SOME CHEMICAL, YIELD AND QUALITY PROPERTIES OF DOMESTIC OAT CULTIVARS

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Abstract

Oat *(Avena sativa* L.) is one of the cereal crops cultivated in climate temperate zones. It is well known as a healthy food in the world, because of its unique biochemical structure. Nowadays the quality of grain for consumers has become important especially in terms of lipids and β-glucan content. The aim of this study was to characterize the yield, volume weight, 1000 kernel weight, husk content and kernel size distribution for two naked and three husked oat cultivars. Some quality analyses were determined, such as protein, starch, lipid and β-glucan contents. Investigations were carried out at the State Stende Cereal Breeding Institute in 2012 and 2013. The obtained results showed significant differences among naked and husked oat cultivars in all tested parameters for example lipid content for husked oat cultivars varied from 58.1–66.8 g kg^{-1}, but for naked oat 92.3–108.8 g kg^{-1}. β-glucan content among husked oat cultivars varied from 3.81–3.85 g 100 g^{-1}, but naked oat breeding line '33793' reached 5.07 g 100 g^{-1}. Little variation between years was detected as well. Research showed that naked oat characterized with better quality and insignificant husk content, what is preferable for consumers', but kernel size uniformity and yielding abilities of husked oat cultivars would be preferable reasons for farmers and food producers to choose them as a raw material. Overall naked oat could be better for food production from consumers' side, but food producers are made to choose husked oat cultivars because of the requirements of production techniques.

Keywords: naked oat, husked oat, quality.

Introduction

Oat *(Avena sativa* L.) is an important crop produced in climate temperate zone and distinct among the cereals due to its multifunctional characteristics and nutritional profile. It is used both for human and animal nutrition. Before using in human nutrition, oat was used for medicine purposes. Oat is a nutritious source of protein, carbohydrate, fiber, vitamins and minerals. Currently, discussion on oat grain dietetic value and suitability for the production of functional foods is more frequently mentioned in scientific literature and scientific projects (Biel et al., 2009).

Grain yield, volume weight and 1000 kernel weight and husk content are the most important economic traits mentioned by the oat consumers, because the end-product outcome is due to these traits when oat grain is processed (Sadiq Butt et al., 2008).

Oat kernel size uniformity is an important parameter for the oat milling industry because the processing of oats for human food generally involves size separation of kernels into different streams before dehulling. Oat spikelets may contain one, two, tree, or more kernels, and the main kernel is always larger than others. Larger oat grains can be dehulled at slower rotor speeds than smaller oat grains, it is because an oat kernel with a larger mass will possess more energy of inertia when impacting the walls of the impact dehuller than smaller oat grains at the same rotor speed. So it is better if oat cultivar is characterized with larger kernel fraction or more of the same size grains (Doehlert et al., 2006b, Doehlert et al., 2004).

Oat breeders through hybridization and selection have improved yielding ability potential of oat varieties; they have developed oat varieties dwarfed in length and more resistant to lodging. On consumers'side lower standards are set forward regarding biochemical composition of grain: protein, lipids, β-glucan, starch contents in grain, though dietetic value of oats is just due to these traits (Wood, 2007). Protein is considered as the most important nutrient for humans and animals as well. The average protein content of cereal grains covers a relatively narrow range (8–11%) variations, however, are quite noticeable. The main part (approximately 40%) of kernel structural component is starch. Because of its unique properties, starch is important for the textural properties of many foods, in particular bread and other baked goods. It is located only in endosperm and is present in granular form. Oat contains relatively high amounts of lipids (approximately from 7%) compared to other cereal grains (Sadiq Butt et al., 2008).

Among the main compounds associated with health-promoting effects in cereals is dietary fiber which is found only in plant origin foods. It consists of both – soluble and insoluble fiber. Both types are important for human health (Manthey et al., 1999). Water-soluble fiber in cereals is composed of non-starchy polysaccharides such as β-glucan also called lichenin. It is presented particularly in barley (3–7%) and oat (3.5–5%), whereas less than 2% β-glucan is found in other cereals. Some of the oat constituents are valuable ingredients or starting materials for several types of products (Brindzova et al., 2008). Oat β-glucan has received the most attention and has a number of potential uses (Wood, 2007).

The aim of this study was to characterize the yield, test weight, 1000 kernel weight, husk content and kernel size distribution for two naked and three husked oat cultivars.

Materials and Methods

Field trials and investigation were carried out at the State Stende Cereals Breeding Institute (SSCBI) in 2012 and 2013. Five local oat cultivars (int. al. two

naked oat and three husked oat cultivars) were used for this research. The soil of the site was sod-podzolic in both, the humus content – 18 g kg^{-1} (2012), 20 g kg^{-1} (2013), the soil pH KCl – 6.2 (2012), 6.6 (2013) , the available for plants content of phosphorus P – 42 mg kg^{-1} (2012), 39 mg kg^{-1} (2013), and that of potassium K – 59 mg kg^{-1} (2012), 53 mg kg^{-1} (2013). The pre-crop was barley for both years. All agro-technical operations were carried out at optimal terms according to the weather conditions during the vegetation period and depending on the plant development phases. Seed rate was 500 seeds per 1 m^2. Before cultivation of the soil, a complex mineral fertilizer was applied: N-51, P–30, and K – 42 kg ha^{-1}. Variants were arranged in four replications with plot size 10 m^2 in a randomized block design.
The temperature and moisture conditions provided good oat field germination in 2012 and 2013 and were shown in Figure 1 and Figure 2, respectively.

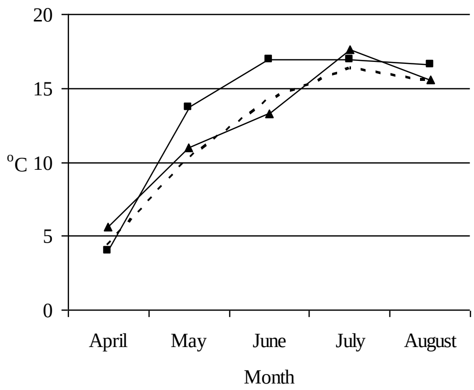

Figure 1. The mean daily temperature at SSCBI
– year 2012, – year 2013, - - - - – long term average

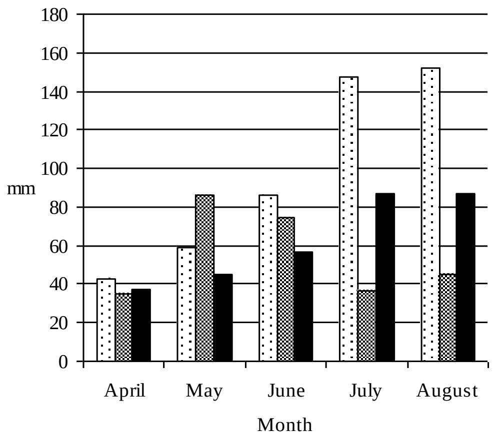

Figure 2. Sum of precipitation at SSCBI
– year 2012, – year 2013, – long term average

The mean daily temperature in 2012 was close to long term average, but weather observations in 2013 were high above it. Vegetation period in 2012 characterized by abundant rainfall and mean values of all months exceeded the long-term observed monthly norm. Harvesting was delayed approximately by ten days because of heavy rainfalls at first decade of August. The opposite situation was in 2013. Precipitation in May was excellent for germination, and lack of moisture in end of vegetation period ripened grains in panicles.
Mean samples from all replications (0.5 kg) were taken for testing with Infratec Analyser 1241 (test weight, protein, starch, β-glucan and lipid content) performed at the State Stende Cereals Breeding Institute. 1000 kernel weight was detected by standard method LVS EN ISO 520:2011. Kernel size classifications were carried out with SORTIMAT separator machine. Cleaned sample of 100 g to be weighed on a balance accurate to 0.01 g and then placed onto the top sieve. The sieving period was set for 3 minutes, recommended by producers. The sieves were used with diameters of 2.5 and 2.2 mm. With a weighed batch of 100 g, the percentage proportion was then obtained by weighing the individual fractions. Husk content was determined by four samples of 5 g of each cultivar, separating husk from kernel manually and weighed, percentage proportion was calculated.
The obtained results were statistically processed by MS Excel program package using the methods of descriptive statistics. ANOVA procedures were used for data analysis.

Results and Discussion

Quality

Nowadays, oat in Latvia has been widely studied as a raw material for human diet. For using oat meals in human nutrition, it is necessary to investigate its quality and thereby suitability. In this study, protein, starch, lipid and β-glucan contents were determined as quality parameters for naked and husked oat cultivars, the results were shown in Table 1.

Table 1

Quality of naked and husked oat cultivars (means calculated according to two years results, g kg^{-1}±sd on dry matter basis)

Cultivar	Protein*	Starch*	Lipids*
Naked oat cultivars			
S-156	168.8 ± 0.13^{ab}	299.8 ± 1.26^{b}	108.8 ± 0.21^{ab}
33793	163.9 ± 0.15^{ab}	349.8 ± 0.87^{b}	92.3 ± 0.16^{ab}
Husked oat cultivars			
'Arta'	114.8 ± 0.10^{b}	462.8 ± 0.17^{ab}	58.1 ± 0.09^{b}
'Laima'	100.8 ± 0.06^{b}	458.5 ± 0.20^{ab}	65.6 ± 0.23^{b}
'Stendes Dārta'	100.9 ± 0.07^{b}	456.5 ± 0.23^{ab}	66.8 ± 0.16^{b}

*difference are significant between naked and husked oat cultivars with the level of $p<0.05$, [a] trait mean values significantly higher comparing husked and naked oat cultivars, [b] differences significant between years.

Starch is the major storage carbohydrate of cereals and an important compound for human nutrition. Starch contents of naked oats were significantly ($p<0.05$)

lower than that of husked oat cultivars. Mean starch content for naked oats was 324.8 g kg^{-1}, but for husked oats – 459.3 g kg^{-1}. Opposite results were reported in the study of Givens et al. (2003), who were found that husked oat cultivars had significantly lower starch contents than that of naked ones (400 g kg^{-1} and 580 g kg^{-1}, respectively). Starch content in oat grain is subjected to variety, nitrogen treatment and weather conditions. In this study, nitrogen treatment was the same in both years, but chosen varieties and meteorological conditions might affect starch contents according to our results.

Protein and lipid contents of naked oat cultivars were significantly high ($p<0.05$). Lipids in foods are an important nutritional factor and their profile may play a crucial role as concerns the stability of cereal products (Brindzova et al., 2008). Oat grain has soft kernel and lipid distributed throughout the seed, which makes the milling process more difficult than wheat and corn. To prevent from atmospheric oxidation, the oat is hydrothermally treated before processing (Sadiq Butt et al., 2008). The high lipid content is not desirable for food producers, but crucial component for human diet, because of consistence of vitamin E and fatty acids, which is located in lipids. The highest lipid content (108.8 g kg^{-1}) was observed with naked oat breeding line of S-156. Conciatori et al. (2000) determined mean lipid content for naked oat as 116.4 g kg^{-1} which was close to our results. The lowest lipid content (66.8 g kg^{-1}) was observed with husked oat variety of Stendes Dārta, similar result obtained with common oat as 72 g kg^{-1} (Koehler and Wieser, 2013). Lipid content in oat cultivars is strongly dependent on meteorological conditions of sowing year which was indicated by Givens et al. (2003). It was also seen in our research, where lipid content for naked oat cultivars was significantly ($p<0.05$) higher in 2013. Significant difference ($p<0.05$) was observed only for naked oat cultivars.

The highest protein content (168.8 g kg^{-1}) among naked oat cultivars was detected with the breeding line of S-156. Among the husked oat cultivars, the highest protein content (114.8 g kg^{-1}) was obtained with the sample of Arta. In the literature, for husked oat, average protein content is reported as 115.0 g kg^{-1}, for naked oat, it was reported as 143.4 g kg^{-1} (Biel et al., 2009). Protein content in oat grain is dependent on mostly agro-meteorological conditions: variety, nitrogen treatment, sowing date and weather conditions (Givens et al., 2003). That is the reason why significant differences were found between husked and naked oat cultivars, also between varieties and years.

β-glucan, which is a soluble dietary fiber, is an important component of oat grain with health promoting effect. It could have beneficial role in gastrointestinal diseases, lowering of cholesterol level, promoting heart health, preventing diabetes and even cancer (Daou, Zhang, 2012). When naked and husked oat cultivars were compared, husked oat had significantly lower β-glucan content, as shown in Figure 3. The cultivar of Stendes Dārta had the highest β-glucan content among the husked oat cultivars, like 3.85 g 100 g^{-1}. The naked oat breeding line of 33793 had the highest β-glucan content (5.07 g 100 g^{-1}) among all cultivars studied. In the literature, β-glucan contents for oats were reported between 2.3–8.5 g 100 g^{-1}. Cultivars studied in this research demonstrated average results compared to data reported previously.

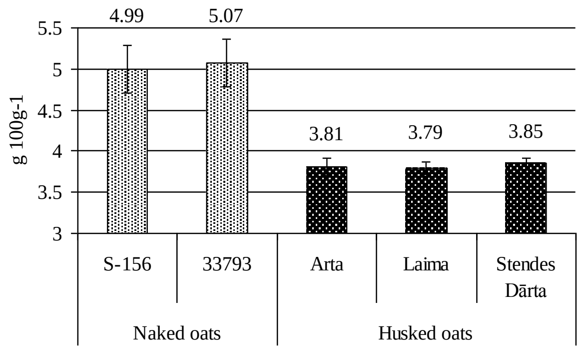

Figure 3. β-glucan (g 100 g^{-1}) contents of oat cultivars

▒ – naked oat cultivars, ▓ – husked oat cultivars

Productivity

Productivity parameters used in this study were yield, 1000 kernel size, test weight and husk content. Yield results shown in Table 2 varied from 4.31 t ha^{-1} to 5.30 t ha^{-1} for husked oat genotypes, but for naked ones the highest yield was obtained with the sample of S-156 as 3.69 t ha^{-1}. Zute et al. (2010) reported husked oat yield about 5.02 t ha^{-1} between 1993 and 2009 years. Same as quality parameters, yield is also dependent on meteorological conditions.

Table 2

Yield and husk contents of naked and husked oat cultivars

Cultivar	Yield*, t ha^{-1}	Husk content*, %
Naked oat cultivars		
S-156	3.69±0.33	0.06±0.02 [b]
33793	3.20±0.06	0.10±0.02 [b]
Husked oat cultivars		
Arta	4.31±0.31 [a]	23.23±0.65 [ab]
Laima	5.30±0.02 [a]	26.44±0.18 [ab]
Stendes Dārta	5.25±0.04 [a]	26.14±0.75 [ab]

*difference are significant between naked and husked oat cultivars with the level of $p<0.05$, [a] trait mean values significantly higher comparing husked and naked oat cultivars, [b] differences significant between years

Husk content of oat grain is about 25–30 % of the seed. The grain is dehulled before use, whereas husk after processing may be used in food industry. Unprocessed husk contains silicate particles, which are harmful to nature and can irritate the mouth, esophagus and gastrointestinal tract (Sadiq Butt et al., 2008). The highest husk content was detected with the cultivar of Laima, as 26.4% (Table 2). Husk contents of naked oat cultivars were not significant. Yield consists of husk and groat weight. Although naked oat cultivars had low amount of husk, their groat yields were close to the yield of husked oat cultivars.

1000 kernel weight is a parameter which characterizes kernel weight. The results showed that husked oat cultivars have significantly higher ($p<0.05$) 1000 kernel weight comparing with naked oat cultivars and variation between years was significant as well. Volume weight is most commonly used to evaluate grain quality. Volume weight was significantly ($p<0.05$) higher for naked oat cultivars also observed by Doehlert et al. (2001), and also its value was influenced by sowing year.

Kernel size distribution

Kernel size uniformity test showed that the distribution of kernel size was dependent mostly on cultivar and two distribution classes (>2.5 and <2.2) on sowing year (Table 3).

Table 3

Kernel size distribution (%) of husked and naked oat cultivars (sieve hole diameters of 2.5 and 2.2 mm)

Cultivar	>2.5	2.5–2.2	<2.2
	2012*		
Naked oat cultivars			
33793	17.6[b]	42.0	40.4[ab]
S-156	18.5[b]	44.7	36.8[ab]
Husked oat cultivars			
Stendes Dārta	47.7[ab]	40.5	11.8[b]
Arta	63.0[ab]	27.6	9.4[b]
Laima	36.3[ab]	51.9	11.8[b]
Cultivar	**>2.5**	**2.5–2.2**	**<2.2**
	2013*		
Naked oat cultivars			
33793	14.1[b]	39.8	46.0[ab]
S-156	12.1[b]	42.8	45.1[ab]
Husked oat cultivars			
Stendes Dārta	55.7[ab]	40.3	4.0[b]
Arta	67.4[ab]	27.1	5.4[b]
Laima	44.5[ab]	49.8	5.7[b]

*difference are significant between husked and naked oat cultivars with the level of $p<0.05$, [a] trait mean values significantly higher comparing husked and naked oat cultivars, [b] differences significant between years.

With larger kernels (>2.5 mm) characterized as husked oat cultivars. For example 63.0% of kernels in 2012 and 67.4% of kernels in 2013 were observed in class of >2.5 mm for the cultivar of Arta. For food production, such cultivar with larger grains is more suitable than others, because it requires lower rotor speed in dehulling process (Doehlert et al., 2004). As the husked oat spikelets may contain 1 to mostly 3 florets, naked oat spiklets consists of up to 12 florets (Doehlert et al. 2006a). It means that the kernels of naked oat cultivars are smaller comparing with husked oat. As we mentioned that kernel size distribution is quite dependent on cultivar, the results of other scientists were much different from ours. Doehlert et al. (2004) worked with four sieve classes, like 3.18, 2.58, 2.38, 1.98 mm slot sieves. The most of husked cultivars were characterized as small grains (2.38–1.98 mm slot) in that research. Kernel size uniformity is an important character for food producers, but it is hard to find cultivars with required quality parameters, such as large grains.

Conclusions

For all tested parameters, there were significant ($p<0.05$) differences between naked and husked oat cultivars. The naked oat cultivars exhibited better quality parameters, for example they had the highest protein and the lowest starch contents. The lipid contents of naked oat cultivars was higher than the reported literature findings, however β-glucan level failed to meet expectations and average value was obtained in studied years. Productivity of tested cultivars showed that yield, husk content and 1000 kernel weight results of husked oat cultivars were higher than naked oat cultivars. Besides, volume weight results of naked oat cultivars were higher than that of husked oat cultivars. Such parameters, like larger grain size, yield and lower lipid content could be main reasons for food producers to choose husked oat cultivars. When the low processing requirements is considered, the naked oat cultivars can be more valuable for food industry.

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