CHEMICAL COMPOSITION OF OATS GROWN IN CONDITION OF ORGANIC PRODUCTION

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ABSTRACT

The research was conducted in 2015 and 2016, at 11 oats genotypes in terms of organic production. Three of the populations were domestic: *Krivogashtani*, *Trebenishta* and *Kuchevishte*. The rest were introduced varieties, including *Rajac*, *Slavuj* and *Lovcen* from Serbia and varieties: *Kupa*, *Baranja*, *Explorer*, *Shampionka* and *Istra* from Croatia.

On average, for both years, the variety *Shampionka* has the highest protein content (14.80%), which indicates that the grain has a high nutritional value. There is a statistically significant difference between the examined genotypes. The percentage of fat in oats, grown organically, in both years of research is statistically different in different genotypes. On average, in both years of research, the fat content ranged from 2.31% in the population *Trebenishta*, up to 4.47% in the population of *Krivogashtani*. The variety *Baranja* is with the highest ash content in the grains (4,35%) in average, for the research period. In the same group **a**, variety *Shampionka* is ranked, with 4.30%. Among the genotypes there is a statistically significant difference. It is interesting that for the period 2015-2016, all examined genotypes belong to group **a**, that is, all varieties and populations contain high cellulose content. A statistically significant difference between varieties and populations was established. Analysis of variance for the quality of oats grain shows that the content of protein, fat and ash values are relatively constant in the research period. The weather conditions had a weaker effect on the genotype. The strength of the genotype is 65.06%, 67.06% and 72.04%, respectively. The three properties are influenced by the interaction between the genotype and the weather conditions in the year of research.

Key words: *Variety, population, proteins, fats, ash, cellulose*

INTRODUCTION

Oats (*Avena sativa* L.) is one of the oldest cereals grown as an independent culture because of its high economic qualities, high content of proteins with a good balanced composition of amino acids [8], [19], [3]. Unlike other cereals, it has a favorable relationship between the nutritional properties and high digestibility, which determine oats as irreplaceable, concentrated feed in the diet of farm animals.

The agricultural significance of the oats is due to the quality of the grain and small requirements to the conditions of cultivation, so it can succeed in the areas where other cereals produce low yields [14]. With the development of the food industry and the growing need for healthy and dietary food, the importance of oats as a balanced diet for humans has also increased. Oat breeding aims at producing as high yielding varieties as possible, but also some irreplaceable properties of the grain related to the production of valuable food and nutritional products are also required [11], [6].

The oats grains have features that are not found in other cereals. Among them are high fat content, protein with a balanced amino acid content [8], [19], [3], and high-beta-gluten-rich fibers [18], [15]. The grain is rich in high-quality proteins, and in the food industry, a range of easily digestible, high-nutritional products such as oat flakes, meal, oat flour are produced from oat grains [1].

Many authors examined the content of these prized ingredients in oats grain and concluded that the content varies depending on the variety and conditions of cultivation of culture [12], [18], [15].

Oats is one of the most suitable cereals for organic production [14]. This is consistent with studies of other authors [7] that examining varieties of oats in terms of organic production, discovered that oats is very suitable cereal for organic production, considering the high yields they have received, which ranged from 4 up to 5 t / ha.

The purpose of our research was to survey the chemical properties of the oat's grains, in conditions of organic production, which will enable determining the significance of varieties and their recommendation in modern culinary and food technology.

MATERIAL AND METHODS

The tests were carried out in 2015 and 2016, in field and laboratory conditions. Field experiments were placed on the field of experiments at the Faculty of Agriculture at the Goce Delcev University, Stip, in Strumica, and the laboratory analyses were carried out at the laboratories of the Faculty of Agriculture. Eleven genotypes of oats have been analyzed, three of which are domestic populations: the population of *Krivogastani*, *Trebenista* and *Kuceviste*. The others are varieties introduced from Serbia and Croatia. Three varieties from Serbia were analyzed: the variety *Slavuj*, *Rajac* and *Lovken*. The other five varieties are from Croatia: the variety *Kupa*, *Baranja*, *Eksplorer*, *Sampionka* and *Istra*.

The trials were set in three replications, distributed by the random block system method, with a dimension of the basic plot of 5 m^2. The distance between the variants was 0.5 m, and between replications 1 m. The distance between raw was 20 cm. It was used sowing seed rate of 550 grains of 1 m^2. The basic soil treatment was performed at a depth of 35 cm. Prior to sowing, additional processing and fertilization with 30 t/ha biological fertilizers were carried out according to the regulations for organic production.

Before the harvest, material from 1 m^2 plot for laboratory analysis is taken, where the chemical properties of the oat grains are determined. Chemical properties of grain were determined by the following methods:

Cellulose: Intermediate filtration method (ISO 6865:2000). Animal Feed - Determination of the content of raw fibers;

Proteins: Cereals and legumes - Determination of nitrogen content and calculation of the content of raw proteins according to Kjeldahl method (ISO 20483:2006);

Ash: Cereals, legumes and by-products - Determination of the amount of ash by incineration (ISO 2171:2007);

Fats: Animal Feed - Determination of fat content (МКС ISO 6492:2012).

The statistical analysis of the results was performed using the Variance Analysis and Principal Component Analysis, using the JMP program.

RESULTS AND DISCUSSION

Protein content

The oat grains are rich in quality proteins and therefore, in the food industry, a range of easily digestible products of high nutritional value are produced, such as oat flakes, meal, oat flour [1].

Among the constituents of the oats, the concentration of proteins often ranks with the highest importance due to its importance in the diet.

In the first year of the survey, the content of proteins at oat grains grown in organic farming (Table 1) ranged from 12.6% in the variety *Baranja* to 14.3% in the variety *Sampionka*.

In the second year of the research, the the variety *Sampionka* is with the highest protein content (15.3%) and belongs to group a (tab.1). The lowest percentage of protein was obtained from the variety *Lovken* (12.9%).

Average for the two years of research, the the variety *Sampionka* is with the highest protein content (14.80%), indicating that the grain is of high nutritional value (Table 2). Among the examined genotypes there is a statistically significant difference.

Fat content

The oats compared to the remaining cereals have more favorable fat composition, since most fatty acids in triglycerides consist of oleic and linolenic acid [9]. Oat grains are relatively rich in fat compared to other cereals and can vary from 3% to 11% of the weight of the grains in different varieties, with lines containing up to 18% [4].

The fat content of the oat grains (Table 1) in both years of examination is statistically different in different genotypes. In 2015, the highest fat content was shown by the genotype *Krivogashtani* (4.57%) and *Kucheviste* (4.43%) and based on LSD values are in group a. The smallest fat content, in 2015 had the variety *Baranja* (2.35%).

In 2016, the fat content ranged from 2.08% in the variety *Kupa*, up to 4.36% in the population *Krivogashtani*, which means it is again in group a.

Among the genotypes, the variation, mean for the test period, is greater. The variation coefficient (Table 2) is 19,37%. Compared to VC% other properties it becomes clear that only fat variation is stronger.

Average for the both years, the variety *Krivogashtani* is with the highest in fat content (4.47%), which indicates that the grain is of high nutritional value (Table 2). Among the examined genotypes there is a statistically significant difference.

Ash content

Oat grain in terms of dry weight, on average contains 10-13% protein, 58-65% starch, 4.2 - 5.5% fat 11.6 - 14% crude fiber, 1.4 to 2% sugar and 3.2-3.8% ash [10].

Regardless of the year and the method of production, as the best genotype of the tested varieties for high ash content in the grain it proved the variety *Baranja*, with 4.2% in 2015 and 4.5% in 2016 (Table 1). The lowest ash content in both years of testing had a variety *Istra*, 3.3% in 2015 and 3.1% in 2016. Among the varieties there is a highly significant statistical difference.

Average, for the period of examination, the variety *Baranja* are with the highest ash content in the grains - 4,35% (Table 2). Together with it, in the group a, is also ranked the variety *Sampionka* with 4.30%. Among the genotypes there is a statistically significant difference.

Cellulose content

Cellulose is located in the pericarp, in an amount of 10.0-11.50%. Its quantity, above all, depends inversely on the size of the grains and the climatic conditions of the region in which it is grown [16].

The content of cellulose in the grain is significantly higher in 2016. The average value independent of the genotypes in 2016 is 24.29%, and in 2015, 14.62%. The variation of this property is 14.62% and shows a stronger variation between the varieties. In 2015 only the population *Kucheviste* is high in cellulose content - 17.5% (Table 1), while in 2016 two varieties are of the highest value: *Rajac* and *Baranja*, with 30.2% and 30.6%, respectively (tab.1). The smallest content of cellulose, in 2015, had the population *Krivogashtani* (11.7%), and in the year 2016, the variety *Istra* (17.8%).

In average for the period 2015-2016, all tested genotypes belong to a group a, or all varieties and populations contain a high content of cellulose (Tab. 2). A statistically significant difference between varieties and populations was established.

Table 2. Chemical composition for organic oats production for the period 2015-2016

Varieties / Populations	content (%)	Fat content (%)	Ash content (%)	Cellulose content (%)
Krivogashtani	13.75 ab	4.47 a	3.90 ab	14.95 a
Trebenishta	13.25 b	2.31 c	3.90 ab	17.55 a
Kucheviste	13.50 b	3.65 ab	4.00 ab	21.15 a
Rajac	13.65 b	3.80 ab	3.75 b	23.15 a
Slavuj	13.75 ab	3.48 abc	3.95 ab	19.70 a
Lovken	12.85 b	3.53 abc	3.90 ab	21.85 a
Kupa	12.95 b	2.61 bc	3.75 b	19.50 a
Baranja	13.05 b	2.81 bc	4.35 a	23.20 a
Eksplorer	13.60 b	2.64 bc	3.95 ab	19.85 a
Shampionka	14.80 a	3.12 bc	4.30 a	17.80 a
Istra	13.65 b	3.23 abc	3.20 c	15.00 a
Average	13.53	3.23	3.90	19.46
LSD	1.1	1.27	0.52	16.01
VC%	3.69	19.37	6.15	37.42

Table 1. Chemical composition of oats grown in organic production in 2015 and 2016

Varieties / Populations	Protein content (%)	Fat content (%)	Ash content (%)	Cellulose content (%)
2015				
Krivogashtani	13.7 a	4.57 a	3.6 cde	11.7 g
Trebenishta	13.1 bc	2.42 g	3.7 cd	13.4 e
Kucheviste	13.0 bc	4.43 a	3.8 bcd	17.5 a
Rajac	12.9 c	4.26 b	3.9 abc	16.1 b
Slavuj	13.6 ab	3.59 d	3.8 bcd	14.2 cd
Lovken	12.8 c	3.62 d	3.8 bcd	14.6 c
Kupa	12.8 c	3.14 e	3.5 de	14.0 d
Baranja	12.6 c	2.35 g	4.2 a	15.8 b
Eksplorer	13.8 a	2.74 f	4.1 ab	15.7 b
Shampionka	14.3a	2.77 f	4.2 a	15.7
Istra	13.8 a	3.87 c	3.3 e	12.2 f
Average	13.31	3.43	3.81	14.62
LSD	0.67	0.15	0.37	0.42
VC%	3.01	2.62	6.04	1.64
2016				
Krivogashtani	13.8 cde	4.36 a	4.2 abc	18.2 h
Trebenishta	13.4 ef	2.28 g	4.0 cd	21.7 f
Kucheviste	14.0 bc	2.87 e	4.2 abc	24.8 d
Rajac	14.4 b	3.33 cd	3.6 e	30.2 a
Slavuj	13.9 cd	3.36 bcd	4.1 bcd	25.2 d
Lovken	12.9 g	3.43 bc	4.0 cd	29.1 b
Kupa	13.1 fg	2.08 h	4.0 cd	25.7 c
Baranja	13.5 def	3.27 d	4.5 a	30.6 a
Eksplorer	13.4 ef	2.53 f	3.8 de	24.0 e
Shampionka	15.3 a	3.47 b	4.4 ab	19.9 g
Istra	13.5 def	2.59 f	3.1 f	17.8 h
Average	13.78	3.05	3.99	24.29
LSD	0.42	0.13	0.40	0.46
VC%	1.82	2.30	5.76	1.11

MS - mean squares; **η** – effect of factor

Table 3. Analyzes of the variance of grain quality in oats for the period 2015-2016

Proteperties	Source of variation					
	Genotype		Year		Interaction	
	MS	η	MS	η	MS	η
Protein content	1.618***	65.06	1.559***	12.54	0.557***	22.39
Fat content	2.292***	67.06	0.994***	5.82	0.927***	27.12
Ash content	0.549***	72.40	0.549***	8.53	0.145***	19.07
Cellulose content	45.570***	21.64	759.584***	69.12	20.312***	9.24

MS - mean squares; **η** – effect of factor

Table 4. Component vector analysis of the tested properties by years and average for the period 2015-2016

Main components	2015			2016			Avergae for the period 2015-2016		
	Limit load value	Percent of variability (%)	Cumulative percentage (%)	Limit load value	Percent of variability (%)	Cumulative percentage (%)	Limit load value	Percent of variability (%)	Cumulative percentage (%)
1	1.92	48.09	48.09	1.67	41.76	41.76	1.61	40.21	40.21
2	1.10	27.51	75.60	1.22	30.57	72.33	1.23	30.69	70.90

CONCLUSION

Based on the two-year trials and the obtained results for the chemical composition of oats grown in organic production, we can conclude that:

- On average, for both years, the variety *Shampionka* is with the highest protein content (14.80%), which indicates that the grain has a high nutritional value. Among the examined genotypes there is a statistically significant difference.
- The fat content of oat grains in both years of examination is statistically different in different genotypes. In 2015, the highest fat content was shown by the genotype *Krivogashtani* (4.57%) and *Kucheviste* (4.43%), while in 2016 the fat content ranged from 2.08% in the variety *Kupa*, to 4.36% in the *Krivogashtani* population, which means that the population of *Krivogashtani* is in group **a**.
- Average for the test period, the variety *Baranja* is with the highest ash content in the grains, 4,35%. In the same group **a** it is also ranked variety *Shampionka*, with 4.30%. Among the genotypes there is a statistically significant difference.
- Average for the period 2015-2016, all investigated genotypes belong to group **a**, ie, all varieties and populations contain high cellulose content. A statistically significant difference between varieties and populations was established.
- Properties, protein, fat and ash content are strongly influenced by the interaction between the genotype and the conditions of the year, while the cellulose content is strongly influenced by the year.

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