potatoes' tubers is discussed in terms of their nutritional utility. Sweet potatoes can help reducing nutritional problems and can be especially recommended for diabetics.

* **Corresponding Author:** Katarzyna Paradowska ✉ katarzyna.paradowska@wum.edu.pl

Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam.), known as a patata, is well known long-term species in a warm and hot climate zone and an annual plant (spring) in temperate zone. This species has moist and delicate tubers with a sweetish taste, pleasant and aromatic smell. It has also a high nutritional value – about 50% higher than the potato. Therefore, it plays an important role in the diet of the world's population (Ofori *et al.,* (2005). Tubers are main usable part of the sweet potato, although leaves can also be used. Tubers are characterized by a high unit mass (1–3 and even 5 kg); diverse shapes – spherical, oval, spherical-oval, fusiform; skin and flesh: white, cream, yellow, orange, red, claret and even purple, depending on a cultivar (Maloney *et al.* (2012). The main nutritional material in sweet potato's tubers are carbohydrates (starches and simple sugars), protein, fat and fat-soluble vitamins. Moreover, cultivars with a yellow flesh also contain significant amounts of carotenes (Allen *et al.* (2012). Maloney *et al.* (2012) pointed out that potentially valuable proteins can be extracted from the peel during the processing of sweet potatoes.

Sweet potato's tubers have anti-diabetic, anti-oxidant and anti-proliferative properties due to the presence of valuable nutritional and mineral components (Jaarsveld et al. 2005; Abubakar *et al.* (2010). Furthermore, *Ipomoea batatas* tubers, which are steady item in the Americans' diet, appear to be very beneficial in the diet of diabetics and consumers with an insulin resistance, because they have a low glycemic index (Ludvik *et al.* (2004), Allen *et al.* (2012). Knowledge of the glycemic index (GI) diet for diabetes may help to predict their daily diet in order to control a blood glucose level. GI of a pure glucose, which is used as the standard and a pattern for other products, is 100, while the GI of sweet potato's tubers, depending on whether they are boiled, baked or prepared in a microwave, is: 63 ± 3.6; 64 ± 4.3 or 66 ± 5.7, respectively. It encourages using them in the diet of diabetics (Allen *et al.* (2012); Maloney, 2012). Recently, in Poland has been increasing interest in the cultivation of these vegetables, as raw material with excellent nutritional values, mainly for the food and pharmaceutical industries. However, the knowledge about these species is not sufficient, especially on their nutritional values.

Hence, the aim of this study was to evaluate the chemical composition and nutritional value of three sweet potato's cultivars, which are cultivated in south–western Poland.

Materials and methods

Plant material and preparation plantation

Three cultivars of sweet potato were studied: Carmen Rubin, Goldstar and White Triumph – with a different morphological and physiological type. The research material was from a field experiment conducted in 2009–2011 in Zyznow (Poland, Podkarpackie Voivodeship), on a brown soil of the faulty wheat complex. The field experiment was realized using the randomized blocks method in 3 replications. Organic fertilization, at a dose of 25 ha^{-1}and mineral fertilization, phosphorus and potassium (P – 43.6 kg; K – 124.5 kg ha^{-1}) was applied in the autumn, while a nitrogen fertilization in the amount of 100 kg ha^{-1} in the spring before planting. Forecrop of the sweet potato was the spring barley. Rooted sweet potato cuttings (from in vitro reproduction) were propagating material. Plants were planted into the soil between 25–26 May in spacing: 75 × 40 cm. Area of plots for harvest was 15 m^2. Mechanical cultivation involving the double ridging and hand weeding was used in the experiment.

Chemical analysis

The harvest was realized during the technical maturity, in early October. During the harvest, samples were taken (30 tubers of various sizes in proportion to their share in the crop) from every plot, in order to determine a chemical composition of tubers. Immediately after the harvest, in a fresh weight of tubers following parameters were evaluated: dry matter – drier method, total protein content – Kjeldahl method, starch content – polarimetrically (according to Ewers–Grossfeld); content of sugar sum and reducing sugars – Luff–Schoorl jodometric method in the Scales modification; vitamins C – spectrophotometrically via Tillmans. In the dry weight of tubers were identified: general content of phosphorus, potassium, calcium, magnesium and sodium – in a stock solution, which was obtained after the “dry” mineralization of tubers in a muffle furnace at 450°C.

Crude ash, which was obtained in a porcelain crucible, was completely poured over by an aqueous solution of hydrochloric acid HCI (1:1) in order to dissolve carbonates and separate silica (SiO_2) and evaporated in a sand bath. 10 cm^3 of 5% HCI helps to obtain a solution containing chlorides of analyzed elements and phosphoric acid (V). This solution was transferred to a volumetric flask (100 cm^3) and the silica was separated on a hard filter. Furthermore, the crucible was washed 3 times with deionised water, and the solution was transferred via the filter in order to remove chlorides and completed the volumetric flask (AOAC, 2000). In such a prepared stock solution, the concentration of examined macronutrients was determined using ICP-AES method on an emission spectrometer with the inductively coupled plasma (argon) Optima 3200 RL, produced by the Perkin Elmer Company. For this purpose, the following wavelengths were used: for P – 214.914 nm; K – 766.490 nm; Ca – 315.887 nm; Mg – 285.213 nm; Na – 330.237 nm. Operating parameters of the camera were as follows: RF – 1300 W, flow rate of cooling argon – 15 L min^{-1}, auxiliary argon – 0.5 L min^{-1}, nebulizated argon – 0.8 L min^{-1} and the speed of sample loading – 1.5 L min^{-1}.

Data analyses

The statistics was carried out using the analysis of variance. The significance of variation sources was checked by the Fisher-Snedecor “F” test. The significance of object differences for researched traits was evaluated using the Turkeys test. Furthermore some features descriptive statistics, such as: standard deviation, median, kurtosis and coefficients of variation for the studied traits were also examined.

Rainfalls and air temperature during the growing period of sweet potatoes

Distribution of temperature and precipitation in analyzed years was diversified, as illustrated in Figure 1. In 2009 only May and July were wet and warm, and the remainder of the growing season was characterized by the deficiency of rainfall and average air temperature. In 2010, May and July were wet and cool – total precipitation significantly exceeded the amount of several years, while August was average, both in terms of precipitation and air temperature, September and October were dry. In 2011, May, June, August, September and October were dry and cool, and July was very wet and warm.

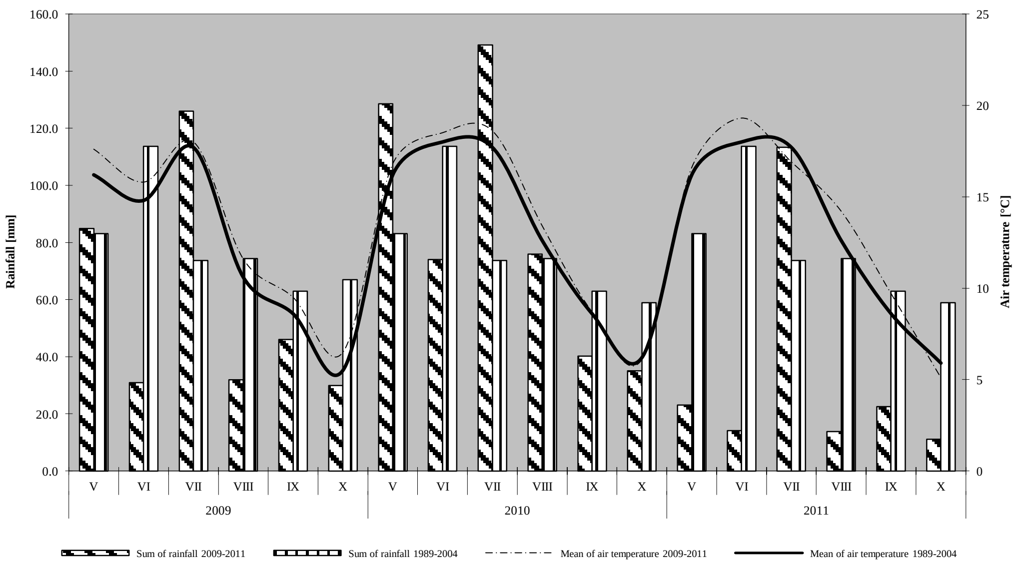

Fig. 1. Rainfalls and air temperature during the growing period of sweet potatoes according to the meteorological station of IMGW in Dukla

Results and discussion

Contents of chemical components

The content of tested nutrients in sweet potato's tubers appeared to be significantly dependent on the specific characteristics (Table 2). The amount of dry matter in tubers reaches 24.19 g 100 g^{-1} with fluctuations from 19.69 g to 29.91 g, while the coefficient of variation of this trait was V = 18.13% – it means its relatively high stability. A variation with the highest content of dry matter in tubers was White Triumph, while the lowest one – Carmen Rubin; however, Goldstar had higher content that Carmen Rubin (Table 1).

Table 1. Content of dry matter and chemical components in fresh matter Ipomoea batatas tubers (mean for 2009-2011)

Cultivars	Dry matter g 100 g^{-1}	Starch g 100 g^{-1}	Total sugars g 100 g^{-1}	Reducing sugars g 100 g^{-1}	Total protein g 100 g^{-1}	Ash g 100 g^{-1}	Crude fibre g 100 g^{-1}	Vitamin C mg 100 g^{-1}	Ascorbic acid mg 100 g^{-1}
Goldstar	23.80	14.90	2.90	1.09	1.50	1.38	0.86	24.20	19.81
Carmen Rubin	19.69	14.70	2.16	0.93	0.93	1.07	1.14	20.26	17.46
White Triumph	29.91	14.91	3.85	1.60	1.63	1.52	0.97	24.20	21.23
Mean	21.75	14.84	2.97	1.21	1.35	1.32	0.99	22.89	19.50
LSD_{05}	1.35	n*	0.16	0.06	0.07	0.07	0.05	1.26	1.07

* – not significant at $P<0.05$

The coefficient of variation in this trait, which is a measure of the dispersion in obtained results, was V = 18.1% (Table 2) indicating that this characteristics is quite stable. The content of dry matter in tubers, which was presented by Sawicka et al. (2004), was slightly higher and it averaged 27.15 g 100 g^{-1} with fluctuations from 21.51 to 34.36 g. According to the USDA National Nutrient Database for Standard Reference (2007), the dry weight averages 22.72 g 100 g^{-1} of a fresh weight of sweet potato's tubers.

Table 2. Statistical characteristics of chemical components of tubers of sweet potatoes

Traits	Mean ± standard deviation	Kurtosis	Slant	Variability coefficient %
Dry matter g·100 g^{-1} fresh matter	24.47 ±4.43	-0.93	0.27	18.10
Starch g·100 g^{-1} fresh matter	14.83 ±0.68	-1.61	-0.81	4.59
Total sugars g·100 g^{-1} fresh matter	2.97 ±0.64	-1.65	0.17	21.55
Reducing sugars g.100 g^{-1} fresh matter	1.21 ±0.29	-1.65	0.63	23.97
Protein g·100 g^{-1} fresh matter	1.35 ±0.32	-1.68	-0.70	23.70
Crude fibre g·100 g^{-1} fresh matter	0.99±0.28	-1.66	0.29	28.88
Ash g·100 g^{-1} fresh matter	1.32 ±0.45	-1.65	-0.49	34.09
Vitamin C mg·100 g^{-1} fresh matter	22.89 ±9.62	2.95	-0.81	42.03
Ascorbic acid mg·100 g^{-1} fresh matter	19.50 ±8.19	-1.65	-0.33	42.00
Potassium mg 100 g^{-1} dry matter	2.12 ±0.19	-1.69	0.11	8.96
Phosphorus mg 100 g^{-1} dry matter	0.26 ±0.03	-1.65	0.57	11.54
Calcium mg 100 g^{-1} dry matter	0.51 ±0.26	2.67	-0.59	50.98
Magnesium mg 100 g^{-1} dry matter	0.13 ±0.05	-1.63	-0.44	38.46
Sodium mg 100 g^{-1} dry matter	0.19±0.04	-1.66	-0.61	21.05

The content of starch, in 100 g of fresh weight of sweet potato's tubers, averaged 14.83 g, with a coefficient of variation V = 4.60%, which means a very high stability of this trait (Tables 1 and 2). The highest content of this component in tubers was accumulated by the White Triumph variation, while the lowest – Carmen Rubin. Goldstar and White Triumph variations were homogeneous in terms of the amount of this component (Table 1). In tubers of Cananua variation, which was cultivated in the central-eastern part of Poland, Sawicka *et al.*

(2004) obtained an average amount of starch: 21.98 g·100 g^{-1} with fluctuations from 15.96 to 26.24 g·100 g^{-1}. In China's conditions, the average value of starch in the fresh weight of sweet potato's tuber is 24.4 g 100 g^{-1} (Katayama *et al.,* 2004). According to the USDA National Nutrient Database for Standard Reference (2007), carbohydrates are 20.12 g 100 g^{-1} of a fresh weight of tubers. Katayama *et al.* (2004) showed that the content of starch in sweet potato's tubers, depending on the geographic area, may range from 9.3 to 28.8 g·100 g^{-1}.

The average content of sugars in tested cultivars of sweet potato was 2.97 g·100 g^{-1} (fresh tubers) and 12.16 g·100 g^{-1} (dry weight), and reducing sugars 1.21g 100g^{-1} and 2.88g/100 g^{-1} in a fresh and dry weight, respectively (Table 1). Coefficients of variation for total sugars and reducing sugars were 21.55% and 23.97%, respectively (Table 2). Genetic variation of researched variations decided about the accumulation of both sugars sum and reducing sugars. A variation with the highest concentration of these components was White Triumph; so, due to their high content, it can serve as a dietetic and easily digestible food for children as well as for diabetics. The lowest value of tested characteristics was observed in Carmen Rubin tubers. The content of soluble sugars in Goldstar tubers appeared to be higher than in Carmen Rubin variation, but it was significantly lower in comparison with the White Triumph variation (Table 1).

In conditions of the central-eastern Poland, Sawicka *et al.* (2004) got an average of 2.16 g of soluble sugars in 100 g of a fresh weight, with fluctuations from 1.97 g to 2.43 g, while for reducing sugars – 1.11g with fluctuations in the range between 1.06-1.17g. Ofiori *et al.* (2005) state that the total sugar content in the dry weight of tubers oscillates, depending on the variety and growing conditions, from 5.53 to 16.99 g·100g^{-1}, and reducing sugar – 0.53-1.62 g·100 g^{-1}. According to the USDA (2007), the content of soluble sugars in a fresh weight of sweet potato is about 4.18 g·100g^{-1}, including reducing sugars (mostly fructose and glucose), which represent about 1.66 g·100g^{-1}. The rest (i.e. about 2.52 g·100 g^{-1}) of sugars is sucrose. The total content of protein averaged 1.35g·100 g^{-1} of a fresh weight, while the coefficient of variation of this trait V = 23.70% (Table 1, 2). In conditions of the central-eastern Poland, Sawicka *et al.* (2004) stated double value of protein (2.82 g·100 g^{-1}) in a fresh weight of tubers in the Cananua variety, with a coefficient of variation V = 6.9%. After recalculation of the results, expressed as the dry weight, the content of protein in the studied sweet potato's tubers was 4.7-6.3 g·100 g^{-1}. These values were in a range found for this vegetable, which was determined by Ofori *et al.,* (2005) and Katayama *et al.,* (2004) – 3.74-8.63 g·100 g^{-1}.

According to the USDA National Nutrient Database for Standard Reference (2007), a daily energy requirement for men is 2700 kcal and for women – 2000 kcal, including 8.3% in a form of protein. Sweet potato's tubers have an energy value about 86 kcal, including 6% in a form of protein. Therefore, food products from the sweet potato provide sufficient amount of protein for a suitable, calorific diet (Katayama *et al.,* 2004). According to Gopalakrishnan *et al.* (2011) in Papua New Guinea, protein from *Ipomoea batatas* represents about 50% of the total protein intake in a diet. These authors found from 0.8g to 1.4 g of protein in 100g fresh weight of this vegetable. On the other hand, according to Katayama *et al.* (2004), the total content of protein can fluctuate in a slightly wider range – from 0.49 g to 2.13 g·100 g^{-1} of a fresh weight, while according to the USDA National Nutrient Database for Standard Reference (2007), the content of this component was 1.57 g in 100g of fresh tubers.

The content of vitamin C in sweet potato's tubers was between 20.26-24.20 mg·100 g^{-1}, and the content of L–ascorbic acid represented 82-88% of the total content of this vitamin. Results, which were obtained in this study, were similar to amounts given by Sawicka *et al.* (2004) and Krochmal-Marczak and Sawicka (2007). According to Otieno *et al.* (2008), the content of vitamin C in the fresh weight of this vegetable is in the range of 16.13-23.42 mg·100 g^{-1}. According to Ukom *et al.* (2009), fresh sweet potato's tubers contain slightly higher amounts of this nutrient, what is mainly modified by genetic characteristics of cultivars. In the Sawicka's opinion (2000), observed differences in the chemical composition of tubers are conditioned by the phenotypic variability of tuber cultivars. They reflect a combined effect of genetic and environmental variation. It is worth mentioning a high and stable content of crude protein and vitamin C over the years, and also a crude ash and fiber. In functional food, this last component is mainly highlighted.

In view of the rich chemical composition of *Ipomoea batatas*, and also due to the content of β-amylase, it is included to the plants with a much higher nutritional value than tuberous species known in our country, such as: potato or Jerusalem artichoke (Sawicka *et al.,* 2000, Krochmal-Marczak, Sawicka, 2007). The content of fibre in a fresh weight of *Ipomoea batatas* tubers averaged 0.99% with a coefficient of variation V = 28,88% (Table 1,2). In Polish conditions, Sawicka *et al.* (2004) obtained the content of fiber in a fresh weight of tubers at the level of 0.93 g with fluctuations from 0.84 g to 1.07 g·100 g^{-1}. Chandy *et al.* (Indian researches) (2013) obtained a similar content of this component (1.0 g·100 g^{-1} in a fresh weight). Abubakar et *al.* (2010) stated that cooked sweet potato's tubers have about 0.84 g·100 g^{-1} of a crude fibre. According to the USDA (2007), the content of a total, digestible fibre is 3.0 g·100 g^{-1} of a fresh weight. The content of this component significantly depended on genetic characteristics in examined cultivars. The highest content of this component was observed in the Israeli variety Carmen Rubin, and the lowest one in Goldstar (American variety). White Triumph variety produced less fibre than Carmen Rubin variety, but significantly more than Goldstar variety. An influence of varietals characteristics on the chemical composition trait of tubers is confirmed by Sawicka *et al.* (2004), Ukom *et al.* (2009), Abubakar *et al.* (2010), Maloney *et al.* (2012) and Chandy (2013).

The ash content in sweet potato's tubers averaged 1.32 g·100g^{-1} of their fresh weight; with a coefficient of variation V = 34.09% (Tables 1 and 2). In Polish conditions, Sawicka *et al.* (2004) noted 1.51 g·100 g^{-1} of a fresh weight. Ukam *et al.* (2009) in Pakistan stated 1.02-1.70 g·100 g^{-1} of this component in a fresh weight, depending on the variety. Abubakar *et al.* (2010) detected in cooked sweet potato's tubers 1.03-1.23 g·100 g^{-1} of ash. The variety, which accumulates the most amount of element was the White Triumph, while the least amount – Carmen Rubin. Influence of varietal characteristics on the content of mineral compound in sweet potato's tubers was confirmed by Sawicka *et al.* (2004); Ukom *et al.* (2009), Abubakar *et al.* (2010) and Chandy (2013).

Contents of macronutrient

The studied sweet potato's tubers are rich in phosphorus, potassium, calcium and sodium, while low in magnesium. The content of macro-elements in sweet potato's tubers, due to the stability, can be ranged as follows: potassium – phosphorus – sodium – magnesium – calcium (Table 2,3), therefore, the least stable trait of mineral composition proved to be calcium. According to the USDA (2007), sweet potato's tubers have in 100 g of a fresh weight: 337 mg of potassium, 55 mg of sodium, 47 mg of phosphorus, 30 mg of calcium and 25 mg of magnesium. Colato Antonio *et al.* (2011) showed in a dry weight of the tuber: 320 mg of potassium, 47 mg of phosphorus, 22 mg of calcium and 13 mg of magnesium.

The average content of potassium was an average of 2.12 g·100 g^{-1} in a dry weight of sweet potato's tubers (Table 1). The coefficient of valuation of this trait was low (V = 8. 96%) and it testifies a high stability of this characteristic. In Polish conditions, the content of this element in *Ipomoea batatas* tubers corresponds with the amount of this element in potato and Jerusalem artichoke tubers (Sawicka 2000, Sawicka and Kalembasa 2008). According to the USDA (2007), its average concentration in tubers is 337 mg·100g^{-1} of a fresh weight, in Ukom *et al.* study (2009) – 115-203 mg·100 g^{-1}, depending on the variety.

The average content of phosphorus in tested tubers was 0.26 g·100g^{-1} of a dry weight with the coefficient of variation V=11,54% (Table 3,2) and it was in the normal range (Bergman 1992). Genetic characteristics of examined cultivars did not have a significant influence on the content of this element. These results are confirmed in Krochmal-Marczak and Sawicka studies (2007). A little higher content of this element was noted by Sawicka *et al.* (2004). In the study of Ukom *et al.* (2009), the content of phosphorus was 20.10-27.5 g·100g^{-1} in tubers, and according to the USDA (2007) – 47mg·100 g^{-1} of a fresh weight of tubers.

Table 3. Content macronutrients dry matter tubers Ipomoea batatas (g·100 g^{-1}) (Mean for 2009-2011)

Cultivar	Phosphorus	Potassium	Calcium	Magnesium	Sodium
Goldstar	0.26	2.25	0.55	0.14	0.21
Carmen Rubin	0.26	1.99	0.35	0.10	0.17
White Triumph	0.27	2.11	0.62	0.16	0.20
Mean	0.26	2.12	0.51	0.13	0.19
LSD_{05}	n*	0.12	0.03	0.01	0.01

* – not significant at $P<0.05$

Calcium is the basic mineral component of bones and teeth. It takes part in blood coagulation processes and it is essential for the proper functioning of nerves and muscle contractions. Therefore, it's content in vegetables is very important (Colato Antonio *et at.,* 2011). In the studied tubers, the content of this element averaged 0.51 g·100 g^{-1} with the coefficient of valuation V=50.98%. This amount testifies its low stability (Table 2,3). Among the tested cultivars, the richest in calcium was White Triumph variety, while the poorest – Carmen Rubin. Goldstar variety contained a significantly higher amount of this element than the Carmen Rubin variety, but considerably less than the White Triumph. In Ukom *et al.* studies (2009), the content of calcium reached the level of 40-91 mg·100 g^{-1}, while according to the USDA (2007) – only 30 mg·100 g^{-1}.

The average content of magnesium averaged 0.13 g·100 g^{-1} in a weight of sweet potato's tubers. Genetic characteristics of researched cultivars proved to be a significantly modifying factor of the potassium content in a dry weight of tubers. Tubers of the White Triumph variety were the most abundant in this element. Tubers in the Carmen Rubin variety accumulated the least amount of magnesium. On the other hand, the Goldstar variety accumulated more of this element (in tubers) than the Carmen Rubin variety, but significantly less than the White Triumph variety (Table 3). This macro-element showed an antagonist activity for K^+ and NH_4^+ ions, and it reduces their accumulation and binding with variety of enzymes. Magnesium creates ionic bonds (bridge type), for example with protein and ATP, and also participates in the pH regulation in a cell. In opinion of Barłóg's and Frąckowiak – Pawlak's, (2008) and Touyz (2003), food products of vegetable origin often contain too small amounts of magnesium. This low level in human and animal organisms (due to its role in the activation of enzymatic processes) accelerates processes of atherosclerosis and disorders of nervous and muscle system.

The content of sodium in sweet potato's tubers formed at the level of 0.19 g·100 g^{-1} with a coefficient of variation V = 21.05%. According to the USDA (2007), the content of this element is 55 mg·100 g^{-1}, while in Ukom *et al.* studies (2009) – 28-33 mg·100 g^{-1} in tubers.

It was found, during the evaluation of relative proportions of mineral components in plant material, that the Ca:P proportion significantly deviates from a recognized optimum (Table 4). Relative proportions Ca:Mg and K:Mg were below, and K:Ca – above the optimum ration of these components. Only K (Ca+Mg) proportion can be considered as the optimal.

The standard deviation, as a measure of volatility a classic, in addition to the arithmetic mean, it tells you how widely the values of the treats are scattered around the mean. The smaller the standard deviation, the more observations are concentrated around its mean, and vice versa: it is the greater the value characteristics are more varied. The low value of the standard deviation for example, the dry matter content of tubers say with a high concentration of this trait. The median of the data set is a value dividing the set, in this case, the content of each component of the chemical composition of tubers in two parts half of the data is below a half - than the median.

Table 4. The proportion of mineral components in Ipomoea batatas tubers (Mean weighed with years 2009-2011)

Cultivars	K: (Ca + Mg)	Ca: Mg	K : Ca	K: Mg	Ca : P
Goldstar	1.48	2.38	2.10	5.00	16.35
Carmen Rubin	1.98	2.12	2.91	6.19	10.28
White Triumph	1.22	2.35	1.74	4.10	17.68
Mean	1.56	2.29	2.25	5.09	14.77
Optimum	**1.65**	**3.00**	**2.00**	**6.00**	**2.00**

Kurtosis was in turn strongly varied and ranged between -0.93 - for dry matter and 2.95 - for vitamin C (Table 2). Skewness coefficient is set to zero for a symmetric distribution, negative values for distributions with left-sided asymmetry (left arm extended distribution) and positive for distributions with right-sided asymmetry (right arm extended distribution). A negative value for the left-hand side asymmetric distributions (left arm extended decomposition) was observed for the starch, protein, vitamin C, ascorbic acid, ash, calcium and sodium. Negative kurtosis for the studied traits indicates a flattening of its scope. The positive coefficient of skewness level, for dry weight, total sugars and reducing sugars, crude fibre, phosphorus and potassium, is evidence of right-hand distribution of features around the mean, or the right-hand asymmetry. In contrast to the standard deviation, which determines absolute differences characteristics, the coefficient of variation is a measure of the absolute, depending on the size of the arithmetic average and the measure of the spread of the results. The greatest variation among the examined characteristics of the chemical composition of tubers was characterized by calcium (50.98%), while the lowest – starch (4.59%), which means that the value of the latter, in the conditions of south-eastern Polish, is a treat very stable, while the calcium content of the sweet potato tubers - most characteristic variable.

Conclusions

1. The sweet potato's tubers are rich in protein, total sugars, reducing sugars, vitamin C, ascorbic acid and macro-elements. The level of vitamin C and starch in sweet potato's tubers was similar to the level in tuberous vegetables, which are cultivated in Poland. On the other hand, the level of sugar sum and reducing sugars in tubers was higher than in tuberous vegetables in Poland.
2. Genetic characteristics of researched cultivars significantly influenced the nutrient content in sweet potato's tubers. The most valuable variety appeared to be White Triumph variation, because it had the highest amount of dry weight, total sugars and reducing sugars, protein, vitamin C, ascorbic acid calcium and magnesium in comparison with other cultivars.
3. The amounts of phosphorus, potassium, calcium and sodium were proved to be high, while of magnesium – low. Goldstar variety was characterized by the highest content of potassium and sodium, while the lowest content of magnesium and calcium was observed in the Carmen Rubin variety.
4. During the assessment of relative proportions of mineral components in *Ipomoea batatas* tubers, it was found that the K:(Ca + Mg) ratio is the most optimal.
5. Conducted studies indicate that nutrients, which are contained in available for consumption sweet potato's tubers, can significantly improve the nutritional status of consumers and reduce their nutrition and health problems.

References

Abubakar HN, Olayiwola IO, Sanni SA, Idowu M. A. 2010. Chemical composition of sweet potato (Ipomoea batatas Lam) dishes as consumed in Kwara state, Nigeria. International Food Research Journal **17**, 411–416.

Allen JC, Corbitt AD, Maloney KP, Butt MS, Truong VD. 2012. Glycemic index of sweet potato as affected by cooking methods. The Open Nutrition Journal **6**, 1–11.

Barłóg P, Frąckowiak – Pawlak K. 2008. Effect of mineral fertilization on yield of maize cultivars differing in maturity scale. Acta Scientarium Polonorum **7**, 6–17

Chandy KT. 2013. Sweet Potato 180. Vegetable Production. VPS – 37, http://www.inseda.org/ .../73.../Sweet%20Potato-180.doc

Colato Antonio G, Yoshie Takeiti C, Augustus de Oliveira R, Jin Park K. 2011. Sweet potato: Production, Morphological and Physicochemical Characteristics, and Technological Proces. Fruit, Vegetable and Cereal Science and Biotechnology **5**, 1–18.

Gopalakrishnan J, Menon R, Padmaja G, Sankarankutty Sajeev M, Subramoney Narayana Moorthy SN. 2011. Nutritional and Functional Characteristics of Protein-Fortified Pasta from Sweet Potato. Food and Nutrition Sciences **2**, 944–955. **Igbokwe PE., Huam LC., Chukwuma FO., Huam J.** 2005. Sweet potato yield and quality as influenced by cropping systems. Journal of Vegetable Science 11, 35-46.

Jaarsveld PJ, Faber M, Tanumihardjo SA, Nestel P, Lombard. CJ, Spinnler Benadé J. 2005. Beta-Carotene – rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. American Journal of Clinical Nutrition **81**, 1080–1087.

Katayama K, Tamiya S, Ishiguro K. 2004. Starch properties of new sweet potato lines having low pasting temperature. Starch/Stärke **56,** 563–569.

Krochmal-Marczak B, Sawicka B. 2007. Fluctuation of Selected Microelements in Ipomoea batatas (L.) Lam. tubers. Polish Journal of Environmental Studies **16**, 163–165.

Ludvik B, Neuffer B, Pacini G. 2004. Efficacy of Ipomoea batatas (Caiapo) on diabetes control in type 2 diabetic subject treated with diet. Diabetes Care **27**, 436–440.

Maloney K, Truong Van Den, Allen JC. 2012. Chemical Optimization of Protein Extraction from Sweet Potato (Ipomoea batatas) Peel. Journal of Food Science **77**, 306–312.

OAC. 2000. Official Methods of Analysis Association of Official Analytical Chemist. EUA

Ofori G, Oduro I, Elis, HK Dapaah. 2005. Assessment of vitamin A content and sensory attributes of new sweet potato (Ipomoea batatas) genotypes in Ghana. AfricanJournal of Food Science **3**, 184–192.

Otieno K, Okitoi LO, Ndolo PJ, Potts M. 2008. Incorporating dried chipped sweet potato roots as an energy suplement in diets for dairy cows: experiences with on-farm dairy cattle feeding in western Kenya. Volume 20, Article #95. Retrieved, April 4, 2014, http://www.lrrd.org/lrrd20 /6/otie20095.htm

Sawicka B. 2000. Effect of nitrogen fertilization on the biological value of tubers of Helianthus tuberosus L. Annals of Agricultural University of Poznan, Gardening **323**, 447–451 (in Polish)

Sawicka B, Kalembasa D. 2008. Variability of macronutrient content in tubers Helianthus tuberosus (L.) under the influence of nitrogen fertilization. Acta Scientiarium Polonorum Agricultura **7**, 67–82 (in Polish)

Sawicka B, Pszczółkowski P, Krochmal-Marczak B. 2004. Quality tubers (Ipomoea batatas (L.) Lam.) under conditions of nitrogen fertilization. Annales Universitatis Mariae Curie - Skłodowska, Section E **59,** 1223–1232 (in Polish)

Sawicka B, Pszczółkowski P, Mikos-Bielak M. 2000. The biological value of the tubers of

(Ipomoea batatas (L.) Lam.) in the Lublin region. Annals of Agricultural University of Poznan, Gardening **1,** 453–457 (in Polish)

Touyz RM. 2003. Role of magnesium in the pathogenesis of hypertension. Molecular Aspects of Medicine **24**, 107– 136

Ukom AN, Oijmelukwe PC, Pokara DA. 2009. Nutrient composition of selected sweet potato (Ipomoea batatas (L.) Lam) cultivars as influenced by different levels of nitrogen fertilizer application. Pakistan Journal of Nutrition **8,** 1791-1795 (in Polish)

USDA National Nutrient Database for Standard Reference, Release 20, 2007 http://www.nal.usda.gov/fnic/foodcomp/search