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OIL PROFILE OF SOME GENOTYPES OF FLAX (*LINUM USITATISSIMUM* L.) MANUFACTURED IN THE STRUMICA REGION, REPUBLIC OF MACEDONIA

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Abstract

Flax (*Linum usitatissimum* L.) is an industrial crop and has great importance for humans and economy. For the production of large amounts of flaxseed oil, the oil industry needs flax genotypes which have higher oil content.

Analysis of five different flax genotypes, produced in the Strumica region, Republic of Macedonia, in 2014 and 2015 are made, with regard to the oil content in the flax seed. The experiment consisted of five variants in three repetitions, divided by the method of randomized block system. During the vegetation, standard farming practices for field flax production were used. Analysis of the fat content in flaxseed was made in the Laboratory for plant and environmental protection, at the Faculty of Agriculture, "Goce Delcev" University - Stip (No. LT - 028, Standard: MKCEN ISO/IEC 17025:2006). The fat content of the flaxseed was analyzed by Soxhlet method. The results were statistically processed by the method of analysis of variance, and the differences were tested by LSD - test.

The fat content in flaxseed of the tested genotypes ranged from 18.9% to 33.8%. All flax genotypes had higher percentage of fat content in the seed compared to standard Velušina, regardless the year of examination. So, Duferin genotype (27.7%) have 7.7% more fat content than the standard; Belan genotype (30.8%) - 10.8% more, Viking genotype (26.2%) - 6.2% more and Belinka genotype (30.9%) - 10.9% more. The difference of the fat content in the flaxseed is due to the variety specificity. The genotypes Belinka (30.9%) and Belan (30.8%) are characterized by the highest average fat content in the seed, regardless the year of production.

Belinka, Belan and Duferin are perspective genotypes for the oil industry, as they have higher fat content in the seed than the other analyzed genotypes.

***Key words**: Flax, Seed, Content, Genotype, Percent, Oil.*

1. Introduction

Flax or linseed is among of the oldest crop plant cultivated for the purpose of oil and fiber production [1]. From the large number of species (200) of flax, the most important for production has one species - *Linum usitatissimum* L. [2]. The flax is an industrial crop and it`s grown for fiber, seed and combined fiber and seed [3]. Almost every part of the flaxseed plant is utilized commercially, either directly or after processing [4]. Seeds from flax are crushed to produce linseed oil and linseed meal. Linseed oil is a major ingredient in many fine paints, varnishes, and stains that are used to preserve, protect and beautify wooden surfaces [5]. Flaxseed is emerging as one of the key sources of phytochemicals in the functional food arena. In addition to being one of the richest sources of α-linolenic acid oil and lignans, flaxseed is an essential source of high-quality protein and soluble fiber and has considerable potential as a source of phenolic compounds [6]. In many countries around the world, flax is one of the most important crops in healthy human consumption, due to the high content of dietary fiber, omega - 3 fatty acids and anticancer lignin [7].

In the Republic of Macedonia, on the Faculty of Agricultural Sciences and Food in Skopje land in 2005 – 2006, as a research project flax is grown on small surfaces for seed production (as bird food) [8]. Interest for oilseed flax in recent years has increased as a result of the increased capacity of oil production. Starting from that point, reintroducing of the flax surfaces in Republic of Macedonia imposed the need for an investigation

of the characteristics of certain varieties of flax, their acclimatization, production and quality characteristics.

Main aim of this examination was to determine the oil content in the seeds of different flax genotypes, produced in agro-ecological conditions in the Strumica region, Macedonia, and to offer better information to manufacturers and industry which flax genotype is best to be used if oil content in the seed is a priority factor. On the size of content of oil in the flaxseeds largely influence have: specific variety, soil and climate conditions, applied agro-technical measures, method of storage and more.

2. Materials and Methods

The research was conducted in the field and laboratory conditions. Field examinations were set up at the experimental field in Strumica at Uniservice - Agro d.o.o.e.l., Faculty of Agriculture, University "Goce Delchev" - Stip. The research was conducted in the period of two years (2014 and 2015).

As a work material were used five flax genotypes:

1. Velusina
2. Duferin
3. Belan
4. Belinka
5. Viking

Four of them are domestic intermediate flax genotypes (Velusina, Duferin, Belan, Belinka), and one is a French introduced fiber flax variety (Viking).

The experiment consisted a five variants in three repetitions, divided by the method of random block system with the parcel basic dimension of 10 m^2. The distance between the variants was 50 cm and 100 cm between repetitions. The distance between rows was 30 cm.

The seeding rate was 50 kg/ha or 50 g per parcel. In two years of testing, a pre-culture of flax was wheat. The soil was prepared in the same way. Primary tillage was plowing at a depth of 35 cm and the surface was fertilized with granulated NPK 15:15:15 fertilizer in an amount of 300 kg/ha and also a pre-sowing tillage was performed with a tiller. Sowing was performed manually in rows at a depth of 2 - 3 cm.

After sowing and before germination, the parcels was treating with herbicide Dual Gold 960 EC, against certain annual and perennial broadleaf weeds in an amount of 3 L/ha.

During the vegetation, standard farming practices for field production of flax were used.

Analysis of the oil content in flaxseed was made in the Laboratory for plant and environmental protection, at the Faculty of Agriculture, "Goce Delcev" University - Stip (No. LT - 028, Standard: MKCEN ISO/IEC 17025:2006). The fat content of the flaxseed was analyzed by Soxhlet method. The results were statistically processed by the method of analysis of variance, and the differences were tested by LSD test.

3. Results and Discussion

The results of oil content in flaxseed are shown in Table 1 and Figure 1.

Table 1. Content of oil in flaxseed presented in percent (%)

Genotype	Year		Average on genotype
	2014	2015	
Velusina	18.9	21.1	20.0
Duferin	25.3	30.1*	27.7
Bellan	27.8*	33.8*	30.8
Viking	24.2	28.2	26.2
Belinka	32.0**	29.9*	30.9
Average/year	24.6	28.6	**27.1** General average
LSD 0,05	**7,23**		
0,01	**12,99**		

* Statistically significant difference on the level of probability of 0.05.

** Statistically significant difference on the level of probability of 0.01.

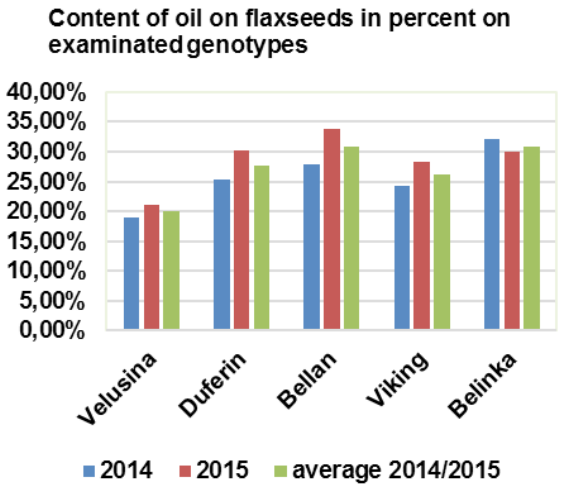

Figure 1. Content of oil in seed (%) of examination genotypes of flax

In Table 1 and Figure 1 is presented the flaxseeds content of oil. The ranges of oil content was from 18.9 to 33.8%. General average oil content in the seeds of the flax, was 27.1%. In study on Středa and Bjelková, [9], the average seed oil content varied from 36.6 to 44.0%. Our results for oil content in the seeds from examined genotypes was lowest from compared results in other authors' research. This parameter is largely influenced by: specific variety, soil and climate conditions, the applied agro-technical measures, method of storage and

more. In examination from Charlton and Ehrensing [5], optimum oil content ranges from 40 to 48 percent under ideal conditions. Oil content averaged 30 percent for both varieties (Neche and Omega), which is well below the optimum range, suggesting that oil production may not be feasible in the short-season climate of Klamath basin. Excessive heat during late July and early August may have contributed to the low oil content.

In our tests, the genotype for fiber - Viking, had lower oil content in the seeds of the remaining intermediate genotypes, other than Velušina.

In study on Saastamoinen *at al*., [10], were examined flax oil and protein content, and their variation in 8 oil and 2 fiber linseed varieties. Fiber varieties 'Belinka' and 'Martta' had higher protein and lower oil contents than oil linseed varieties.

In the first year of the examination (2014), the oil content in the seeds, independent of genotype was 24.6%. The highest oil content in this year of testing had genotype Belinka (32.0%) and the lowest content had standard genotype Velušina (18.9%). The other genotypes in this year (Viking, Duferin and Belan) had greatly better oil content in the seeds (24.2%, 25.3 % and 27.8%).

All genotypes tested in 2014 had a higher percentage of oil content in the seeds compared to standard genotype Velušina (18.9%). So, Duferin genotype (25.3%) had a higher oil content in the seeds by 6.4%, Belan (27.8%) higher oil content by 8.9%, Viking (24.2%) higher oil content by 5.3% and Belinka (32.0%) of even 13.1% higher oil content.

Comparing the average oil content in the seeds of flax in 2014 (24.6%) with oil content separately in tested genotypes may be said that Duferin, Belan and Belinka have a greater, while Viking and Velušina a lower content.

In the second year (2015) of the examination, the oil content in the flaxseeds, independent of genotype, was 28.6%. The highest oil content in this year of testing had genotype Belan (33.8%) and lowest (21.1%), the standard genotype Velušina. The other genotypes (Viking, Belinka and Duferin) had greatly better oil content in the seeds in 2015 (28.2%, 29.9% and 30.1%).

All genotypes tested in 2015 had a higher percentage of oil content in the seeds compared to standard genotype Velušina (21.1%). So Duferin genotype (30.1%) was 9.0% higher fat content, Belan (33.8%) 12.7%, Viking (28.2%) by 7.1% and Belinka (29.9%) by 8.8%.

Comparing the average oil content in the flaxseeds in 2015 (28.6%) with oil content separately in tested genotypes, can be concluded that Duferin, Belan and Belinka have a greater percentage of oil in the seed in this year, while Velušina and Viking smaller.

When comparing the general average of genotypes of the two years of testing, it may be noted that Belinka (30.9%) and Belan genotype (30.8%) are characterized by the highest average oil content in the seeds, and the lowest oil content in the seeds (20.0%) had standard genotype Velušina. Regardless of the year of examination, all genotypes had a higher percentage of oil content in the seeds compared to standard Velušina (20.0%). So, Duferin genotype (27.7%) had higher oil content by 7.7%, Belan (30.8%) or higher oil content by 10.8%, Viking (26.2%) or higher oil content by 6.2% and Belinka (30.9%) or for 10.9% higher oil content. These obtained differences in percentages of oil in flaxseed in tested genotypes is due to the variety specificity.

In examination on Colovic *et al*., [11], the examined linseed cultivars statistically differed ($p \leq 0.05$) in the content of protein (from 18.9 to 27.0%) and fat (from 34.1% to 40.7%). Wide variation was observed for oil content (range from 38.31 - 47.80%) of linseed (*Linum usitatissimum L.*) genotypes grown at three locations of Himachal Pradesh in examination on Sharma *et al.*, [12].

Comparing the average oil content in the flaxseeds from both years (27.1%) with a two-year average fat content separately in tested genotypes, may be said that Duferin, Belan and Belinka have a greater percentage of oil in the seeds, while Velušina and Viking smaller. From the received information can be concluded that the greatest percentage of oil in flaxseed had genotype Belan (33.8%) in 2015.

Statistically significant difference on the level of probability of 0.05 and 0.01 does exist between examined genotypes.

Independently of the year of production, oil industry as the perspective genotypes which have a greatly higher oil content in the seeds, should use genotypes Belinka, Belan and Duferin.

4. Conclusions

Based on research and the results of the oil content in the seeds of the five examined genotypes of flax produced in 2014 and 2015 in the Strumica region, Republic of Macedonia, may be concluded the following:

- The oil content in the seeds of flax ranges is from 18.9 to 33.8%. This parameter largely influenced by: specific variety, soil and climate conditions, the applied agro-technical measures, method of storage and more.

- Genotypes Belinka (30.9%) and Belan (30.8%) are characterized by the highest average oil content in the seeds, regardless of the year of production.

- Lowest oil content in the seeds had a standard genotype Velušina (20.0%).

- Independently of the year of examination, all genotypes have a greater percentage of oil content in the seeds compared to standard genotype Velušina (20.0%).

- Industry for cooking oil production, because of larger oil quantities should use flaxseed from genotypes Belinka, Belan and Duferin, and which are produced in climate conditions like in Strumica region in Republic of Macedonia.

- In order to be gained better flax oil content, examinations on different flax genotypes in Republic of Macedonia should continue.

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