Dynamics of oil content and fatty acids composition variation in soybean cultivars of domestic breeding

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Abstract. This paper presents the study of vegetative characteristics and chemical composition of soybean cultivars of domestic breeding. The data on yield, protein content, oil content and fatty acids composition of cultivars studied are presented. The conformity of lower oil content in seeds with higher level of protein accumulation is established. Some minor cultivar-dependent fluctuations in the fatty acids ratio along with harvest year dependence have been observed. The greatest fluctuations have been observed in the concentrations of oleic and linoleic acids. The data obtained indicate the presence of cultivar-dependent variations in the fatty acids composition of the oils studied due to genotypic features. However, despite the variations, the cultivars studied demonstrate stability of fatty acids composition and are recommended for further breeding.

1. Introduction

Vegetable oils are well-known as a source of liquid edible oils, confectionery fats, margarines and are widely used in the paint industry, cosmetology and other spheres of the national economy. The widespread use of oils is based on their unique properties; in addition, vegetable fats are the main nutritional source of energy [1].

Oilseeds, which provide the basic needs for vegetable oils, are renewable resources, and the world breeding achievements have made their production consistently high. The main share of vegetable oil production in the world falls on soybeans, low-glycosinolate oilseed rape lacking ericidic acid and corn.

Soybean oil is a product of versatile and diverse use due to a number of valuable properties and qualities. Among them, a small loss during refining, the presence of pigments that are easily destroyed during heating, providing clarification significantly below the threshold value. As a result of hydrogenation and fractionation, large crystals are formed, which are easily removed by filtration. Due to the high iodine number, a substance suitable for further transformation into a wide product range is formed as a result of hydrogenation. Initially high content of tocopherols (about 1300 mg / kg of crude oil) remains significant after treatment (up to 500 mg / kg), which provides for high oxidative resistance. The oil is characterized by high content of essential nutrition factors of lipid nature -essential fatty acids (oleic, linoleic and linolenic) [1].

The aim of the study was to determine the oil content and fatty acids composition of soybean cultivars of domestic selection.
2. Materials and methods
The following samples were selected as the objects of research: Sibniik 315 (originator Siberian Federal Scientific Centre of Agro-BioTechnologies of the Russian Academy of Sciences), Zaryanitsa (originators Krasnoyarsk State Agrarian University and Omsk Agricultural Scientific Center), Light (Federal Scientific Agroengineering Center VIM), Dina (Omsk Agricultural Scientific Center), Beautiful dream (Federal Scientific Center of Legumes and Groats Crops), Lancet (Center of Legumes and Groats Crops and Belgorod State Agrarian University), authentic breeding line B-9 (origin: Light × Dina).

Field research was carried out at educational and scientific complex "Borsky "(56°26'15"n, 92°54'11"e) of Krasnoyarsk State Agrarian University. The experimental production base was located in Sukhobuzimsky district, Kansk-Krasnoyarsk forest-steppe. The depth of the arable horizon was 26 cm, high humus content (7.3%). The acidity of soil was neutral (pH 6.7), mobile forms of phosphorus (P₂O₅ 190 mg/kg) and nitrate nitrogen (N-NO₃ 18 mg/kg) levels were medium, potassium level (K₂O 230 mg/kg) was high, ammonium nitrogen level (N-NH₄ 17 mg/kg) was low. Field experiments were carried out in the grain-crop rotation complete fallow-potatoes-soybeans-spring wheat.

The main treatment was autumn flat-cut loosening to a depth of 15-17 cm [2]. In spring, spring harrowing and pre-sowing cultivation to a depth of 5-6 cm were performed. The seeding of soybean breeding nurseries was performed on May 18-20th with a selection seeder SSFK-7 by raw-seeding method, taking into account the germination, purity and weight of a thousand of seeds. The sowing coefficient was optimal for the study zone [3] and amounted 0.8 mln of germinating seeds per 1 hectare. The seeding was followed by the rolling with ring-spur rollers. The Sibniik 315 was sown as a standard, seeded after each 4 samples. Field experiments and observations of plant development were performed in accordance with generally accepted recommendations for field experiments with cultures [4, 5]. For weed control the crops were treated with Paradox, VRK, (imazamoks 120 g/l) 0.2 l/ha on June 19th. The cultivated plants were in the phase of two triple leaves, the operating solution consumption was 200 l/ha. Strait-cutting of crops was performed by “Terrion” combine harvester at full-ripe stage.

The protein content was determined in accordance with GOST 10846-91 “Grain and its derivatives. Method of protein determination”. The oil content was determined according to GOST 10857-64 “Oilseeds. Methods of oil content determination (with Alteration N1)”. The identification of fatty acids in oil was carried out in accordance with GOST 30418-96 “Interstate standard. Vegetable oils. Method of fatty acids composition determination”.

Statistical processing of data was carried out by methods of dispersion and correlation analysis using MSExcel program.

3. Results and discussion
The vegetative characteristics of the studied soybean cultivars for 2017 and 2018 were determined. Taking into account a variety of forms, soybeans have a fairly wide range of vegetation period duration and its constituent phases. The limited bioclimatic potential of the research region is suitable for ripening only precocious soybean samples. According to VIR classification [6] the studied forms could be assigned to the group with a medium-short period from germination to wax ripeness.

Data on yield, vegetation period and protein content in the studied soybean cultivars are presented in table 1.

Stability of such technological indicator as oil content is the main condition for further selection work with soybeans. The seeds of 2017 and 2018 harvest were analyzed in order to determine the dynamics of oil content. The oil content in all samples analyzed showed only slight fluctuations ranging from 0.61 to 3.57% which proves overall stability of this parameter (figure 1).

The correlation between lower oil content in seeds and higher level of protein accumulation was established. Determination of a pair of attributes was 11% at normal mean distribution (NMD) 0.01n-2=94, r=-0.332±0.267.
Table 1. Dynamics of the growing season, yield and protein content in soybean cultivars of domestic selection.

| Sample         | Vegetation period, days | Yield, kg / m² | Protein content, % a.d.w. |
|----------------|-------------------------|----------------|--------------------------|
|                | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Sibniik 315    | 102  | 106  | 0.225 | 0.176 | 36.31 | 41.56 |
| Zaryanitsa     | 104  | 107  | 0.219 | 0.181 | 27.13 | 40.25 |
| B-9 (EOS)      | 100  | 105  | 0.235 | 0.189 | 37.19 | 33.25 |
| Dina           | 102  | 105  | 0.247 | 0.167 | 33.36 | 31.50 |
| Light          | 100  | 103  | 0.233 | 0.144 | 36.96 | 41.56 |
| Beautiful dream| 106  | 108  | 0.228 | 0.195 | 34.76 | 38.50 |
| Lancet         | 106  | 109  | 0.344 | 0.184 | 32.84 | 35.90 |

![Figure 1. Changes in the oil content of soybean varieties of domestic selection for 2017-2018.](image)

The fatty acid composition of the oil is variable, depending on the ambient temperature, humidity, pressure, altitude. The content of certain fatty acids is closely related to other fatty acids, and changing any of them leads to a change in the amount of others, and therefore the entire component composition of the oil. Table 2 shows the dynamics of changes in the fatty acid composition of oils in cultivars Zaryanitsa, B-9 and Beautiful dream.

Table 2. Dynamics of fatty acid composition of soybeans of domestic cultivars.

| Fatty acid | Zaryanitsa | B-9 | Beautiful dream |
|------------|------------|-----|-----------------|
|            | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| C14:0 Myristic acid | 0.059 | 0.095 | 0.065 | 0.062 | 0.070 | 0.110 |
| C16:0 Palmitic acid | 11.300 | 11.136 | 11.269 | 11.855 | 11.434 | 11.814 |
| C17:0 Margaric acid | 0.145 | 0.131 | 0.076 | 0.131 | 0.074 | 0.062 |
| C18:0 Stearic acid | 3.729 | 3.609 | 3.996 | 3.688 | 4.882 | 4.823 |
| C20:0 Arachinic acid | - | - | 0.229 | 0.214 | 0.389 | 0.374 |
| C22:0 Behenic acid | - | 0.328 | 0.319 | - | 0.470 | 0.361 |
| C23:0 Tricosanoic acid | 0.127 | 0.054 | 0.062 | 0.062 | 0.051 | 0.037 |
| C24:0 Lignoerocic acid | - | 0.105 | 0.102 | 0.096 | 0.161 | 0.142 |
| C16:1 Palmitoleic acid | 0.059 | 0.065 | 0.069 | 0.063 | 0.087 | 0.083 |
| C18:1 Oleic acid | 17.611 | 18.164 | 19.237 | 17.877 | 19.764 | 22.455 |
| C18:2 Linoleic acid | 52.522 | 54.029 | 53.796 | 54.517 | 49.979 | 49.124 |
| C18:3 Linolenic acid | 13.1289 | 11.1926 | 10.530 | 11.023 | 11.879 | 10.387 |
| C20:2 Eicosadiene acid | 0.0159 | 0.0138 | - | - | 0.055 | 0.0392 |
| C24:1 Nervonic acid | - | 0.145 | 0.177 | - | 0.654 | - |
All oils of the studied samples contained mainly of myristic, palmitic, stearic, oleic, linoleic and linolenic fatty acids. It should be noted that there were small fluctuations in the ratios of fatty acids by cultivars, and different results could be observed in the same cultivars of soybeans at different harvest years. The greatest fluctuations were observed in the content of both oleic and linoleic acids. Thus cultivar Zaryanitsa of 2017 and 2018 harvest showed oleic acid content variation from 17.61 to 19.76%, and the content of linoleic acid varied from 52.53 to 49.97 % respectively. In the seeds of the B-9 line of the 2017 and 2018 harvest, the content of oleic acid varied from 19.49 to 22.45%, and the content of linoleic acid - from 53.98 to 49.12 % respectively. The Beautiful dream cultivar had oleic acid content of 17.87 in 2017 and 20.17 % in 2018, linoleic acid was 54.51 and 52.48 % respectively.

The total content of saturated and unsaturated fatty acids is shown at figures 2 and 3.

**Figure 2.** Saturated fatty acids content in soybean cultivars of domestic selection, % of total.

**Figure 3.** Unsaturated fatty acids content in soybean cultivars of domestic selection, % of total.

4. Conclusions
The data obtained indicate occurrence of genotype-based cultivar variations of fatty acid composition of the oils studied. Still despite of the cultivar variations, the cultivars studied showed a rather stable fatty acid composition and could be recommended for further selection.

Acknowledgments
The study was carried out with the financial support of the Ministry of Agriculture of the Russian Federation within the framework of the state task on the topic No. 1: "Creation of non-genetically modified soybean hybrids for Eastern Siberia with an increased content of saturated fatty acids".

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