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Relationship Between The Physical and Chemical Quality Parameters of Common Buckwheat (*Fagopyrum Esculentum Moench*) and Tartary Buckwheat (*Fagopyrum Tataricum Moench*)

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Abstract **- The aim of this study was to determine the influence of the physical characteristics on the chemical parameters of the grains of common (*Fagopyrum esculentum Moench*) and tatary buckwheat (*Fagopyrum tataricum Moench*). For this experiment 5 samples of buckwheat (4 samples of common buckwheat and 1 sample of tatary buckwheat) were used. Samples of common buckwheat from the locality of central Bosnia and Herzegovina were produced in 2012, while the sample of the tatary buckwheat was produced in 2013. The physical characteristics of grain were determined (test weight and 1000 grain weight), and chemical parameters: pH, titratable acidity, pH, moisture, fat, protein, ash, total phenols and antioxidant activity. The results are processed by PCA analysis - multivariate data analysis. PCA is applied to a set of 9 variables (2 physical and 7 chemical) with the aim of interpreting the relationship between the samples and the correlative relationship within the aforementioned physical and chemical parameters. PCA analysis shows that the total explained variance is 78%. According to the data of the correlative relations there is a very strong correlation between the antioxidant activity and total phenols. However, a very strong correlation is shown between total phenols and antioxidants with the pH value. Tatary buckwheat had a characteristically high content of antioxidants and phenols. From obtained results it is evident that the sample of the tatary buckwheat showed about 9 times higher content of antioxidants and about 20 times higher phenolic content compared to other tested samples of buckwheat.**

Keywords **— Common Buckwheat, Physical and Chemical Quality Parameters, Tatary Buckwheat.**

I. INTRODUCTION

Buckwheat (*Fagopyrum esculentum Moench*) is a very old plant native to mountainous areas of central and northeast Asia. The Mongols brought it to Europe in the late 14th century, from where in the 16th century it was moved to America [1]. Buckwheat is an annual herbaceous plant that belongs to the botanical order of *Polygonales*, family *Polygonaceae*, genus *Fagopyrum* [2], but by the way of processing, similar use, chemical composition, and the structure of the grain it is similar cereals. That is why it is often classified as pseudocereal [3]-[4]. The largest producer of buckwheat in 2013 was Russia, which produces 833.936 tons per year, in the second place is China, which produces 633.000 tons per year, and in third place is Ukraine which produces 179.020 tons per year [5]. In the composition of buckwheat grain starch is present to the greatest extent is in the amount of 54.5%, followed by the proteins in the amount of 12.3% [6]. Buckwheat contains 2.5 times more lysine than wheat [7]. It is a good source of rutin and kaempferol-3-rutinoside, and contains in traces flavonol triglycoside [8]. Antioxidant potential of buckwheat compared to antioxidant activity of the most commonly used cereals is much higher due to the high content of antioxidant polyphenolic compounds, primarely rutin [9]. Bioflavonoid rutin is important for the prevention of diseases of the circulatory system [10]. Reference [11] shows that endosperm and the outlayer of buckwheat have 2-7 times higher antioxidant activity with respect to barley, triticale and oats. In addition to common buckwheat, in recent times tatary buckwheat is increasingly researched, which is also promoted and recommended as a valuable raw material in both the food and the pharmaceutical industry [12]. Grains of tatary buckwheat contain traces of quercitrin and quercetin, flavonoids, which are not found in common buckwheat grain [13]. Dependence of the polyphenol content of agro-ecological conditions of production in leaves of common and tatary buckwheat was studied in a perennial research, which was carried out to examine the tannin in tatary buckwheat, variety darja and buckwheat of autochthonous population from the territory of Bosnia and Herzegovina, where the autochthonous population showed high values of tannins, more than in darja variety [14]. Reference [11] shows that extracted tatary buckwheat with methanol contains more routin (8-17 mg/g d.m.) compared to common buckwheat (0.1 mg/g d.m.). The concept of enrichment of bakery and confectionery products with flour or grain of buckwheat is a great choice regarding to improving the value of nutritional products with regard to the added value that products with buckwheat offer [12]. Proteins of buckwheat are nutritionally more valuable than proteins of cereals, but do not contain gluten and are therefore suitable for people with celiac disease [8].

The current study was aimed to ascertain the basic quality parameters in buckwheat samples, and determine correlations between phisical and chemical characteristic of the samples focusing on antioxidant activity.

II. MATERIALS AND METHODS

Four samples of autochthonous common buckwheat were examined from the central Bosnia lokalities (CB1, CB2, CB3, CB4) grown in 2012 (*Fig.1*), and the sample of tatary buckwheat variety darja (TB1) which was grown in 2013

(*Fig.1*). Samples were cultivated in ecological system without fertilizer and any chemical treatment.

The samples of grain were kept in appropriate conditions, in the paper bags in an amount of 15 kg, in the dry and air-conditioned rooms at a temperature of 20 ± 3 °C and a relative humidity of 40 ± 5%, until the analysis. Samples were purified using an air separator (Airsep 8000), and then tested for germination which in all the samples was in accordance with the applicable Regulations in Bosnia and Herzegovina [15].

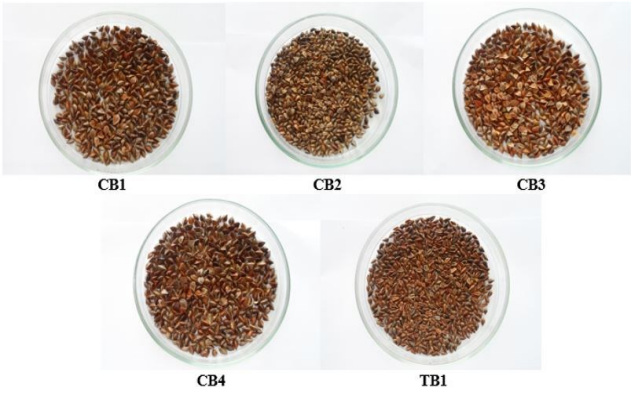

Figure 1: The analyzed samples of buckhwheat grains (CB1- common buckwheat 2012, CB2- common buckwheat 2012, CB3- common buckwheat 2012, CB4 common buckwheat 2012, TB1-tatary buckwheat 2013)

Methods for determining the physical characteristics of grain included: 1000 kernels weight and test weight as in [16]. Methods for determining the chemical characteristics of buckweaht samples as in [16] included: moisture content, titratable acidity, pH value, fat content according to Soxhlet method, protein content according to Kjeldahl-u (Nx6,25), and ash content. Moisture content in all of the samples was in accordance with the applicable Regulations [17]. Results of moisture content are not presented in this paper. Determination of total polyphenols and antioxidant activity FRAP (*Ferrie Reducing Antioxidant Power*) was done as in [18]. In determining the total phenols and antioxidants with the standard method it was not possible to read the absorbance of the sample TB1 and therefore a dilution of 50 times was carried out. The results were statistically analyzed using SPSS statistical software version 20.0 (SPSS Inc., Chicago, IL, USA), and single factorial analysis of variance (ANOVA), and in the case of determining statistically significant difference Tukey test at a significance level of 0.05 was conducted. For the correlation and presentation of the results multivariate data analysis was used -analysis of the basic components or PCA analysis. PCA analysis was performed in the program StatBox 6.7, Grimmer Soft, France. Principal component analysis was applied to 9 variables (7 chemical and 2 physical properties) in order to interpret the connections between the samples. The interpretation of the coefficient of correlation was made as in [19], where r from ±0.00 to ±0.20 has no or insignificant correlation, r from ±0.20 to ±0.40 weak correlation, r from ±0.40 to ±0.70 significant correlation and r from ±0.70 to ±1,00 shows strong or very strong correlation.

III. Results and Discussion

The results of determining the physical characteristics of the samples include the following: 1000 grains weight and test weight, while determining the chemical characteristics of the sample include the following: titratable acidity, pH, fat, protein, ash, total polyphenols and antioxidant activity. Physical and chemical parameters of analyzed buckwheat samples are presented in Table 1.

Table 1: Physical and chemical characteristics of the samples of common and tatary buckwheat

Characteristic	CB1	CB2	CB3	CB4	TB1
1000 kernels weight (g d.m. basis)	21,64±0,05^{a}	15,67±0,19^{b}	18,08±0,00^{c}	21,20±0,04^{d}	13,26±0,06^{e}
Test weight (Kg/HL)	66,40±0,14^{a}	66,60±0,14^{a}	57,70±0,28^{b}	59,30±0,14^{c}	58,10±0,14^{bd}
Titratable acidity	2,30±0,14^{a}	2,90±0,14^{a}	2,10±0,14^{a}	5,48±0,42^{bc}	4,50±0,14^{b}
pH value	6,82±0,00^{a}	6,67±0,00^{bd}	6,64±0,01^{bd}	6,64±0,01^{d}	5,84±0,02^{c}
Fat (% d.m.)	2,99±0,11^{a}	2,35±0,06^{ab}	1,81±0,18^{b}	2,06±0,49^{ab}	2,64±0,01^{ab}
Proteins (NX6,25) (% d.m)	13,23±0,33^{a}	9,65±0,23^{b}	13,79±0,28^{a}	8,56±0,21^{b}	9,75±0,50^{b}
Ash (% d.m)	2,00±0,02^{a}	1,65±0,62^{a}	2,28±0,19^{a}	2,07±0,10^{a}	1,28±0,04^{a}
Total polyphenols (mg GA/L)	37,61±0,98^{a}	40,65±0,40^{a}	38,64±1,12^{a}	38,74±0,35^{a}	918,95±61,48^{b}
Antioxidant activity (μmolFe^{2+}/L)	870,47±7,10^{a}	885,80±8,95^{a}	867,47±7,54^{a}	873,47±22,63^{a}	7945,00±35,35^{b}

Different letters in rows from a to e for each parameter indicate significantly different values among buckwheat samples at $p< 0,05$.

The value of the 1000 kernels weight ranges from 13.26 g (TB1) to 21.64 g (CB1) (Table 1.). Tatary buckwheat grain size was significantly lower than in the samples CB1 and CB2, while it is similar to CB3 sample size as determined by the statistical analysis of data. References [20]-[21]-[22] show that tatary buckwheat has a lower 1000 kernel weight compared to common buckwheat. The highest value of test weight has the sample CB2 (66.60 Kg/HL), while the lowest value has the sample CB3 in the amount of 57.70 Kg/HL (Table 1.). Through analysis of the obtained results it was found that there were statistically significant differences in the amount of test weight between the sample TB1 and the samples CB1, CB2 and CB4. The results of titratable acidity (Table 1.) range from 2.10 in the CB3 to 5.48 to the sample CB4, which is in accordance to the results as in [18]-[23]. Through the analysis of the obtained results it was found that the sample TB1 is statistically significantly different in the amount of titratable acidity compared to samples of common buckwheat CB1, CB2, CB3 and CB4. Tatary buckwheat (TB1) stands out with the lowest pH value of 5.84 (Table 1.), a statistically significantly different compared to samples of common buckwheat, and the results obtained are consistent with the results as in [23]. The results of the determination of fat range from 1.81% (CB3) to 2.99% (CB1) (Table 1.) and there is a statistically significant difference in fat content between two samples. Those values are lower than the results obtained from a survey as in [24]-[25]. Tatary buckwheat does not differ in fat content compared to common buckwheat samples. This means that the type of buckwheat does not affect the fat content, which was also established as in [22]-[26]. The research identified a protein content of 8.56% in the sample CB4 to 13.79% in the sample CB3 (Table 1.). The results are lower compared to the results as in [24]-[25]-[27]. Samples of common buckwheat CB1 and CB3 significantly differ in protein content compared to the sample of tatary buckwheat TB1. References [22]-[28] show that common buckwheat contains more proteins as compared to tatary buckwheat. The ash content ranges from 1.28% in the sample TB1 to 2.28% in the sample CB3 (Table 1.). Tatary buckwheat has lower ash content in the grain compared to common buckwheat which was also established in research as in [22]-[29]. Although tatary buckwheat stands out with the lowest ash content, the results are not statistically different between the samples, and are consistent with the results as in [23]-[24]-[27], while they are quite higher compared to the results as in [18]. Total phenol content in the analyzed samples ranges from GA 37.61 mg/L in the sample extract CB1 to 918.95 mg GA/L in the sample extract of TB1 (Table 1.). The results obtained are higher compared to the research as in [18]-[23]. Reference [22] shows that tatary buckwheat contains significantly more total phenols in comparison to common buckwheat. Results of the determination of antioxidant activity range from 867.47 μmolFe^{2+}/L in the CB3 sample extract to 7945.00 μmolFe^{2+}/L in the TB1 sample extract (Table 1.). The results obtained are higher compared to the research as in [18]. Statistical analysis of data revealed that tatary buckwheat (TB1) significantly differs in content of total phenol and antioxidant activity compared to samples of common buckwheat (CB1, CB2, CB3, and CB4). Reference [30] shows that tatary buckwheat has a higher antioxidant potential than common buckwheat.

The results of PCA analysis of samples of buckwheat

Correlations within the measured physical and chemical parameters are presented in Table 2.

Table 2: Correlations of physical and chemical parameters on samples of buckwheat

	TA	pH	1000 KW	TW	Fat	Protein	Ash	TF	AA
TA	1	-0,46	-0,07	-0,43	-0,11	-0,86	-0,34	0,40	0,40
pH	-0,46	1	0,78	0,55	-0,15	0,37	0,79	**-0,98**	**0,98**
1000 KW	-0,07	0,78	1	0,23	0,00	0,28	0,79	-0,74	-0,74
TW	-0,43	0,55	0,23	1	0,58	0,08	-0,06	-0,44	-0,44
Fat	-0,11	-0,15	0,00	0,58	1	0,06	-0,50	0,32	0,32
Protein	-0,86	0,37	0,28	0,08	0,06	1	0,53	-0,30	-0,30
Ash	-0,34	0,79	0,79	-0,06	-0,50	0,53	1	-0,82	-0,82
TF	0,40	**-0,98**	-0,74	-0,44	0,32	-0,30	-0,82	1	**1,00**
AA	0,40	**-0,98**	-0,74	-0,44	0,32	-0,30	-0,82	**1,00**	1

AA – antioxidant activity; TF – total phenol; TA – titratable acidity; 1000 KW- 1000 kernel weight; TW- test weight

In terms of the physical - physical parameters test weight and 1000 kernels weight are weakly correlated (0.23), because the 1000 kernels weight depends on the size of a grain and test weight depends on the compactness of the grains. In terms of physical - chemical parameters strongly correlated (0.79) are the 1000 kernels weight and ash which indicates that the content of ash depends on the grain size. Further, strong correlation (0.78) was found between pH and 1000 kernels weight. In terms of chemical - chemical parameters in a very strong correlation (1.00) are totalphenols and antioxidant activity, followed by the strong negative correlation (-0.98) by total phenols and pH value, as well as a significant negative correlation (-0.82) of total phenols with ashes, which indicates that the total phenols depend on the weight and size of the grains rather than compactness. Sample TB1 stands out compared to other samples because it has the smallest 1000 kernels weight, the smallest ash content, the lowest pH value, the highest total phenol content and antioxidant activity (Fig. 2)

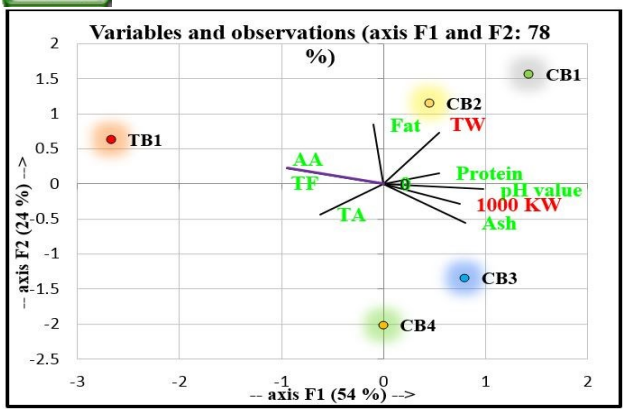

Figure 2: Multivariate analysis of analytical data - PCA, graphic indicators of buckwheat samples according to their physical (red color) and chemical (green color) parameters, relationship factors GK1 : GK2 (Abbreviations: AA – antioxidant activity; TF – total phenol; TA – titratable acidity; 1000 KW- 1000 kernel weight; TW- test weight)

The Fig. 2 shows that the samples of buckwheat that are subjected to testing are different in terms of physical and chemical characteristics. The variance is explained in a total of 78%, with the first component 54% and with the second component 24%. The first main component is closely related to the 1000 kernels weight, test weight, fat, protein, and pH. However, for the second main component closely related are antioxidant activity, phenols, titratable acidity and ashes. In the second multivariate analysis of analytical data shown in Fig. 3 proteins are determined, so from the figure can be seen that sample CB3 has high protein content. The variance is explained by 68%, with the first principal component 54% and the third with 14%. From the figure 2. it can be seen that the sample TB1 has a very high value of antioxidant activity and phenols. Samples CB1 and CB2 have a high fat content and the high value of test weight, while the sample CB3 shows high values of pH, 1000 kernels weight and high ash content. Sample CB4 is not designated with any of the components, nor does it show values of certain parameters.

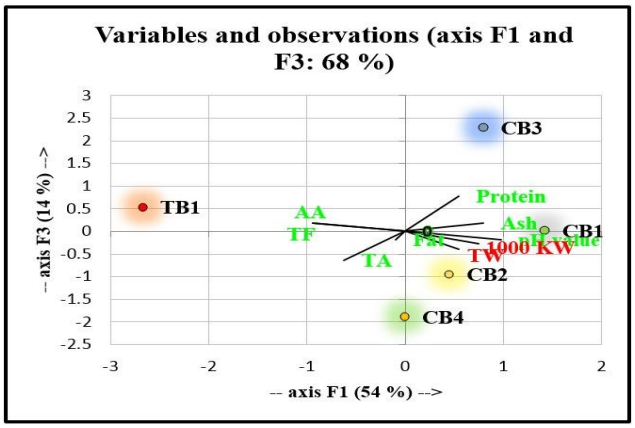

Figure 3: Multivariate analysis of analytical data - PCA, graphic indicators of buckwheat samples according to their physical (red color) and chemical (green color) parameters, relationship factors GK1 : GK3 (Abbreviations: AA – antioxidant activity; TF – total phenol; TA – titratable acidity; 1000 KW- 1000 kernel weight; TW- test weight)

IV. Conclusion

Based on this study it can be concluded that the samples are different in terms of physical and chemical characteristics. Both PCA plots show that the sample of tatary buckwheat (TB1) completely determins the total phenols and antioxidant activity. Tatary buckwheat (TB1) sample showed about 9 times higher content of antioxidant activity in comparison to the other samples and about 20 times higher total phenol content. Furthermore, it can be concluded that there is strong correlation of the antioxidant activity with total phenols, as well as of total phenols and antioxidant activity with the pH value.

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Munevera Begić was born on 23.02.1991. in Vlasenica. She graduated from University of Sarajevo, Faculty of Agriculture and Food Sciences with a degree *Bachelor of Food Sciences*. Based on the decision made by Senate of the University of Sarajevo in 2012, she was the winner of the *Golden Badge* as the best student of the first cycle of studies from the Faculty of Agriculture and Food Sciences. She finished her MA, Department of Food Sciences at the Faculty of Agriculture and Food Sciences in 2014 and earned *Masters degree*. She is currently employed at the Faculty of Agriculture and Food Sciences, University of Sarajevo, and she is studying her PhD at the Department of Food Sciences. She has taken part in the realisation of the international project. Munevera has published as an author and a co-author four scientific works.