

## Research Article

### Polyunsaturated Fatty Acids Content in Soybean Oil

<sup>1</sup>Tamara Lee, <sup>1</sup>Zere Spankulova, <sup>1</sup>Ultash Orazbayeva, <sup>2</sup>Svetlana Didorenko and <sup>3</sup>Saule Atabayeva

<sup>1</sup>Institute of Plant Biology and Biotechnology, 050040 Almaty,

<sup>2</sup>Kazakh Institute of Agriculture and Crop Production, Almatybak,

<sup>3</sup>Al-Farabi Kazakh National University, 050040 Almaty, Kazakhstan

**Abstract:** The fatty acids composition analysis was carried out by Gas Chromatography (GC) to determine the mass fraction of methyl esters of individual fatty acids to their sum. Based on our study, the seeds of all 30 varieties from the nursery of competitive variety trials had similar (but not identical) fatty acid compositions and contained low amounts 12-14% of saturated fatty acids and high amounts 82-86% of unsaturated fatty acids. It has been confirmed that the unsaturated fatty acids were pre-dominant in all varieties. Received results confirm the presence of unsaturated oleic (C18:1) and polyunsaturated linoleic (C18:2) and linolenic (C18:3) acids in all soybean seed oils. Linoleic acid was the main fatty acid in the present study: Linoleic acid  $\geq$  Oleic acid  $\geq$  Palmitic acid  $\geq$  Linolenic acid  $\geq$  Stearic acid. Screening on the content of polyunsaturated fatty acids (PUFA) in the soybean oil demonstrated that all 30 varieties so far were characterized by a high content of PUFA nearly 60%. The lowest content of PUFA of about 57% was seen in standard Misula and vrs. V10/1012, ZR-30, B44/21. The saturated/unsaturated acid ratio was generally low. The lowest and highest are 0.15 (varieties ZPR-13, V21/311 and B40/623) and 0.18 (varieties Misulast., A16/145, A9/363, A9-562, B-47/53, V5/221), respectively.

**Keywords:** Essential fatty acids, methyl esters, saturated/unsaturated acid ratio

## INTRODUCTION

Soybean seed lipids function as energy storage for the plant, constituents of membranes, signaling molecules, defense against pathogens, *etc.* Storage lipids are deposited mainly in the form of triacylglycerols in oil bodies. A triacylglycerol molecule is composed of three fatty acids esterified to a glycerol backbone. The most abundant fatty acid in triacylglycerols of commodity soybeans is linoleic acid (18:2), followed by oleic (18:1), palmitic (16:0), linolenic (18:3) and stearic (18:0) acids (Medic *et al.*, 2014).

The phase of grain filling is the most dependent on environmental factors and temperature stage of soybean development. Oil starts to accumulate in the developing soybean seeds 15-20 days after flowering. Fastest oil accumulation comes in 20-40 days after flowering and lasts for 70 days (Rose, 1988).

Both oil and protein content in soybean (*Glycine max*[L.]Merr.) seed have been shown to be subject to a positional effect (Collins and Cartter, 1956; Bennett *et al.*, 2003). Seeds that develop in the upper one-fourth of the plant contain a higher concentration of protein and lower concentration of oil than seeds from the lower one-fourth of the plant. Gas chromatographic

analysis of fatty acids indicated that only oleic (18:0) and linoleic (18:2) acids showed variability in accumulation at different nodes. Neither the abundance nor the distribution of the fatty acids was altered by nitrogen application.

Fatty acid composition and distribution determine oil quality, nutritional value, flavor, oxidative stability, melting point, crystallization form *etc.* (Yadav, 1996). Soybean oil has a high nutritional value because it is a rich source of unsaturated fatty acids, such as oleic, linoleic and linolenic acids with one, two and three double bonds, respectively. Unsaturated fatty acids exhibit several positive effects on human health, such as prevention of atherosclerosis, reduction of total and low-density lipoprotein (LDL) cholesterol and triacylglycerol levels in plasma and suppression of inflammatory processes (Bahrami, 2009). Linoleic and linolenic acids are also essential fatty acids that mammals cannot synthesize and, thus, need to be obtained from their diets.

Soybean oil contains 14 fatty acids. Five of these fatty acids, palmitic (C16: 0), stearic (C18: 0), oleic (C18: 1), linoleic (C18: 2) and linolenic (C18: 3), considered as essential fatty acid (EFA), as they should be in our daily diet (Kinney, 1996; Firestone, 1999; Chapkin, 2007).

**Corresponding Author:** Tamara Lee, Institute of Plant Biology and Biotechnology, 050040 Almaty, Kazakhstan, Tel.: 8(727)3947557; Fax: 8(727)3947562

This work is licensed under a Creative Commons Attribution 4.0 International License (URL: <http://creativecommons.org/licenses/by/4.0/>).

A special place in human nutrition occupy the polyunsaturated fatty acids (PUFA) – linoleic and linolenic. Its deficiency leads to changes in fatty acid composition of cell membranes, resulting to a violation of their functional stability, which ultimately leads to a variety of diseases: obesity, arrhythmia, hypertension, atherosclerosis, thrombosis, diabetes, psoriasis, inflammation, rheumatoid arthritis, ulcerative colitis, benign tumors and cancer. PUFA are found in vegetable oils and absent in animal fats (Chavarro *et al.*, 2007).

La *et al.* (2014) and Kim *et al.* (2015) investigated that an increased oleic acid concentration improves the nutritional value and oxidative stability of soybean seed oil. High oleic acid soybean cultivars should have desirable agronomic and compositional traits such as a high seed yield, protein and oil concentrations compared to popular, commercially grown cultivars. Therefore, high oleic acid lines such as JD11-0070 could be used as genetic resources to develop soybeans for various foods such as tofu, soybean paste, soy sauce, natto and sprouts. They could also be used to produce more desirable, higher quality soybean oil similar to olive oil that would have broader uses in many other food applications to improve human health as well as have additional uses including industrial products.

Since soy is a rich source of protein and oil, one of the main objectives of breeders around the world is to enhance the nutritional quality of soybean seeds by the increase of protein content or oil. However, for successful breeding programs it is very important to understand the biochemical mechanisms of the accumulation of protein and oil in soybean (Min *et al.*, 2015).

The purpose of the present research was to study the fatty acid composition, especially PUFA of the soybean varieties which represent natural resources for use in human nutrition.

## MATERIALS AND METHODS

The study used 30 soybean lines from the nursery of competitive variety trials: 3 medium early- ripening varieties (110-120 days), variety Misula was used as a standard, regionalized in Kazakhstan, 16 middle-ripening (121-130 days) with standard Zhansaya and 11 late-ripening varieties (over 130 days) with standard Lastochka.

**Determination of fatty acids in soybean oil by Gas Chromatography (GC):** Methods for obtaining fatty acids methyl esters are intended for gas chromatography, thin layer chromatography, infrared spectrometry and other analytical purposes. This method is applicable to vegetable oils. Sample

preparation: 0.5 mL oil was obtained from 5g of soybean seeds by cold squeezing.

**Preparation of fatty acids methyl esters:** Eight  $\mu$ L oil is dissolved in 2 mL of hexane. In the hexane solution is added 0.1 mL of a 5% solution of sodium methylate in methanol, the mixture is shaken every 10 min 3 times, then is added 1 ml of distilled water, shake and leave for complete settling. Then, 1 mL of the upper hexane layer is transferred to a vial until complete evaporation of hexane and after drying, is added 600  $\mu$ L chemically pure hexane. The resultant solution is ready for analysis by gas chromatography.

**Determination of fatty acids in the soybean oil:** The fatty acids analysis was carried out by gas chromatograph Crystal 2000 (Russia) to determine the components in accordance with GOST R51486-99- Vegetable oils and animal fats. Determination by gas chromatography the mass fraction of methyl esters of individual fatty acids to their sum (GOST R51486-99, 2001). The identification of the components was carried out using the software "Chromatech Analytic 2.6." Fatty acid methyl esters were identified using standards Supelco 37 FAME Mix Component Catalog N 47885-U. The analyses were repeated thrice.

**Data analysis:** The statistical evaluations of the obtained results were conducted using ANOVA. In the analyses differences with  $p \leq 0.05$  were considered to be significant.

## RESULTS AND DISCUSSION

Table 1 shows the chemical composition and component of fatty acids.

By GC was defined fatty acids composition in oil of 30 soybean lines from the nursery of competitive variety trials. These results allowed determining the content of the 14 fatty acids, especially PUFA in soybeans which constitute presumably an average of 60% of total fatty acids (Fig. 1, Table 2).

Table 1: Chemical formula and component composition of fatty acids

Fatty acid	Component	Chemical formula
Myristic acid	C14:0	C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>
Palmitic acid	C16:0	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>
Palmitoleic acid †	C16:1	C <sub>16</sub> H <sub>30</sub> O <sub>2</sub>
Margarine acid	C17:0	C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>
Cis-10-acid hexadecenoic	C17:1	C <sub>17</sub> H <sub>32</sub> O <sub>2</sub>
Stearic acid †	C18:0	C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>
Oleic acid †	C18:1n9c	C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>
Linoleic acid †	C18:2n6c	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>
Linolenic acid †	C18:3n3	C <sub>18</sub> H <sub>30</sub> O <sub>2</sub>
Arachidonic acid	C20:0	C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>
Cis-11-eicosenoic acid	C20:1n9	C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>
Behenic acid	C22:0	C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>
Tricosanoic acid	C23:0	C <sub>23</sub> H <sub>46</sub> O <sub>2</sub>
Lignoceric acid	C24:0	C <sub>24</sub> H <sub>48</sub> O <sub>2</sub>
Nervonic acid	C24:1	C <sub>24</sub> H <sub>46</sub> O <sub>2</sub>

† essential fatty acids

Table 2: Fatty acid composition (%) of oil from seeds of 30 varieties of soybean

Breeding number	Myristic acid	Palmitic acid	Margarine acid	Stearic acid	Arachidonic acid	Behenic acid
Misula	0.09±0.01	10.15±0.2	0.10±0.01	4.09±0.5	0.44±0.01	0.48±0.04
A16/145	0.08±0.00	10.49±0.6	0.09±0.00	3.87±0.6	0.31±0.03	0.32±0.01
A9/363	0.07±0.00	10.07±0.7	0.10±0.02	4.43±0.8	0.31±0.02	0.3±0.08
V11/311	0.07±0.01	8.99±1.2	0.09±0.01	4.12±0.3	0.32±0.01	0.31±0.01
Zhansaya	0.07±0.01	9.65±0.08	0.10±0.01	4.49±0.2	0.36±0.01	0.35±0.06
A9-562	0.07±0.00	10.28±0.4	0.10±0.01	4.25±0.01	0.32±0.01	0.32±0.03
B47/541	0.06±0.01	9.61±0.6	0.09±0.00	4.46±0.4	0.34±0.03	0.32±0.02
V10/1012	0.07±0.00	9.44±0.7	0.08±0.01	3.78±0.00	0.31±0.01	0.34±0.02
B48/232	0.06±0.00	9.86±1.5	0.09±0.03	3.95±0.6	0.28±0.01	0.28±0.00
B48/221	0.06±0.01	9.6±0.5	0.11±0.01	3.92±0.2	0.29±0.00	0.3±0.04
A8/2-2	0.07±0.01	10.14±1.6	0.09±0.01	3.99±0.7	0.29±0.00	0.29±0.01
B-47/53	0.06±0.00	9.98±2.0	0.09±0.01	4.44±1.0	0.33±0.01	0.31±0.01
B37/153	0.06±0.01	8.94±0.9	0.10±0.00	4.71±0.4	0.42±0.01	0.41±0.02
ZPR-30	0.07±0.02	9.59±0.7	0.09±0.01	4.56±2.3	0.43±0.01	0.43±0.03
B47/323	0.06±0.01	9.37±0.4	0.11±0.01	4.64±0.7	0.35±0.01	0.33±0.04
ZPR-13	0.07±0.00	8.9±0.3	0.08±0.01	3.7±0.9	0.31±0.02	0.32±0.00
B4/53	0.06±0.01	8.91±0.7	0.09±0.01	4.19±1.4	0.32±0.00	0.32±0.06
B19/622	0.06±0.01	9.62±0.8	0.09±0.01	4.2±0.5	0.30±0.01	0.29±0.01
V18/731	0.07±0.02	8.95±0.9	0.09±0.01	4.71±0.4	0.45±0.01	0.45±0.02
Lastochka	0.06±0.01	8.68±2.1	0.09±0.01	4.42±0.4	0.40±0.00	0.39±0.00
B44/21	0.07±0.00	9.32±1.6	0.09±0.00	4.49±0.6	0.38±0.02	0.33±0.03
V21/311	0.06±0.00	8.64±0.7	0.10±0.01	4.14±0.8	0.33±0.02	0.33±0.04
ZPR-38	0.06±0.01	9.51±0.3	0.10±0.02	4.12±0.7	0.32±0.01	0.32±0.07
B40/623	0.06±0.01	9.06±0.8	0.10±0.01	3.79±0.8	0.29±0.01	0.31±0.00
V5/212	0.07±0.02	10.17±0.7	0.09±0.02	3.55±0.7	0.34±0.01	0.39±0.07
B-34/313	0.07±0.00	8.86±0.8	0.11±0.02	4.83±0.5	0.35±0.01	0.35±0.03
B37/85-21	0.06±0.01	8.83±1.5	0.10±0.03	4.77±0.7	0.42±0.01	0.39±0.00
B37/13-13	0.06±0.01	9.21±2.3	0.10±0.01	4.71±0.7	0.36±0.03	0.17±0.01
B44/51	0.06±0.01	9.82±0.6	0.10±0.01	4.12±0.4	0.31±0.01	0.33±0.08
B40/622	0.06±0.00	9.53±0.4	0.10±0.00	4.16±1.0	0.33±0.03	0.33±0.04
V5/221	0.08±0.01	10.54±1.6	0.09±0.01	3.9±0.8	0.38±0.01	0.42±0.01
ZPR-107-3	0.07±0.02	9.28±2.5	0.08±0.01	4.42±0.9	0.35±0.01	0.37±0.01
ZPR154	0.06±0.01	9.3±1.3	0.07±0.01	3.72±0.6	0.32±0.01	0.34±0.03
Breeding number	Oleic acid	Linoleic acid	Linolenic acid	∑ Sat.	∑ Unsat.	Sat./Unsat.
Misula	26.37±0.5	50.65±9.4	6.96±0.4	14.81±0.07	83.98±9.4	0.18 ±0.01
A16/145	24.53±1.5	51.82±6.4	7.92±0.6	14.76±1.0	84.27±10.6	0.18±0.03
A9/363	23.49±0.7	54.15±1.4	6.61±1.5	14.87±0.3	84.25±12.6	0.18±0.02
V11/311	25.18±1.6	52.99±3.4	7.47±0.4	13.49±0.8	85.64±3.4	0.16±0.03
Zhansaya	25.28±1.3	52.03±4.6	7.12±1.3	14.56±0.05	84.43±12.0	0.17±0.00
A9-562	24.41±2.7	53.08±6.4	6.67±0.14	14.92±1.0	84.16±4.6	0.18±0.00
B47/541	24.72±0.6	53.2±2.4	6.7±0.5	14.45±0.3	84.62±8.4	0.17±0.01
V10/1012	28.27±0.8	51.23±3.6	5.97±2.6	13.63±2.4	85.47±6.7	0.16±0.02
B48/232	23.67±2.0	54.07±3.1	7.29±1.0	14.15±0.7	85.03±2.8	0.17±0.01
B48/221	23.62±0.6	54.41±5.4	7.21±1.0	13.88±1.6	85.24±3.4	0.16±0.02
A8/2-2	23.74±1.7	54.63±2.7	6.14±0.6	14.49±0.7	84.51±1.5	0.17±0.02
B-47/53	25.39±3.8	52.34±1.3	6.67±0.7	14.79±2.4	84.4±2.8	0.18±0.00
B37/153	26.34±4.1	52.71±5.0	5.72±0.6	14.12±3.4	84.77±3.4	0.17±0.01
ZPR-30	26.6±0.9	51.07±2.4	6.59±0.9	14.65±1.6	84.26±2.6	0.17±0.01
B47/323	24.46±2.7	52.75±1.6	7.38±0.7	14.4±2.7	84.59±.34	0.17±0.01
ZPR-13	23.42±6.4	55.15±2.8	6.08±0.6	12.99±3.4	84.65±1.9	0.15±0.03
B4/53	24.97±4.5	54.09±4.5	6.6±0.4	13.48±2.0	85.66±5.4	0.16±0.00
B19/622	24.1±0.6	53.08±2.4	7.81±0.01	14.17±4.1	84.99±3.7	0.17±0.00
V18/731	25.34±0.7	53.01±2.4	6.47±0.8	14.18±8.0	84.82±2.0	0.17±0.00
Lastochka	24.3±2.4	55.37±5.7	5.59±2.0	13.55±0.07	85.26±3.4	0.16±0.01
B44/21	27.51±2.7	51.14±0.1	5.98±0.7	14.21±3.4	84.63±6.1	0.17±0.02
V21/311	24.14±3.7	53.91±2.4	7.61±1.3	13.17±2.1	85.66±3.1	0.15±0.01
ZPR-38	24.76±6.0	53.58±4.7	6.69±2.4	14.01±3.4	85.03±2.4	0.16±0.01
B40/623	22.78±0.7	55.16±3.6	7.88±1.3	13.22±1.6	85.82±1.6	0.15±0.01
V5/212	25.86±2.1	51.41±1.5	7.51±3.0	14.18±0.5	84.78±4.0	0.17±0.01
B-34/313	23.6±5.0	53.46±2.0	7.92±0.5	14.11±2.4	84.98±6.0	0.17±0.01
B37/85-21	24.54±0.7	53.85±4.3	6.42±0.7	14.05±3.1	84.81±2.8	0.17±0.00
B37/13-13	24.28±0.6	53.4±1.8	6.91±0.9	14.15±4.0	84.59±3.9	0.17±0.03
B44/51	24.86±0.4	53±3.7	6.85±0.8	14.33±2.1	84.71±1.7	0.17±0.02
B40/622	23.85±3.0	54.16±4.8	7.05±0.6	14.08±3.2	85.06±2.4	0.17±0.02
V5/221	24.43±1.6	50.66±9.0	7.57±0.4	14.94±1.5	82.66±3.1	0.18±0.01
ZPR-107-3	24.83±1.8	51.67±3.7	7.19±0.8	14.14±1.8	83.69±2.6	0.17±0.02
ZPR154	23.07 ±3.4	53.37±4.6	8±0.7	13.42±2.4	84.44±1.4	0.16±0.02

The values are means of three replicates (n = 3) ±SD with non-significant differences within varieties (p≥0.05)

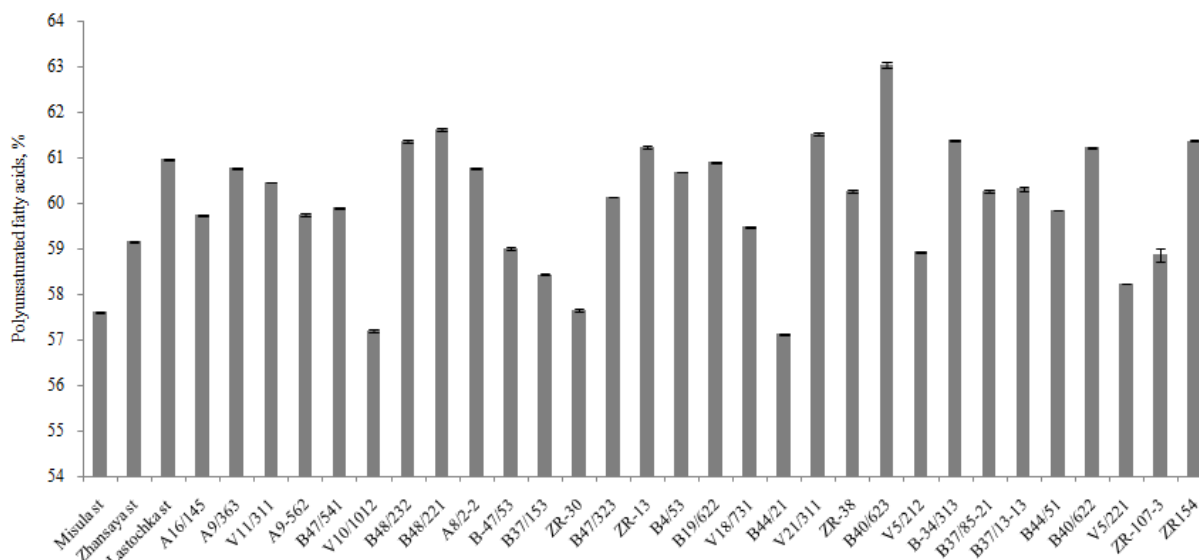


Fig. 1: The content of polyunsaturated fatty acids to total fatty acids in soybean oil (%) with non-significant differences within varieties ( $p \geq 0.05$ ) Vertical bars represent  $\pm$ SD of three replicates ( $n = 3$ )

It has been confirmed that the unsaturated fatty acids were pre-dominant in all varieties. Linoleic acid was the main fatty acid in the present study:

Linoleic acid  $\geq$  Oleic acid  $\geq$  Palmitic acid  $\geq$  Linolenic acid  $\geq$  Stearic acid

Our results demonstrated the presence of unsaturated oleic (C18:1) and polyunsaturated linoleic (C18:2) and linolenic (C18:3) acid in all soybean seed oils. The saturated/unsaturated acid ratio was generally low (Table 2). The lowest and highest are 0.15 (varieties ZPR-13, V21/311 and B40/623) and 0.18 (varieties Misula st., A16/145, A9/363, A9-562, B-47/53, V5/221), respectively.

Analysis of PUFA content in 30 soybean lines showed that for varieties of the first group (standard Misula) the total content of linoleic and linolenic acids ranged between 59-61%; for the second group (standard Zhansaya) and late-ripening varieties of the third group (standard Lastochka) the total content of linoleic and linolenic acids ranged between 59% and above 61% and only in the late-ripening variety B40/623 was indicated the maximum content of PUFA 63%. The low content of PUFA of about 57% was seen in standard Misula and vrs. V10/1012, ZR-30, B 44/21 (Fig. 1).

In general, except for the standard Misula and vrs. V10/1012, ZR-30, B 44/21 with a minimum content of fatty acids of about 57%, all the tested soybean lines had a high content of PUFA nearly 60% (Fig. 1).

In our research linoleic acid was the pre-dominant fatty acid in 30 soybean varieties. Its amounts ranged between 50.6 and 55.2%. Oleic acid was determined to be the second most abundant in these samples. Percent of oleic acid was between 22.8 and 28.3.

The results obtained in this study (Song *et al.*, 2015) were consistent with our investigations. The average contents and ranges of palmitic and stearic acid, saturated fatty acids (SFA), were 10.6% with a range of 4.1~18.1% and 2.9% with a range of 1.9~12.7% respectively, while those of oleic, linoleic and linolenic acid, unsaturated fatty acids (USFA), were 28.2% with a range of 15.3~56%, 51.2% with a range of 24.4~68% and 7.1% with a range of 3.4~11.1% respectively. The average linoleic( $\omega$ -6)/linolenic( $\omega$ -3) acid ratio was 7.5 ranging from 3.8~17 and the average SFA and USFA contents were 13.5% ranging from 6.7~21.7% and 86.5% ranging 78.3~93.4% respectively. Accessions with better essential properties were selected as useful resources for the development of high oil content and quality fatty acid varieties.

Very similar results were presented in the paper Jokić *et al.* (2013). The results highlighted that the soybean oil is rich in Polyunsaturated Fatty Acids (PUFA). The most abundant unsaturated fatty acid in soybean oil was linoleic acid, in amounts higher than 50% in all the fractions analyzed. Oleic acid, belonging to Monounsaturated Fatty Acids (MUFA), was the second most abundant unsaturated fatty acid in soybean oil, amounting from around 21% to around 25%. According to the data obtained, the third unsaturated fatty acid and that is very important, was polyunsaturated linolenic acid, in amounts from around 5% to around 6%. The most dominant saturated fatty acid was palmitic acid and then stearic acid.

The results obtained in another study (Fadavi *et al.*, 2006) were contrast to our investigations. Seven fatty acids were identified in seed oils of 25 pomegranates varieties. Linolenic acid was determined to be pre-dominant fatty acid in 25 pomegranates varieties. Its

amounts ranged between 31.8 and 86.6%. Linoleic acid was determined to be the second most abundant in these samples. Percent of linoleic acid was between 0.7 and 24.4; oleic acid -0.4 and 17.4.

Soybean lines with low linolenic acid content (2-6 %) have been developed for the oilseed industry to produce oils with improved oxidative stability without the need of hydrogenation (Gerde *et al.*, 2007). These lines are targeted for cooking oil, shortening and frying fat markets. To meet current consumer demand for low-saturated-fat foods and need for oils with acceptable oxidative stability, high-oleic acid soybean lines have been produced. In contrast, oils with high concentrations of saturated fatty acids are desirable in the margarine industry (List *et al.*, 1996) and those with elevated levels of linolenic acid are more useful in paint and varnish applications (Cahoon, 2003).

Seed oil triacylglycerol (TAG) composition of 32 soybean varieties were determined and compared using H-1-NMR. In support to our data, the contents of linolenic, linoleic and oleic acids ranged from 10.7 to 19.3, 37.4-50.1% and 15.7-34.1%, respectively. As is evident, linoleic acid was the major fatty acid of soybean oil. Compositional differences among the varieties were observed. Natural oils containing unsaturated groups have been regarded as important nutrient and cosmetic ingredients because of their various biological activities. The TAG profiles of the soybean oils could be useful for distinguishing the origin of seeds and controlling the quality of soybean oils (Kim *et al.*, 2013).

Sangwan *et al.* (1986) and Kermasha *et al.* (1986) investigated the degree of variability in the composition of fatty acids at different stages of soybean seed development. They came back to the conclusion that the oil content in mature seeds was greater than immature seeds because contains minimal amounts of free fatty acids and a higher amount of unsaturated fatty acids, mainly C18: 2 and C18: 3.

Galão *et al.* (2014) compared fatty acid profiles of seed samples from twenty different soybean [*Glycine max* (L.) Merrill] genotypes (14 non-transgenic and six transgenic Roundup-tolerant) grown at two different locations, both in the Parana state, a southern region of Brazil. A total of eleven fatty acids were detected and quantified, among them the most expressive ones were oleic, linoleic, linolenic and palmitic acids. The total unsaturated fatty acids amount was higher than 82%, which was in agreement with our results.

## CONCLUSION

Based on our study, the soybean seeds of all 30 varieties so far had similar (but not identical) fatty acid compositions and contained low amounts 12-14% of saturated fatty acids and high amounts 82-86% of

unsaturated fatty acids. The saturated/unsaturated acid ratio was generally low. The lowest and highest are 0.15 (varieties ZPR-13, V21/311 and B40/623) and 0.18 (varieties Misula st., A16/145, A9/363, A9-562, B-47/53, V5/221), respectively.

The most abundant polyunsaturated fatty acid (PUFA) in soybean oil was linoleic acid, in amounts higher than 50% in all 30 varieties. Oleic acid, belonging to monounsaturated fatty acids (MUFA), was the second most abundant unsaturated fatty acid in soybean oil, amounting from 22.8% to 28.3%. According to the data obtained, the third unsaturated fatty acid and that is very important, was polyunsaturated linolenic acid, in amounts from around 5.6% to around 8%. The most dominant saturated fatty acid was palmitic acid from around 8.6% to around 10.5% and then stearic acid from around 3.5% to around 4.8%.

## ACKNOWLEDGMENT

Financial support for this work was provided by the project for applied researches 1107/GF4 Science Committee of Ministry of Education and Science of Kazakhstan.

## REFERENCES

- Bahrami, G., 2009. Trans and Other Fatty Acids: Effects on Endothelial Functions. In: Watson, R. (Ed.), Fatty Acids in Health Promotion and Disease Causation. AOCS Press, Urbana, 1: 41-42.
- Cahoon, E.B., 2003. Genetic enhancement of soybean oil for industrial uses: prospects and challenges. AgBioForum, 6(1-2): 11-13.
- Chapkin, R.S., 2007. Reappraisal of the Essential Fatty Acids. In: Chow, C. (Ed.), Fatty Acids in Foods and Their Health Implications. Marcel Dekker, New York, pp: 667-675.
- Chavarro, J.E., M.J. Stampfer, H. Li, H. Campos, T. Kurth and J. Ma, 2007. A prospective study of polyunsaturated fatty acid levels in blood and prostate cancer risk. Cancer Epidem. Biomar., 16(7): 1364-1370.
- Collins, F.I. and J.L. Cartter, 1956. Variability in chemical composition of seed from different portions of the soybean plant. Agron. J., 48(5): 216-219.
- Fadavi, A., M. Barzegar and M.H. Azizi, 2006. Determination of fatty acids and total lipid content in oilseed of 25 pomegranates varieties grown in Iran. J. Food Compos. Anal., 19(6-7): 676-680.
- Firestone, D., 1999. Corn Oil. In: Physical and Chemical Characteristics of Oils, Fats and Waxes. AOCS, Champaign, Washington, pp: 31-32.

- Galão, O.F., M.C. Carrão-Panizzi, J.M.G. Mandarino, O.O.S. Júnior, S.A. Maruyama, L.C. Figueiredo, E.G. Bonafe and J.V. Visentainer, 2014. Differences of fatty acid composition in Brazilian genetic and conventional soybeans (*Glycine max* (L.) Merrill) grown in different regions. *Food Res. Int.*, 62: 589-594.
- Gerde, J., C. Hardy, W. Fehr and P.J. White, 2007. Frying performance of no-trans, low-linolenic acid soybean oils. *J. Am. Oil Chem. Soc.*, 84(6): 557-563.
- GOST R51486-99, 2001. Vegetable Oils and Animal Fats. Determination by Gas Chromatography Mass Fraction of Methyl Esters of Individual Fatty Acids to their Sum. Publishing House of Standards, Moscow, pp: 6.
- Jokić, S., R. Sudar, S. Svilović, S. Vidović, M. Bilić, D. Velić and V. Jurković, 2013. Fatty acid composition of oil obtained from soybeans by extraction with supercritical carbon dioxide. *Czech J. Food Sci.*, 31(2): 116-125.
- Kim, H.J., B.K. Ha, K.S. Ha, J.H. Chae, J.H. Park, M.S. Kim, S. Asekova, J.G. Shannon, C.K. Son and J.D. Lee, 2015. Comparison of a high oleic acid soybean line to cultivated cultivars for seed yield, protein and oil concentrations. *Euphytica*, 201(2): 285-292.
- Kim, W.W., H.S. Rho, Y.D. Hong, M.H. Yeom, S.S. Shin, J.G. Yi, M.S. Lee, H.Y. Park and D.H. Cho, 2013. Determination and comparison of seed oil triacylglycerol composition of various soybeans (*Glycine max* (L.)) using 1H-NMR spectroscopy. *Molecules*, 18(11): 14448-14454.
- Kinney, A.J., 1996. Development of genetically engineered soybean oils for food applications. *J. Food Lipids*, 3(4): 273-292.
- La, T.C., S.M. Pathan, T. Vuong, J.D. Lee, A.M. Scaboo, J.R. Smith, A.M. Gillen, J. Gillman, M.R. Ellersieck, H.T. Nguyen and J.G. Shannon, 2014. Effect of high-oleic acid soybean on seed oil, protein concentration, and yield. *Crop Sci.*, 54(5): 2054-2062.
- List, G.R., T.L. Mounts, F. Orthoefer and W.E. Neff, 1996. Potential margarine oils from genetically modified soybeans. *J. Am. Oil Chem. Soc.*, 73(6): 729-732.
- Medic, J., C. Atkinson and C.R. Hurburgh Jr., 2014. Current knowledge in soybean composition. *J. Am. Oil Chem. Soc.*, 91(3): 363-384.
- Min, C.W., R. Gupta, S.W. Kim, S.E. Lee, Y.C. Kim, D.W. Bae, W.Y. Han, B.W. Lee, J.M. Ko, G.K. Agrawal, R. Rakwal and S.T. Kim, 2015. Comparative biochemical and proteomic analyses of soybean seed cultivars differing in protein and oil content. *J. Agr. Food Chem.*, 63(32): 7134-7142.
- Rose, I.A., 1988. Effects of moisture stress on the oil and protein components of soybean seeds. *Aust. J. Agr. Res.*, 39(2): 163-170.
- Sangwan, N.K., K. Gupta and K.S. Dhindsa, 1986. Fatty acid composition of developing soybeans. *J. Agr. Food Chem.*, 34(3): 415-417.
- Song, H.L., E.K. Jang, E.H. Son, K.H. Lee, S.G. Hwang, G.S. Yun, J.D. Lee and H.S. Kim, 2015. Evaluation of oil contents and fatty acid compositions and selection of useful resources in soybean germplasm accessions. *Korean J. Breeding Sci.*, 47(3): 209-218.
- Yadav, N., 1996. Genetic Modification of Soybean Oil Quality. In: Verma, D. and R. Shoemaker (Eds.), *Soybean: Genetics, Molecular Biology, and Biotechnology*. CAB International, pp: 165-188.