LIPID COMPOSITION OF OAT GRAIN GROWN IN LATVIA

Vita Sterna[1], Sanita Zute[2], Linda Brunava[1], Zaiga Vicupe[2]

[1] *Department of Agro-ecologocal Research, State Stende Cereals Breeding Institute, „Dizzemes", Dizstende, Libagi parish, Talsi County, Latvia, e-mail: vitasterna@inbox.lv*

[2] *Department of Cereal Breeding, State Stende Cereals Breeding Institute, Dizzemes, Dizstende, Libagi parish, Talsi County, Latvia*

Abstract

Oat (*Avena sativa* L.) is a well known annual crop in temperate climates. It is recognised as a healthy food containing significant amounts of fat-soluble vitamin E and polyunsaturated fatty acids in the world. There are few investigations of lipid composition in connection with human health in Latvia. Therefore the aim of this study was to characterize the composition of lipids of same oat varieties to grown in Latvian condition. Investigations were performed at the State Stende Cereal Breeding Institute. In the studied samples content of fat, composition of fatty acids and vitamin E (α-tocopherol) were determined, same as ratio most significant for human health like PUFA/SFA and ω-3/ ω-6 were calculate. The total fat was made by Soxlet method, fatty acids by LVS CEN ISO/TS 17764-1:2007 and content α-tocopherol determination was made using high-performance liquid-chromatography. The high concentration was determined as mg kg dry matter. The obtained results showed a wide range of fat content among varieties, it varied from 4.9 to 10.5 g 100 g^{-1}. The content of α-tocopherol in oat grain was determined 8.5–12.3 mg kg^{-1}, and the sum of unsaturated fatty acids accounted 78–81.5% of total fatty acids content. The ratio P/S varied from 2.2 to 2.4. Result of evaluation leads to conclusion that lipid of oat grain are rich with biologicaly significant substances.

***Keywords*:** oat for human health, fat content, fatty acids, vitamin E.

Introduction

Oat is recognised as a healthy food containing significant amounts of fat-soluble vitamin E and polyunsaturated fatty acids in the world.

The fat content of oat grain is the highest among grains and varied from 4.2 to 11.8 g 100 g^{-1}, in comparison with wheat (2.1–3.8 g 100 g^{-1}), rice (2.0–3.1 g 100 g^{-1}), millet (4.0–5.5 g 100 g^{-1}), barley (3.3–4.6 g 100 g^{-1}), rye (2.0–3.5 g 100 g^{-1}) (Zhou, 1999). Total lipid in oat grains averages 4–6 % when based on relatively few varieties. However, larger ranges are apparent when more genotypes are considered, the range of 3.1 to 11.6% was found among more than 4 000 US entries in the world collection (Zhou, 1999). A high lipid content of 15.5% in a US experimental line of groats was reported by Hartunian – Sowa and White, 1992). Morphologically, oat can be classified as husked and naked; naked oat is nutritionally richer than the common husked oat.

Vitamin E activity is provided by the tocopherols and tocotrienols, which together create tocols. Tocols are fat soluble and form part of the total lipid. The vitamin activity of tocols is associated with their antioxidant function *in vivo*. The highest level of vitamin E activity is produced by α-tocopherol, following by β-tocopherol and α-tocotrienol, which have 40% and 30% of the activity of α-tocopherol, respectively on an equal weight basis (Welch, 1995; Zielinski et al., 2001; Jackson et al., 2008). Alpha-tocopherol is a major antioxidant component in crude oat unaltered when the lipid is refined (Webster, 1986). Among the Latvian genotypes, the variety 'Arta' had the highest α-tocopherol concentration – 7.5 mg kg^{-1}, and there was no significant difference between years (Berga et al., 2012).

The fatty acid composition of oat lipids is bound as to oat breeders so to nutritionists because of the nutritional significance of fatty acids. Separate fatty acids (FA) also have different impact on human health. Many studies estimate the beneficial effects of polyunsaturated (PUFA) and monounsaturated fatty acids (MUFA) (Chillard et al., 2000). Linoleic, oleic and palmitic acids are major oat lipid constituents (Brindzova et al., 2008). The proportion of unsaturated fatty acids is about 75% of total and content of palmitic acid as main of saturated fatty acids determined 14–17% (Saastamoinen, 1989).

To compare the potential impact of fat on human health often used fatty acids ratio in the scientific literature. The most commonly used is ratio – sum of polyunsaturated fatty acids to sum of saturated fatty acids – PUFA / SFA. World Health Organization (2003) recommended ratio PUFA/SFA must be higher than 0.4. The decrease in ratio between n-6 and n-3 FA, as well as increase in ratio between stearic / palmitic acids (C18:0 / C16:0) and oleic / stearic acids (C18:1c / C18:0) are desirable for the prevention of number of diseases (Gebauera et al., 2005).

The lipid content of oat grain depends on genetic and environmental factors as well as the method of determination (Zhou, 1999). The limiting heritabilities for fat content is high and polygenic (Karow, Rosberg, 1984)

The aim of this study was to characterize the composition of lipids of same oat varieties to grown in Latvian condition**.**

Materials and Methods

Investigations were performed at the State Stende Cereal Breeding Institute. The material consisted of 7 oat genotypes (int. al. 4 husked and 3 naked). In the studied samples fat, α-tocopherol content and fatty acids composition were determined.

Fat content was made by Sochlet method.

Vitamin E. Mean samples from all replications (0.5 kg) were taken and milled for α-tocopherol determination in the Laboratory of Food and Environmental Investigations of the Institute of Food Safety, Animal

Health and Environment BIOR, using high-performance liquid-chromatography. The method is often used for detection of α-tocopherol in diet samples. Absorption was measured at 292 nm. Chromatography was carried out in a C18 column using methanol / water liquid (98 / 2 v/v). The concentration was determined as mg kg^{-1} in dry matter.

Fatty acids. Previously homogenized samples were prepared for GLC (gas-liquid chromatography) analysis using direct saponification with KOH/methanol followed by a derivatization with (trimethylsilyl) diazomethane. Alltech AT-FAME analytical column was used. The carrier gas (He) flow rate was 2 mL min^{-1}. The injector and detector temperatures were 225 °C and 250 °C, respectively. Peaks were identified using standard mixture Supelco FAME Mix C4-C24, Sigma Aldrich. The concentration was determined as % of total fatty acids.

The content of different fatty acids (FA) was calculated according to formulas 1–3:

$$SFA = \sum C14:0;\ C16:0;\ C18:0;\ C20:0; C22:0 \quad (1)$$

$$MUFA = \sum C16:1, C18:1, C20:1 \quad (2)$$

$$PUFA = \sum C14:0; C16:0; C18:0; C20:0; C22:0 \quad (3)$$

The obtained results were statistically processed using descriptive statistics in the MS Excel software package. Correlation defined as medium close if 0.5<r>0.79. Differences between the groups were tested for significance ($p<0.05$) by ANOVA.

Results and Discussion

Obtained results of fat and α-tocopherol contents in analyzed oat grain samples assumed in the Table 1.

Table 1

Average fat and α-tocopherol contents of oat grain

Genotipes /Lines	fat, g 100 g^{-1}	α-tocopherol	
		mg kg^{-1}	% of fat
Naked oat cultivars			
S-156	8.9	10.3	0.012
33793	7.9	10.2	0.013
33805	10.7	9.0	0.009
Husked oat cultivars			
'St. Līva'	4.0	9.0	0.019
'Laima'	5.65	4.2	0.007
'Arta'	5.32	5.8	0.011
'St. Dārta'	5.67	3.3	0.012

As showed in the table 1, fat content same as content of α-tocopherol in grain samples differed significantly among oat varieties ($p<0.05$). Varieties of husked oat 'Stendes Līva' and 'Arta' had smallest fat content – 4.0 and 5.32 g 100 g^{-1} respectively. The richest in fats was grains of naked oat breeding line '33805'. Data of other investigations show that fat content of oat varied from 5–9% (Morrison, 1979) and 4.2–11.8 g 100 g^{-1} (Zhou, 1999).

Content of α-tocopherol in oats determined from 3 to 12.3 mg kg^{-1}, the richest was grains of breeding lines 'S-156' and '33793' with average α-tocopherol contents 10.3 mg kg^{-1} and 10.2 mg kg^{-1} respectively. Relatively richest with vitamin E was fat of variety 'St.Līva', with α-tocopherol concentration 0.019% of fat content. Previous investigations among the Latvian genotypes show that the variety 'Arta' had the highest α-tocopherol concentration – 7.5 mg kg^{-1} (Berga, 2012). Oat genotypes bred in Latvia did not show a marked difference when compared with material of foreign origin. The difference between husked and naked oat genotypes can be explained by the differences in sample structure.

Correlation between fat and α-tocopherol content reflected in Figure 1.

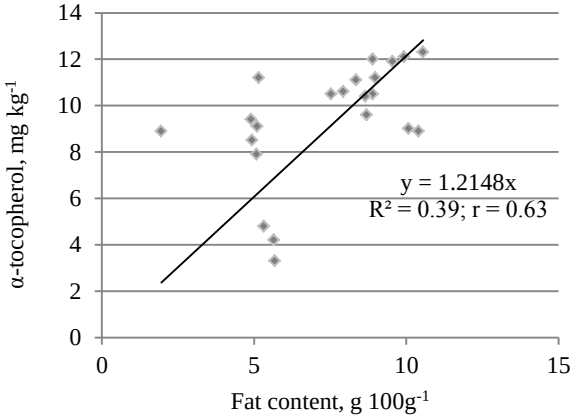

Figure 1. Corelation between fat and α-tocopherol content in oat grain samples

Correlation between fat and α-tocopherol content is not strong r=0.63, in husked oats correlation was calculate r=0.83, but in naked oats r=0.57. Our study confirms that just 39% of α-tocopherol changes could explain with fat content in oat grains, more than 60% explain with other factors such as oats variety impact.

The lipid fraction of the oat grain determines in large measure nutritional quality via the fatty acid composition. The content and degree of unsaturation of the oat total fatty acid was higher in winter sown than in spring sown crops, indicating that low temperatures cause a higher synthesis of unsaturated fatty acids in oats (107).

Fatty acid composition of husked oat grain same as ratio PUFA/SFA, C18/C16; C18:1/C18 assumed in Table 2 and fatty acid composition of naked oat grain with ratios assumed in Table 3.

Obtained results showed that content of oleic acid was determined 36.2–40.4% and content of linoleic acid 38.4–41.6%. Data of other investigations show that content of oleic acid in oat grain varieties determined from 37.2 to 42.1% and content of linoleic acid 38.6–42.5% (Saastamoinen, 1989).

Table 2

Fatty acid composition of husked oat grain, % of total

Fatty acids	Laima	Arta	St.Līva	St.Dārta
C14:0	0.2	–	–	–
C16:0	16.1	16.8	16.4	17.1
C18:0	1.7	2.5	2.3	2.1
C18:1	36.2	37.5	37.6	37.8
C18:2(n-6)	41.6	40.1	39.8	39.4
C18:2	1.2	1.0	1.0	1.1
C18:3(n-3)	1.2	0.9	1.3	0.9
C20:0	0.2	0.2	0.2	0.2
C20:1	0.8	0.7	0.8	0.6
C20:5	0.4	0.2	0.4	0.3
C22:0	0.1	0.1	0.1	0.1
PUFA/SFA	2.4	2.2	2.3	2.2
C18/C16	0.11	0.15	0.14	0.12
C18:1/C18	21.3	15.0	16.4	19.2

Table 3

Fatty acid composition of naked oat grain, % of total

Fatty acids	S-156	33793
C14:0	–	–
C16:0	17.4	15.5
C18:0	1.7	2.4
C18:1	37.9	40.4
C18:2(n-6)	39.1	38.4
C18:2	1.2	0.9
C18:3(n-3)	1.1	0.9
C20:1	0.7	0.7
C20:0	0.2	0.2
C20:5	0.3	0.2
C22:0	0.1	0.1
PUFA/SFA	2.2	2.3
C18/C16	0.10	0.15
C18:1/C18	22.3	16.8

The main saturated fatty acids increased cholesterol level in human blood are myristic acid and palmitic acid. Results of investigation showed that myristic acid determined 0.2% in oats of 'Laima' and content of palmitic acid in oat varieties determined 15.5–17.4%. The reviewed data showed higher content of myristic acid (0.2–4.9%) and palmitic acid (13.2–28.0%) in oat grains.

The evaluation of ratios significant for human health showed that ratio PUFA/SFA of analysed oat samples varied from 2.2 to 2.4, it was 5–6 times higher as WHO (2003) suggested and did not differed among oat varieties ($p>0.05$).

As mentioned before, the increase in ratio between stearic / palmitic acids (C18:0 / C16:0) and oleic / stearc acids (C18:1c / C18:0) are desirable for the prevention of number of diseases. The calculated ratio C18:0 / C16:0 varied from 0.10 to 0.15 and higher was calculated in husked oat variety 'Arta' same as naked oat breeding line '33793'. Evaluation of ratio C18:1 / C18:0 shoved that more healthy are husked oat samples 'Laima' same as naked oat samples 'S-156'.

Assumed saturated, mono unsaturated and polyunsaturated fatty acids in oat grains are showed in the Figure 2.

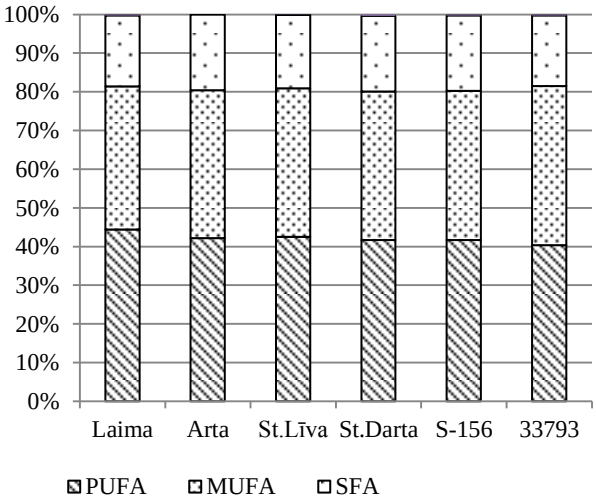

Figure 2. Proportions of fatty acids groups in oat grains

The sum of saturated fatty acids varied from 18.2% to 19.6% of total fatty acids and it was not differed among varieties ($p>0.05$). As showed in Figure 2, the sum of monounsaturated fatty acids accounted 40.4–44.4% and the sum of polyunsaturated fatty acid 37–41.1% of total fatty acids.

The sum of unsaturated fatty acids accounted 78–81.5% of total fatty acids. Saastamoinen et al. (1989) had determined mean content of unsaturated fatty acids about 75%, content of palmitic acid 14–17% for oat varieties which was close to ours.

Conclusions

The fat content was determined from 4 g 100 g^{-1} – in husked oat grains to 10.7 g 100 g^{-1}in naked oat grain samples. There were observed significant ($p<0.05$) difference in fat content among oat varieties.

Content of α-tocopherol in oats determined from 3 to 12.3 mg kg^{-1}, the richest was grains of naked oats breeding lines 'S-156' and '33793' with average α-tocopherol contents 10.3 mg kg^{-1} and 10.2 mg kg^{-1} respectively.

The sum of unsaturated fatty acids accounted 78.0–81.5% of total fatty acids. Result of evaluation leads to conclusion that lipid of oat grain are rich with biologicaly significant substances.

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