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Original research paper

APPLICATION OF PRINCIPAL COMPONENT ANALYSIS IN ASSESSMENT OF MINERAL CONTENT OF NINE CULTIVARS OF BUCKWHEAT GRAIN

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ABSTRACT: Principal component analysis (PCA) was used to investigate the classification of mineral component of nine different cultivars of buckwheat grain. This research showed that copper (-0.92) and iron (–0.90) contributed mostly to the first principal component whereas calcium (–0.86) to the second one. The total variability explained by the first component was around 53.2%, while by the second component it was 24.1%, which means that those two dimensions together accounted for around 77.3% of total variability of the observed set of variables. Principal component analysis (PCA) of the data set was able to distinguish different minerals and cultivars as well.

Key words: PCA**;** buckwheat grain, mineral content

INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench) originates from the middle Asia and was transferred by nomadic people to Central and Eastern Europe. Today, buckwheat celebrates a come–back due to gluten–free diet. Less demands to soil, as well possibillity to double–cropping due to shot growing season (90–110 days), make buckweat very perspective culture (Aubrecht,1998). Group of pseudocereals primary includes amaranth (Amaranthaceae), buckwheat (Polygonacea) and quinoa (*Chenopod*iaceae). Pseudocereals consider plant species that can not be botanicaly classified into grass family, but regarding their nutrition values and possibilities to produce starch–rich grains they are very close to cereals (Kuhn, 1998, Bodroža–Solarov 2005).

Only few limited attempts had been made for genetic improvement of buckwheat grain which released variety of cultivars with high yield potential and better quality. Knowledge of genetic diversity among existing cultivars of any crop is essential for long term success of breeding program and maximizes the exploitation of the germplasm resources (Debnath et al., 2008). Genetic material, collected in Serbia and applied in this research, was examined on morphological features with an overall development plan of breeding program (Nikolić et al., 2010).Testing of content of minerals in grain is one of the important components in selection and development of breeding programs (Chudzinska and Baralkiewicz , 2010).

In general, content of minerals in buckwheat is different depending on the anatomic part of the grain. Buckwheat is rich in macro elements, such as: K, Mg, Ca, Na and microelements: Fe, Mn and Zn (Christa and Soral–Smietnana, 2008).

Buckwheat bran is a dietary source of Zn and Se, as it is indicated in the research of Bonafaccia et al. (2003). Compared with wheat and rice flour, buckwheat flour is relatively higher in the iron content (Ikeda, 2002).

Due to nutritional contribution and the absence of gluten, scientific and research interests for this plant is still growing (Scribble, et al. 2004; Wronkowska, et al. 2010). That buckwheat is an excellent food material with a potential for use as functional food in preventive nutrition was confirmed through many researches in Serbia as well (Filipčev et al., 2011, Sedej, 2011).

Principal component analysis (PCA) is one of many multivariate analysis methods. This method enables transformation of a large number of variables into a smaller number of latent variables (principal components, PCs) which are not intercorrelated. PCA is a powerful tool for pattern recognition, classification, modeling, and other aspects of data evaluation (Csomos et al, 2002).

The aim of this research was to apply the PCA in the classification of mineral components of nine cultivars of buckwheat grain.

MATERIALS AND METODS

Nine cultivars of buckwheat were grown and collected from the organic certified field at Institute for Field and Vegetable Crop, during the 2011 vegetation season.

Dehulling and milling were performed on a laboratory equipment “Eltex” where mixure of flour and hulls was obtained. Hulls were separated through a sieving mill. In further work, only fractions under 355 μm were used.

The contents of Na, Mg, Ca, Zn, Cu, Mn and Fe were determined after dry ashing at 450 ºC, by atomic absorption spectrophotometry (AAS) on a Varian Spectra AA10 (Varian Techtron Pty Limited, Mulgvare Victoria, Australia,1989) atomic absorption spectrophotometer equipped with a background correction (D2–lamp) (FAO 1980).

Experimental design and mineral content of buckwheat grain are presented in Table 1.

Table 1.
Experimental design and mineral content of buckwheat grain (mg/kg)

	Average mineral content (mg/kg)						
Species	**Fe**	**Mn**	**Cu**	**Zn**	**Ca**	**Mg**	**K**
čebelica	44,58	19,89	4,65	26,25	764,24	2031,55	3423
novosadska	36,01	17,71	4,57	24,02	640,51	2012,84	3415
godijevo	66,04	31,42	6,04	31,01	378,31	2033,44	3305
prekmurska	14,7	13,01	4,92	26,32	429,53	1947,64	3018
spacinska	43,46	13,66	5,25	34,1	259,13	2268,98	3192
bamby	14,9	12,97	4,07	28,01	503,63	1785,41	2731
daria	37,22	16,94	4,44	23,32	676,19	1979,99	2851
češka	22,2	15,23	4,4	26,62	522,91	1920,69	2965
francuska	10,1	10,8	4,5	21,94	518,25	2155,23	2570

The algorithm of PCA can be found in standard chemometric material (Oto, 1999). Descriptive analysis of the data and the PCA were performed using the software package STATISTICA 10.0.

RESULTS AND DISCUSSION

The average mineral content ranges of buckwheat cultivars were as follows: iron, 10.10 – 66.05 mg/kg; manganese, 10.80-31.42 mg/kg; copper, 4.07–6.04 mg/kg; zinc, 21.94–34.1 mg/kg; calcium, 259.13 - 764.24 mg/kg; magnesium 1785,41-2268.98, potassium, 2570–3423 mg/kg (Tab. 1). It was revealed that cultivar Godijevo had the highest content of iron, manganese and copper, while Spačinska was the lowest in calcium and the highest in zinc and magnesium (Tab. 1). These results are in concordance with research of Ikeda (2002) regarding the content of iron. Content of zinc in different cultivars in our study is in line with research of Bonaffacia et al. (2003).

The number of factors retained in the model for proper classification of the data from Table 1 was determined by application of Kaiser's and Rice's method (1974). Therefore, two components having eigenvalues >1 were used for further analysis. PCA yields two PCs explaining 77.3% (Fig.1) of the total variance in the data. Loading values (i.e. correlation coefficients) higher than 0.70 were marked throughout Tab. 2. in boldface type.

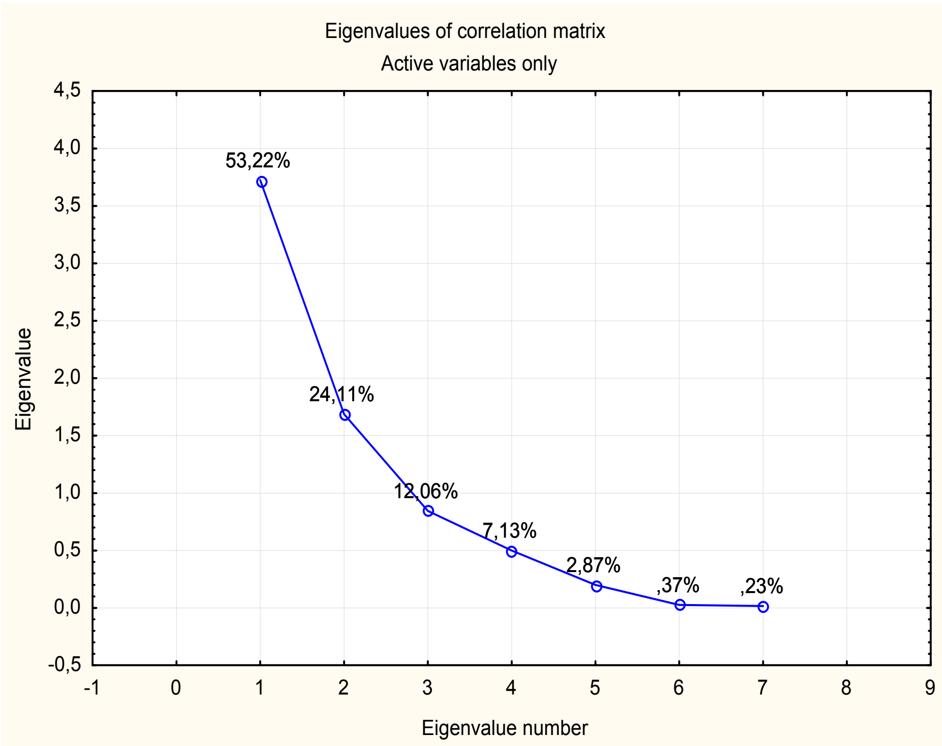

Figure 1. Eigenvalues of correlation matrix

Projection of the variables in the factorial plane (Table 2) indicates that the copper (–0.925) and iron content (–0.901) contributed mostly to the first PC (accounted for 53.22% of the total variability of the basic set of variables). The second PC (which accounted for 24.11% of the variability is contributed mostly by the content of calcium.

The content of copper and iron had the highest contribution to the description of the first PC (they formed the smallest angle with PC1 axis). The loadings plot of components in 2D factorial plane showed that the highest contribution to the description of the second PC had the content of calcium (it formed the smallest angle with PC2 axis) (Fig. 2).

Table 2.
Results of PCA for mineral content of Fagopyrum esculentum grain: Varimax Rotated Principal Component Loadings

Parameters	PC1	PC2
Fe	-0.901	-0.347
Mn	-0.780	-0.495
Cu	-0.925	0.146
Zn	-0.737	0.446
Ca	0.442	-0.847
Mg	-0.450	0.417
K	-0.713	-0.458
Explained variance	*3.73*	*1,69*
Proportion of total variance %	*53.22*	*24.11*

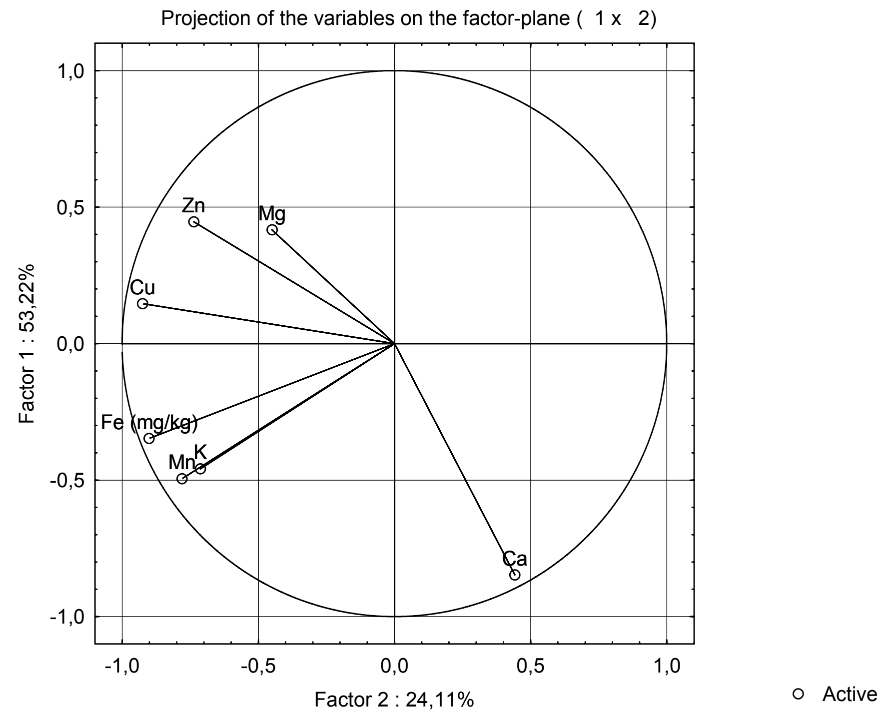

Figure 2. Rotated principal component loadings (mineral content of buckwheat grain)

Factor coordinates of individual observations (Fig. 3) indicate that the total variability of the first component is influenced mostly by cultivar Godijevo, (–3.844). Factor coordinates also showed that the total variability of the second component was influenced mostly by Spačinska (2.302) and Čebelica (–1.852).

PCA is a multivariate analysis of a large number of variables, which enables their examination and quantification, as well as identification of their dependence, *i.e.* links between a larger numbers of variables (Nićin,2008). Figure 3 shows that cultivar Godijevo mostly explains the first PC (content of iron and copper), and Spačinska mostly explains the second PC (content of magnesium). According to the first two PCs, content of all seven minerals was very homogenous at Novosadska and Češka cultivars. Cultivars Francuska and Bamby also have homogenous content of all seven minerals (Fig. 3).

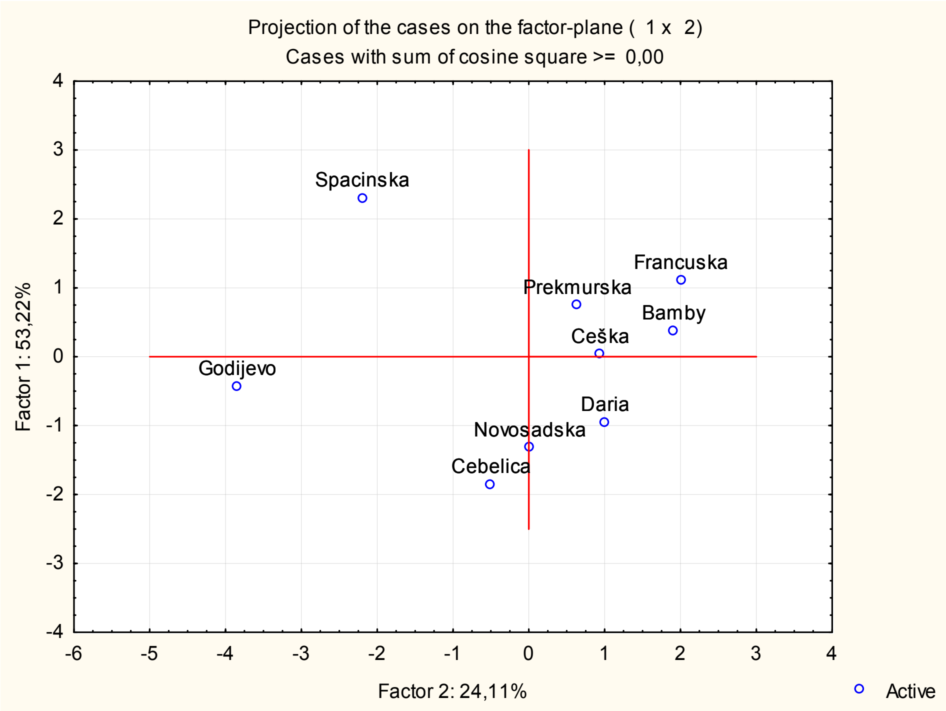

Figure 3. Rotated principal component scores for different species of buckwheat grain

CONCLUSIONS

Principal component analysis (PCA) of data set was able to distinguish between differrent cultivars of buckwheat lots. It was revealed that cultivar Godijevo has the highest content of iron and copper, while variety Spačinska has the lowest content of calcium and the highest content of magnesium. All other cultivars have homogenous mineral content.

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АНАЛИЗА САДРЖАЈА МИНЕРАЛНИХ МАТЕРИЈА ДЕВЕТ СОРТИ *FAGOPIRUM ESQULENTUM* ПРИМЕНОМ МЕТОДЕ ГЛАВНИХ КОМПОНЕНТИ

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Сажетак: Методом анализе главних компоненти (PCA), испитивана је класификација минералних компоненти девет различитих сорти зрна хељде. Ово истраживање је показало да бакар (−0.92) и гвожђе (−0.90) највише доприносе утицају прве главне компоненте, док калцијум (0.86) доприноси другој компоненти. Утврђен је ефекат укупне варијабилности која код прве компоненте износи око 53.2%, док је код друге био 24.1%, што значи да ове две димензије заједно чине око 77.3% укупне варијабилности посматраног скупа променљивих. Из анализе података методом анализе главне компоненте, показано је да постоји разлика између испитиваних сорти хељде у погледу садржаја различитих минералних материја.

Кључне речи: *PCA, зрно хељде, минералне материје*

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