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FATTY ACID COMPOSITION OF MAIZE GERM OIL FROM HIGH-OIL HIBRIDS WET-MILLING PROCESSING

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Maize germ was obtained by wet-milling laboratory processing of domestic high-oil maize hybrids. After separation, the germ was subjected to extraction of maize oil. Fatty acid composition of maize germ oil was determined by gas chromatography. The results showed very high levels of unsaturated fatty acids and a constant sum of oleic and linoleic acids in oils of different maize hybrids.

KEYWORDS: High-oil maize; wet milling; maize germ; gas chromatography; fatty acids

INTRODUCTION

Maize (*Zea mays* L.) is a staple cereal crop today. Its importance is not only evident from the large growing area but also from the most versatile utilization forms since maize is being an excellent source of human food, livestock feed and raw material for industrial processing.

Maize is becoming more and more an industrial plant, so, in addition to standard type hybrids containing around 80% of carbohydrates, 9-10% proteins, and 4-5% oil, other modified hybrids have been developed for special purposes (1). Selection of modified hybrids has been oriented towards quantitative and qualitative changes in constitutive parts, structure and chemical composition of maize. High genetic variability enables the formation of new hybrids for special purposes.

Considering the increased area under maize crop, growing of more productive hybrids, modern cultivation tehnologies, advanced industrial extaction and refining of oil there are real possibilities to increase the oil production from maize. Selection of high-oil hybrids with high genetic potential contributes to the goal (2). There is a considerable vari-

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ability in oil content in maize. When developing new high-oil breeding lines, the quality of oil and other desirable characteristics are also considered.

Maize oil is considered to be a high-quality plant oil. Fatty acid composition in maize oil varies in a wide range. Research results showed that four basic fatty acids – palmitic, stearic (saturated fatty acids) and oleic, linoleic (unsaturated fatty acids) make 96% of total maize germ oil composition. According to published data, when increasing the oil content in maize, the sum of oleic and linoleic acid remains constant, proving strong correlation between the two fatty acids (2).

High quality of maize oil is linked to the high content of unsaturated fatty acids, i.e. favourable ratio of saturated to unsaturated fatty acids. These features rank maize oil to those of the top quality according to nutricionist criteria. During the development of new lines, breeders give a special attention to the ratio of linoleic fatty acid to the sum of saturated fatty acids. Unsaturated fatty acids lower blood cholesterol levels in people, thus reducing risks from coronary heart disease. It is also known that total tocopherol (the most precious minor constituent in oil) content is influenced by the fatty acid composition in oil. Oil with higher content of unsaturated fatty acids contains more tocopherols (3).

Wet corn milling or starch processing is a specific and complex method of separating as completely as possible the anatomic parts of kernels making them available for further processing or direct utilization (4).

During starch processing, part of water soluble compounds are removed from the germ with steeping water (5). Therefore, the oil content in wet milled germ increases two or three times in comparison to the germ separated by dry milling method. Maize germ obtained by wet milling process is dried after separation to 4% of water content. Germ yields 22-29 kg of oil per ton of maize. Germ obtained by dry milling, easily deteriorates because of higher water content so it must be additionally stabilized. Because of lower oil content, dry milled germ processing is not economic in practise.

In this paper, the new selections of high-oil maize hybrids have been evaluated as a raw material for the starch wet milling processing. Also, the quality and quantity of the oil extracted from the isolated high-oil maize germ has been defined and evaluated.

EXPERIMENTAL

Determination of fatty acid composition of maize oil was performed in oil extracted from germs of the following high-oil maize hybrids: ZP702u, ZP703u and ZP704u bred at the Institute of Maize "Zemun polje" in Belgrade and NS735u and NS645u, developed at the Institute of Field and Vegetable Crops in Novi Sad. Considering the fact that the usage of only one hybrid is very rare on the field, the sample of NS blend, representing a blend of high-oil hybrids developed at the Institute of Field and Vegetable Crops in Novi Sad has been analyzed.

Germ separation

An amount of 100 g of sound and manually cleaned maize kernels was weighed. The first phase of maize starch production is steeping. Steeping was performed in a thermostated steep column at 50°C. Columns were closed at both ends with rubber stoppers. Constant steepwater flow was obtained with the aid of a peristatic water pump enabling water circulation through glass pipes fixed on the stoppers. Maize kernels were placed into the steep column and water/sulphur-dioxide mixture (steepwater contained 4.5 g of potasium metabisulphite in 1000 mL of water) was added (water to kernels volume ratio = 2:1). The kernels were steeped for 48 h. After steeping, the steepwater was captured and analyzed for dry matter content representing water soluble components extracted from maize kernels. The germ was manually separated from soaked corn. After separation, the germ was air dried for 24 h and then dried in a drier for 4 h at 50°C. Degerminated maize was ground in order to release other components: starch, gluten and bran. Bran was separated from starch-gluten slury by filtration. Further on, starch and gluten were separated by tabling method. In this way, complete wet-milling process for obtaining starch and by-products was simulated (6).

Oil extraction from germ

Oil extraction from germ was performed according to Soxhlet standard method (7). Petroleum ether was used as a solvent.

Determination of fatty acid composition by gas chromatography

The chloroform extracts were analysed using an AGILENT 4890 D gas chromatograph with the following parameters: FID detector (250°C), carrier gas N_2 15 psi (200°C), injector (220°C) 1µL injection volume manually, split mode (1:25), INNOWAX column 30 m × 0.25 mm × 0.5 m, temperature program was 200°C for 5 min, then increased at 2°C/min to 240°C. The obtained results were processed using AGILENT CHEM STATION software. Quantitative analysis was performed according to the method of internal normalization.

Preparation of fatty acid methyl esters

The preparation procedure of fatty acid methyl esters comprised direct alcoholysis using alcaline catalyst (methanolic 1M KOH) at boiling temperature with reflux condensation for 10 min. The mixture was partioned with chloroform and the chloroform extracts were analyzed by gas chromatography.

RESULTS AND DISCUSSION

The maize hybrids have been characterized by determing their chemical composition. In Table 1, chemical composition of high-oil maize grain is presented showing that, compared to a standard type hybrids, fat content of the high-oil hybrids is higher.

In Table 2 is shown chemical composition and proportion by weight of the maize germ obtained in laboratory wet milling process.

Table 3 presents kernel and germ fat content as well as germ content, showing that increase of fat content in the kernel follows the increase of germ content and germ fat content.

Chromatograms of fatty acid methyl esters in oils of high-oil maize hybrids were obtained by GC analysis and were used to determine the oil fatty acid composition.

Chromatograms of fatty acid methyl esters in oils of high-oil maize hybrids are presented in Fig. 1.

Table 1. Chemical composition og high-oil maize grain

Maize hybrid	Protein content $\%_{d.b.}$	Celulose content $\%_{d.b.}$	Fat content $\%_{d.b.}$	Starch content $\%_{d.b.}$
ZP 702_u	12.4	2.2	5.8	69.07
ZP 703_u	11.1	2.8	6.4	68.82
ZP 704_u	11.0	2.6	7.1	65.29
NS 735_u	10.5	3.2	7.3	69.24
NS 645_u	10.4	2.4	7.4	70.48
high-oil blend*	9.8	4.2	8.2	70.54

*****blend of high-oil maize hybrids

Table 2. Chemical composition of maize germ obtained by laboratory wet milling process

Germ from maize hybrids	Protein content $\%_{d.b.}$	Celulose content $\%_{d.b.}$	Fat content $\%_{d.b.}$	Ash content $\%_{d.b.}$
ZP 702_u	16.47	18.10	48.61	2.10
ZP 703_u	16.14	16.04	49.23	2.02
ZP 704_u	15.96	17.12	52.84	1.78
NS 735_u	15.33	13.45	53.05	2.33
NS 645_u	14.55	14.33	53.29	2.44
high-oil blend*	13.78	14.58	54.21	2.31

Table 3. Kernel fat content, germ content and germ fat content in the maize hybrids samples

Maize hybrid	Kernel fat content $\%_{d.b.}$	Germ content $\%_{d.b.}$	Germ fat content $\%_{d.b.}$
ZP 702_u	5.8	8.39	48.61
ZP 703_u	6.4	8.63	49.23
ZP 704_u	7.1	9.93	52.84
NS 735_u	7.3	10.28	53.05
NS 645_u	7.4	10.61	53.29
high-oil blend*	8.2	11.08	54.21

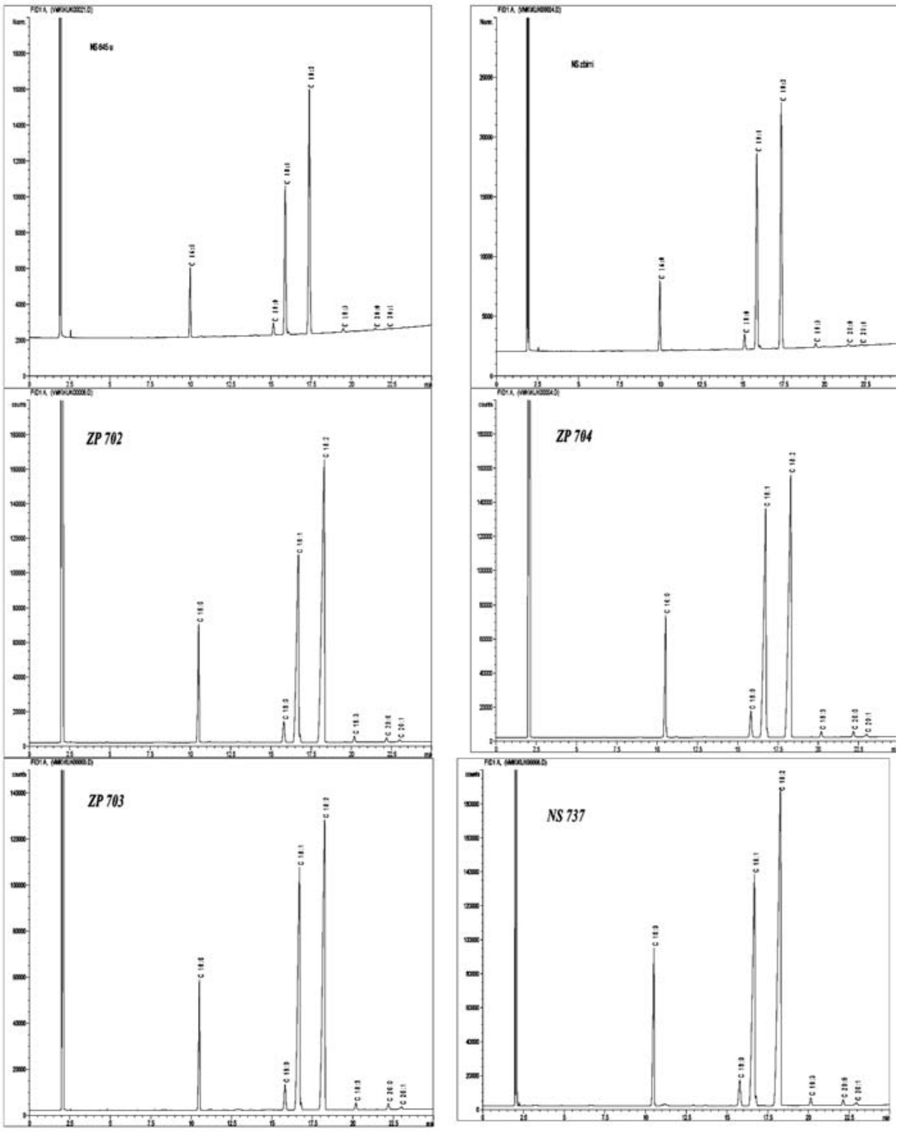

Fig. 1. Chromatograms of fatty acid methyl esters in oil of domestic high-oil maize hybrids

Table 4 summarizes the composition of fatty acids in maize germ oil samples obtained under laboratory conditions. As can be seen, oil of the maize germ contains very high percentage of unsaturated fatty acids, above all linoleic ($C_{18:2}$) and oleic ($C_{18:1}$) as well as low proportion of saturated fatty acids.

Table 4. Fatty acid composition of oil from maize germ processed by laboratory wet milling method

	ZP 702$_u$	ZP 703$_u$	ZP 704$_u$	NS 735$_u$	NS 645$_u$	high-oil blend
C 16:0	10.39	10.76	10.66	11.30	10.74	9.67
C 18:0	2.62	3.00	3.26	2.70	2.46	2.78
C 18:1	30.08	35.64	36.38	31.05	30.67	36.75
C 18:2	54.36	47.38	46.95	52.44	52.80	47.11
C 18:3	0.62	0.74	0.58	0.65	0.79	0.80
C 20:0	0.50	0.70	0.62	0.52	0.36	0.47
C 20:1	0.34	0.40	0.38	0.32	0.20	0.26

The ratio of the most important fatty acids found in the maize germ oil obtained by laboratory wet milling procedure is shown in Table 5. The content of four basic fatty acids: palmitic, stearic (saturated fatty acids) and oleic, linoleic (unsaturated fatty acids) amounts to more than 96% of the total maize germ oil. It was also found that the sum of oleic and linoleic acids remains almost constant in the oils different maize hybrids. Such result points out a strong functional correlation among these fatty acids which is in accordance with the findings of the other authors (2).

Table 5. Proportion of the most important fatty acids of maize germ oil obtained by laboratory wet milling process

Ratio of fatty acids	ZP 702$_u$	ZP 703$_u$	ZP 704$_u$	NS 735$_u$	NS 645$_u$	high-oil blend
$C_{18:1} + C_{18:2}$	84.44	83.02	83.33	83.49	83.47	83.86
$C_{16:0} + C_{18:0}$ $C_{18:1} + C_{18:2}$	97.45	96.78	97.25	97.49	96.67	96.31

CONCLUSIONS

Relatively high yield of the germ fraction, high oil content in the germ, as well as high content of unsaturated fatty acids and favorable ratio of saturated to unsaturated fatty acids, indicate that maize germ is a good source for production of oil for human consumption and that it could be used in this way rather than as a component of animal feed.

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САСТАВ МАСНИХ КИСЕЛИНА УЉА КУКУРУЗНЕ КЛИЦЕ ДОБИЈЕНЕ ПОСТУПКОМ ВЛАЖНОГ МЛЕВЕЊА ВИСОКОУЉАНИХ ХИБРИДА КУКУРУЗА

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Клица из домаћих хибрида високоуљаних кукуруза издвојена је поступком влажног млевења у лабораторијским условима. Из издвојене клице уље је екстраховано petrol-etrom. У раду је приказан састав масних киселина, одређен методом гасне хроматографије уља кукурузне клице. Резултати су потврдили веома висок садржај незасићених масних киселина, као и константан збир олеинске и линолне киселине у уљима различитих хибрида кукуруза.

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