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PROTEIN PROFILE OF SOME GENOTYPES OF FLAX (*Linum usitatissimum* L.) 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.

Analysis of five different flax genotypes, produced in the Strumica region, Republic of Macedonia, in 2014 and 2015 is made, with regard to the content of protein in the flaxseed. 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 protein content in flaxseed was made in the Laboratory for plant and environmental protection, at the Faculty of Agriculture, "Goce Delcev" University – Stip (Standard: ISO 20483:2006). The content of protein in flaxseed was analysed by Kjeldahl method. The results were statistically processed by the method of analysis of variance, and the differences were tested by LSD – test.

The content of protein in flaxseed of the tested genotypes ranged from 26.9% to 29.4%. All flax genotypes had higher percentage of proteins in the seed. But, the genotypes Belinka (29.3%) and Velušina (28.5%) are characterized by the highest average content of protein in the seed, regardless the year of production. Belinka and Velušina are perspective genotypes for the food industry, as they have higher content of protein in the seed than the other analysed genotypes.

Key words: *flaxseed, content, variety, percent, year*

INTRODUCTION

Flax or linseed is among of the oldest crop plant cultivated for the purpose of oil and fiber (Jhala et al., 2010). From the large number of species (200) of flax, the most important for production has one species - *Linum usitatissimum* L. (Jevtic, 1992). The flax is an industrial crop and it is grown for fibre, seed and combined fiber and seed (Egumenovski P. et al., 2003). Almost every part of the flaxseed plant is utilized commercially, either directly or after processing (Singh et al., 2011). Seeds from flax are crushed to produce linseed oil and linseed meal. 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 fibre and has considerable potential as a source of phenolic compounds (Oomah, 2001). 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 fibre, omega - 3 fatty acids and anticancer lignin (Pospišil et al., 2011).

The production of flax in the Republic of Macedonia it is grown on small surfaces for it seed (as bird food) and in 2005-2006 is grown on the Faculty of Agricultural Sciences and Food in Skopje as a research project (Dimov, 2006). Interest for flax in recent years has increased as a result of the increased capacity of oil and protein 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 is to determine the content of protein in the seeds of different genotypes of flax, produced in agro-ecological conditions of the Strumica region of Macedonia and to offer better information to manufacturers and industry who genotype of flax to be used if the same time protein content in the seed is a priority factor.

On the size of content of protein in the flaxseeds, largely influence had a specificity variety, soil and climate conditions, the applied agro-technical measures, method of storage and more. General average protein content in the seeds of the flax, was 28.3%.

MATERIAL 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, Goce Delchev University - Stip. The research was conducted in the period of two years (2014 and 2015).

As a work material were used five flax genotypes:

1. Velušina
2. Duferin
3. Bellan
4. Viking
5. Belinka

Four of which are domestic intermediate flax genotypes (Velušina, Duferin, Bellan and Belinka) and one is a French introduced fiber flax variety (Viking).

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

The seeding rate was 50kg/ha or 50g 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 ploughing at a depth of 35cm and the surface was fertilized with granulated NPK 15:15:15 fertilizer in an amount of 300kg/ha and also a pre-sowing tillage was performed with a tiller. Sowing was performed manually in rows at a depth of 2-3cm.

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 3l/ha.

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

Analysis of the protein content in flaxseed was made in the Laboratory for plant and environmental protection, at the Faculty of Agriculture, "Goce Delcev" University – Stip (Standard: ISO 20483:2006). The protein content of the flaxseed was analysed by Kjeldahl method. The results were statistically processed by the method of analysis of variance, and the differences were tested by LSD–test.

Climatic conditions

The valley of Strumica is characterized by sub-mediterranean influences from the Aegean Sea to the south, which influence is partially stopped by mountain massif Belasica, Ograzden and Plackovica and northwest of continental climate of Ovche Pole. Compared to other valleys of this area in Strumica the influence of the Mediterranean climate it is enhanced. It is settled on 200-300m above the sea level and it is in the group of Continental-Sub-Mediterranean regions. It is a typically transitive area with combined influences of Mediterranean and East-Continental climate (Filipovski et al., 1996).

During the two-year trials, meteorological indicators for medium temperatures in degrees Celsius and monthly sums of precipitation in mm were monitored. The mean annual temperature in Strumica valley for a period of ten years during the vegetation period of flax, amounted to 18.9 °C (Table 1). For a period 2003/2013 in the valley of Strumica, fall 324.7 mm average rainfall (Table 2).

Schedule of rainfall by months and seasons is quite unbalanced (Table 2). The largest average amounts of rainfall (2003/2013) are registered in May, of 68.1 mm. and the lowest average amount of rainfall in June, with 22.3 mm. The analysis of the temperature in the research period 2014 -2015, showed difference with the average temperatures, in the ten-year average (Table 1).

Table 1. Average monthly air temperatures during the testing period in degrees Celsius

Year	Months							Total (III – IX) (°C)	Average (III – IX) (°C)
	III	IV	V	VI	VII	VIII	IX		
2014	10.2	12.8	17.4	21.7	24.1	24.0	18.2	3916.2	18.3
2015	7.2	12.4	19.8	21.4	26.7	24.9	20.9	4066	19.0
2003/2013	8.5	13.3	18.4	22.5	25.2	25.0	19.4	4044.6	18.9

Table 2. Amount of monthly rainfall during the testing period in mm

Year	Months							Total (III – IX) in (mm)
	III	IV	V	VI	VII	VIII	IX	
2014	71.0	125.5	78.7	56.3	34.4	56.9	100.7	523.5
2015	83.0	16.6	16.1	40.1	6.6	65.6	95.0	323
2003/2013	44.3	35.4	68.1	62.2	22.3	39.3	53.1	324.7

The average temperature in 2014 was about 0.6 °C lower, and in 2015 is 0.1 °C higher than the average. According to the data in Table 1, it can be concluded that the monthly average air temperatures during the vegetation of flax in the period of testing, in both years of testing, are the lowest in the final month and the first month of each year, i.e. March (from 7.2 °C in 2014 to 10.2 °C in 2015) and highest in July (24.1 °C to 26.7 °C). From germination to blooming flax requires temperature in the range of 16 °C to 18 °C. The average monthly temperatures prevailing in the vegetation period are considered as good for growing flax. In Table 2 we can see that the annual amounts of rainfall in the Strumica region, during the test period, is within the optimal needs of flax. In 2015 in the month of July the highest deficit of rainfall is registered (only 6.6 mm), (Table 2). The other months and years, the distribution of rainfall is relatively good to meet the needs of water for growing flax.

RESULTS AND DISCUSSION

In Table 3 and Figure 1 the results of content of flaxseed protein are shown. The ranges of content of proteins was from 26.9 to 29.4%. The general average content of protein in the seeds of the flax, was 28.3%. The size of this parameter largely influence have specificity variety, soil and climate conditions, the applied agro-technical measures, method of storage and more.

In our tests, the genotype for fibre - Viking, had lower content of protein in the seeds of the remaining intermediate genotypes, other than Duferin and Bellan.

In study on Saastamoinen at al. (2013), oil and protein content and their variation on 8 oil and 2 fibre linseed varieties were examined. Fibre varieties 'Belinka' and 'Martta' had higher protein and lower oil contents than oil linseed varieties.

Table 3. Content of proteins in flaxseed (percentage of proteins from a dry sample)

Genotype	Year		Average on genotype
	2014	2015	
Velušina	28,5+	28,6	28,5
Duferin	27,8	26,9	27,3
Bellan	27,8	28,2	28,0
Viking	27,9	28,4	28,1
Belinka	29,3	29,4	29,3
Average on year	28,3	28,3	28,3 General average
LSD 0,05	n. s.		
0,01	n. s.		

In both years of the examination (2014 and 2015), the protein content in the seeds, independent of genotype was 28.3%. The highest protein content in 2014 year of testing had genotype Belinka (29.3%) and the lowest content have Duferin and Bellan (27.8%). Comparing the average protein content in the seeds of flax in 2014 (28.3%) with protein content separately in tested genotypes may be said that Belinka and Velušina have a greater, while Viking, Bellan and Duferin a lower content. In the second year (2015) of the examination, the highest protein content had genotype Belinka (29.4%) and lowest (26.9%), genotype Duferin. The other genotypes (Duferin, Bellan and Viking) had better protein content in the seeds in 2015 (28.6%, 28.2% and 28.4%). All genotypes tested in 2015 had a higher percentage of protein content in the seeds. Comparing the average content of protein in the flaxseeds in 2015 (28.3%) with protein content separately in tested genotypes, can be concluded that Belinka, Velušina and Viking have a greater percentage of protein in the seed in this year, while Bellan and Duferin smaller.

In the general average of genotypes of the two years of testing may be noted that Belinka (29.3%) and Velušina genotype (28.5%) are characterized by the highest average protein content in the seeds.

In the general average of genotypes of the two years of testing may be noted that the lowest protein content in the seeds (27.3%) had genotype Duferin. Regardless of the year of examination, only Belinka (29,3%) had a higher percentage of protein content in the seeds compared to standard Velušina (28.5%). So, Duferin genotype (27.3%) was 1,2% smaller protein content compared to standard Velušina (28.5%), Bellan (28.0%) 0.5% and Viking (28.1%) 0.4%. These obtained differences in percentages of protein in flaxseed in tested genotypes is due to the variety specificity.

In examination on Colovic et al. (2016), 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%).

Comparing the average protein content in the flaxseeds from both years (28.3%) with a two-year average protein content separately in tested genotypes, may be said that Belinka and Velušina have a greater percentage of protein in the seeds, while Duferin, Bellan and Viking smaller.

From the received information can be concluded that the greatest percentage of protein in flaxseed had genotype Belinka (29.4%) in 2015 year.

Statistically significant difference on the level of probability of 0.05 and 0.01 does not exist between examined genotypes.

The food industry should be processed and used flaxseed from genotypes Belinka and Velusina, who have more protein content, regardless of the year of manufacture, and which is produced in climate conditions like Strumica region in Republic of Macedonia.

Depending on the years of production, varieties and soil and climatic characteristics of the region, the protein content in the seeds of the flax is 28.3%.

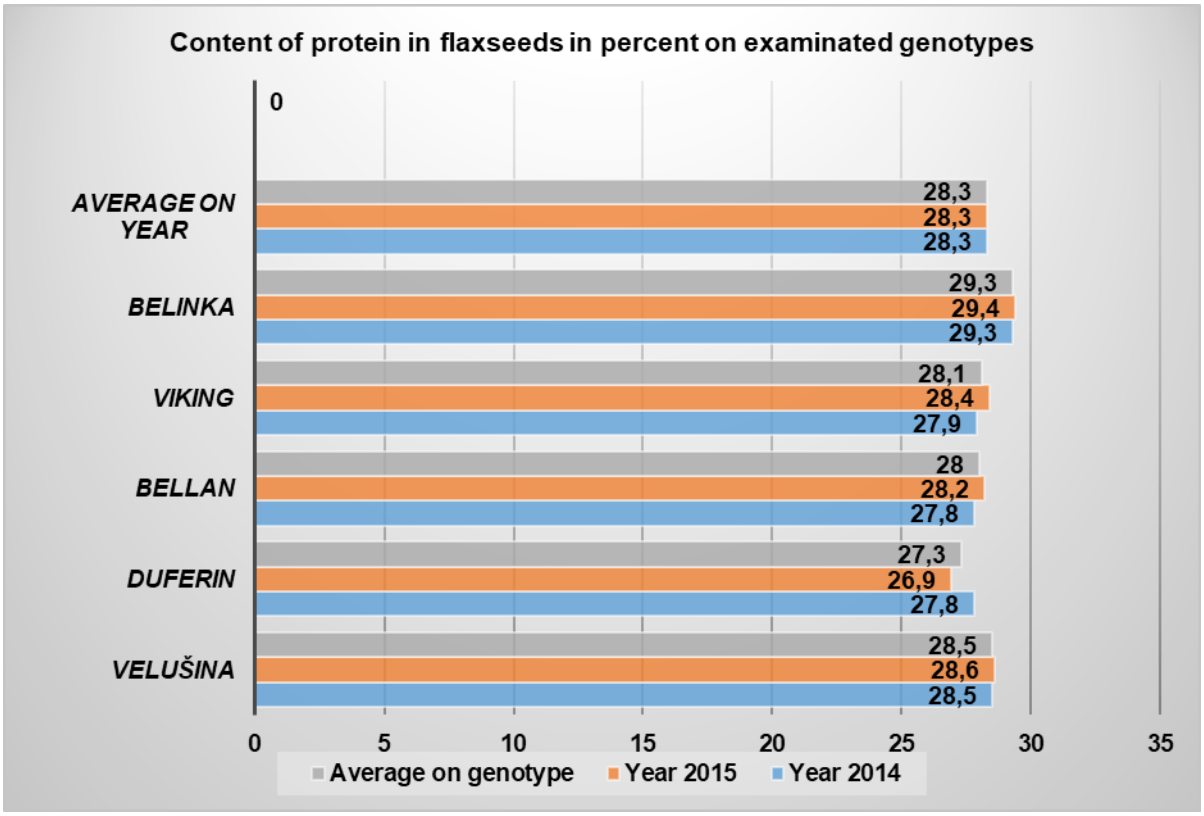

Figure 1. Content of protein in seeds (%) of examination genotypes of flax

CONCLUDING REMARKS

Based on results of the content of protein 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 content of protein in the seeds of flax ranges is from 26.9% to 29.4%. On the size of this parameter largely influence had a specificity variety, soil and climate conditions, the applied agro-technical measures, method of storage and more.

The genotypes Belinka (29.3%) and Velušina (28.5%) are characterized by the highest average content of protein in the seeds, regardless of the year of production.

The lowest content of proteins in the seeds had genotype Duferin (27.3%). Independently of the year of examination, all genotypes have a greater percentage of protein content in the seeds. The differences in the percentages of protein in flaxseed in tested genotypes is due to the variety specificity.

The food industry should be processed and used flaxseed from genotypes Belinka and Velušina, who have more content of proteins, regardless of the year of manufacture, and which is produced in climate conditions like Strumica region in Republic of Macedonia.

The examinations on this field should continue with another genotypes and should give a recommendation for genotypes with better properties for yield and content of proteins for growing in Republic of Macedonia.

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ПРОТЕИНСКИ ПРОФИЛ НА НЕКОИ ГЕНОТИПОВИ НА ЛЕН (*Linum usitatissimum* L.) ВО СТРУМИЧКИОТ РЕГИОН, РЕПУБЛИКА МАКЕДОНИЈА

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Резиме

Ленот (*Linum usitatissimum* L.) е индустриска култура и има големо значење за човекот и индустријата.

Во периодот 2014 и 2015 година беа извршени испитувања на пет сорти на лен, произведени во струмичкиот регион, Република Македонија во однос на содржината на протеини во семето. Експериментот се состоеше од пет варијанти во три повторувања, поставени по рандомизиран блок-систем. Во текот на вегетацијата беше употребувана стандардна агротехника за производство на лен. Анализата за содржината на протеини во семето од лен е извршена во Лабораторијата за заштита на растенијата и животната средина на Земјоделскиот факултет при Универзитетот „Гоце Делчев" – Штип (Standard: ISO 20483:2006). Содржината на протеини во семето од лен е вршена со Келдал методата. Резултатите се статистички обработени по методот Анализа на варијанса, а разликите тестирани по ЛСД тестот.

Содржината на протеини во семето кај испитуваните сорти се движи од 26.9% до 29.4%. Сите сорти на лен имаа висока содржина на протеини во семето. Но, сортите *белинка* (29.3%) и *велушина* (28.5%) се карактеризираат со највисока просечна содржина на протеини во семето, независно од годината на испитување. Во однос на останатите, сортите *белинка* и *велушина* се препорачуваат како перспективни сорти за прехранбената индустрија, бидејќи се со највисока содржина на протеини во семето.

Клучни зборови: *лен, семе, содржина, сорта, процент, протеини*