Improving the Nutritional Value of Foods by Using the Essential Fatty Acids Obtained from Soybean Seeds Through the IR Spectroscopic Method

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Abstract

Soybeans have an oil content of 34-45%, containing about 15% saturated fatty acids and 85% unsaturated fatty acids, of which between 14-43% oleic acid and 44-75% linoleic acids. In recent years, high quality soybean oil has been produced with a diverse range of compositions by developing mid-oleic (43.1% -81.8%) and high-oleic (75-90,7%) soybean varieties. For the correct use of soybean oils in food and other industries, the content of oil, moisture and protein, fatty acid compositions and quality characteristics, must be evaluated both at harvesting and at marketing and processing and a study on consumer behavior regarding consumption of soybean oil. More than 40% of the investigated samples know the nutritional benefits of soybeans oils and the benefits of using it in a healthy diet. The sociological study was carried out on 154 consumers where the sociological research indicated the categories of consumers, nutrition criteria, food safety. Experimentally followed the behaviour of consumers to detect or group the types of consumers according to their gastronomic style.

Key words: soybean, oils, consumer's health
J.E.L. classification: D1, D12

1. Introduction

The use of fast and efficient methods is a necessity when considering the application needs. Alternative technologies such as NIR spectroscopy are being developed. This technology is based on measuring the absorption of electromagnetic radiation in the wavelength range of 400-2500 nm. To this end, studies have been conducted to determine the fat content of the sunflower plant and their fatty acid compositions by NIR spectroscopy.(Davies *et al*, 1987) NIR spectroscopy has been successfully used in the analysis of the fatty acid composition of sunflower seeds to evaluate the content of palmitic acid, stearic acid, oleic acid and linoleic acid, the content of oleic acids and linoleic acids, the analysis of sunflower seeds for fatty acids, moisture content, fats, oleic acid and palmitic, palmitic-oleic, stearic, oleic and linoleic acids.

It is necessary to determine the composition of fatty acids from sunflower seeds and soybean seeds that have an important value in national production, import, as well as in food processing and reproduction programs, by fast and reliable methods. Because analyzes based on NIR spectroscopy do not require labor-intensive sample pre-treatment and processing, the samples are analyzed by simple grinding or as a whole. This study was conducted to evaluate the efficiency of NIR spectroscopy, in determining the composition ratio of the fatty acids consisting of unsaturated fractions (UFA) and saturated fatty acids (SFA).(Biskupek-Korell *et al*, 2006)

2. Research methodology

Materials used for the study: 5 grams of soybeans, analytical balance, Soxhlet extraction device, blender. Several soybean varieties that were sampled for the experimental study were cleaned, dried in the oven, to a moisture content of less than 10%, then milled to a diameter of 1 mm, in a blender. Then 5 grams of soybean were taken, weighed and extracted with the Soxhlet plant, using 150 ml of ether for 3 hours. Analysis of gas chromatography of fatty acids: the crude oil extracted was subjected to chromatographic analysis (GC); after esterification.0.5 grams of oil was transferred to a 10 ml glass container, then 5 ml of n-heptane was added to the container, to which 200 ml of 2 M KOH solution was added in methanol. After mixing, for 20 s, the upper phase was separated and analyzed with a GC equipped with a capillary column and an FID detector. The GC conditions used to determine the fatty acid methyl ester were as follows: injection volume, temperature schedule, starting from 175 ° C, up to temp. 230°C; temp. 260˚C detector; injector temperature 250˚C; gas flow rate N2.1 ml / min; the total running time being 58.5 min.

Spectral analysis and calibration of the curve. The XDS infrared fast analyzer was used to receive spectra and to determine the estimated values of the soybean sample spectrum. These spectra were taken every 2 nm between 400 and 2500 nm wavelength. Calibration equations were created using Win ISI III v.61. This program uses original spectra, either directly after corrections to provide optimal pre-treatment for each evaluated parameter and instrument. The corrections applied are the first and second derivative transformations and the standard normal variation and distribution correction. Modified partial least squares (MPLS), least squares (PLS) methods were used to construct the calibration equations. The most appropriate mathematical model was obtained by using several mathematical models to correlate the results of the analytical reference methods with the results obtained by NIR spectroscopy. (Blanco *et al*, 2002). Calibration statistics include the standard calibration error (SEC) and the coefficient of determination in calibration (R). These statistics were used to develop the calibration model, standard prediction errors (R) were used to determine the validation accuracy. (Shenk *et al*, 1993)

Regarding the sociological study conducted on the consumer behaviour related to the consumption of soybean oil, we recorded the following results: the study was carried out on 154 consumers on isondaje.ro, and the respondents answered a set of questions; sociological research indicates the categories of consumers: men / women, young / old, loyal / occasional consumers; the questions were formulated according to sociological criteria, nutrition criteria, food safety; experimentally followed the behaviour of consumers to detect or group the types of consumers according to their gastronomic style; the primary criteria was the one related to nutrition or metabolism.

3. Findings

The validation statistics for the calibration equations obtained using the PLS regression methodology to predict the fatty acid composition of soybean seeds are presented in Table 1. The intervals of each fatty acid were found to be the following: 4.20–6.86, 2.06–4.90, 17.52–87.54, 3.66–67.90, 0.166–0.333, 0.109–0.262, 0.517–0.3535, 0.152–0.385, 87.13–92.53 and 7.47–12.87% for palmitic, stearic, oleic, linoleic, arachidonic, linolenic, behenic, EPA, UFA, and SFA.

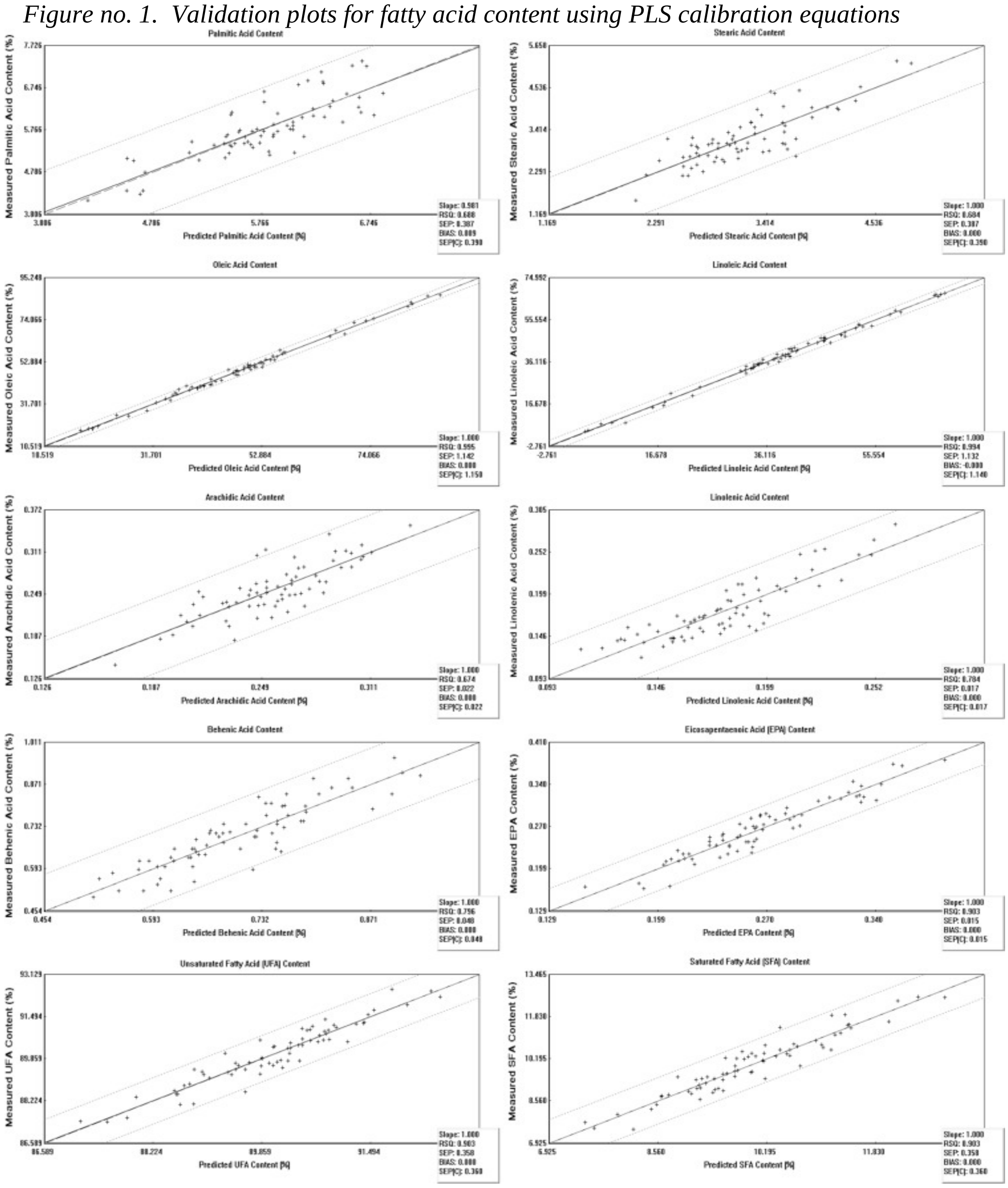
The average percentages of these fatty acids in the order mentioned above were 5.80, 3.20, 48.46, 39.50, 0.255, 0.179, 0.703, 0.265, 90.05 and 9.96%. Table 1 also shows the R 2 and SEP values of the calibration equations obtained by the PLS regression. R2 values were found to be 0.688, 0.684, 0.995, 0.994, 0.674, 0.784, 0.796, 0.903, 0.903 and 0.903, while SEP values were calculated as 0.387, 0.387, 1.142, 1.132, 0.022, 0.017, 0.048, 0.015 , 0.358 and 0.358 for palmitic, stearic, oleic, linoleic, arachidonic, linolenic, behenic, EPA, UFA and SFA.

Table no.1 Validation statistics of the calibration equation of PLS elaborated for estimating the relative composition of fatty acids in soybean seeds by FOSS NIRS system

Properties	**Media ± SD**	**Min. (%)**	**Max. (%)**	**R^2**	**SD**	**Sharing**	**Slope**
Palmitic acid (%)	5,80 ± 0,59	4.20	6,86	0.688	0.387	0.009	0.981
Stearic acid (%)	3,20 ± 0,57	2.06	4,90	0.684	0.387	0.000	1.000
Oleic acid (%)	48,46 ± 15,71	17.52	87.54	0.995	1.142	0.000	1.000
Linoleic acid (%)	39,50 ± 14,84	3,66	67,90	0.994	1.132	- 0.000	1.000
Arahidonic acid	0,255 ± 0,032	0.166	0.333	0.674	0.022	0.000	1.000
Linolenic acid	0,179 ± 0,032	0.109	0.262	0.784	0.017	0.000	1.000
Behenic	0,703 ± 0,096	0.517	0.935	0.796	0.048	0.000	1.000
EPA	0,265 ± 0,046	0.152	0.385	0.903	0.015	0.000	1.000
UFA	90,05 ± 1,10	87.13	92.53	0.903	0.358	0.000	1.000
SFA	9,96 ± 1,10	7,47	12,87	0.903	0.358	0.000	1.000

Source (Velasco et al, 1999)

Figure no. 1. Validation plots for fatty acid content using PLS calibration equations



Source (Velasco et al, 1999)

PLS, partial minimum squares; SD, standard deviation in the validation model; R 2, coefficient of determination in prediction; SEP, standard prediction error; EPA, eicosapentaenoic acid; UFA, unsaturated fatty acid; SFA, saturated fatty acid.

They found R 2 values of 0.88 for both oleic and linoleic acids in their validation study comparing NIRS and GC. We found that the comparison of NIRS and GC, the R 2 values determined by using the PLS and MPLS regression methods were higher than those reported. The regression methodology used was not indicated in the study, the R 2 values being 0.83, 0.92 and 0.93 for stearic, oleic and linoleic acid, respectively. In our study comparing GC and NIRS, the R2 values found for oleic and linoleic acids by both regression methodologies were higher than those reported. However, the calculated R2 values for stearic acid were lower than the R2 value reported in the study. The SEP values calculated in their study were very low for all fatty acids. This may be due to the larger number of samples analysed. (Velasco *et al*, 1999).

They reported R 2 values 0.987 for oleic acid in their study, comparing the reference values and the values obtained by NIR calibration using the MLR regression method. The R2 values calculated in this study are similar to the R 2 values reported.

The comparison of the NIRS fatty acid composition ratio and the fatty acid composition ratio obtained by GC analysis (reference values) is shown in Fig. 1. Because the calibration coefficients (R 2 = RSQ) were higher, the tangents of the calibration lines were equal to or closer to 1. When the standard prediction error (SEP) is close to zero and R 2 is close to 1, it means that model calibration is most appropriate. This shows that the predicted values are closely correlated with the real values.

Otherwise the evolution of the consumption of soybean oils indicates to us the following facts:

It is observed that the dynamics of the buyers by gender indicates that 72.73% of the respondents are women and 27.27% are men (figure no 2) on different age segments (figure no. 3).

Figure no. 2. Dynamics of byers by gender

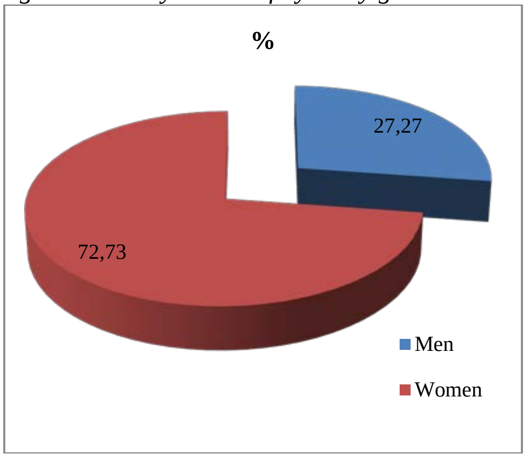


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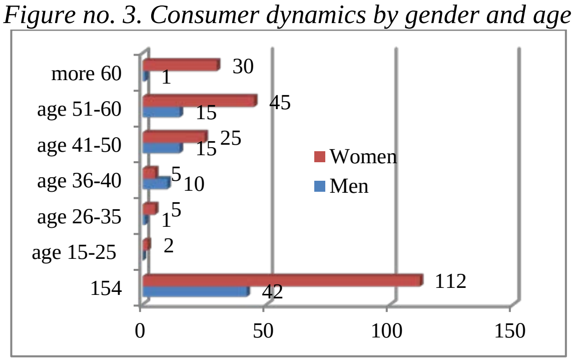
Figure no. 3. Consumer dynamics by gender and age segments



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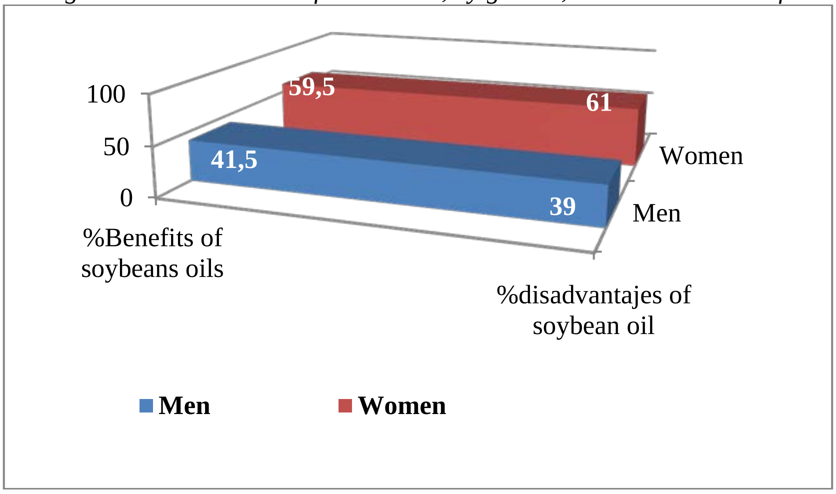
Also, the highest weight was registered by women's, 50% more than in men. This also explains the manifestation of obesity predominantly in women. In all age groups, women are in first place in the consumption of soybean oil. The highest percentage is in the age range over 60, 30 women compared to man, which indicates that the third generation food trend is to use vegetarian diets cooked with oil. This is counted with immediate effect in the health of the consumers, who after long periods of fasting diets immediately register increases of cholesterol, something not allowed especially in the case of cardiovascular, coronary diseases.

From the information provided by consumers, 41% of men know the benefits of soy oil, while 59% of women do not know them. Approximately the same was also recorded if the respondents were asked about the disadvantages of soybean oil (figure no.4). When asked about the fatty acids role played in nutrition, 20% of consumers knew the role of omega 3- oleic acid or omega 6- linoleic acid, while only 5% knew the role of triglycerides and respectively only 7% of cholesterol for human metabolism (Figure no.5).

Figure no. 4. The share of consumers, by gender, who know the benefits/disadvantages of soybean oils



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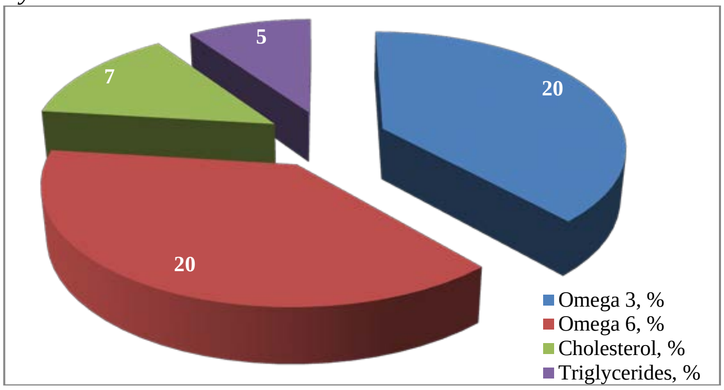
A significant percentage 54% do not know what cholesterol means and 37% do not know about triglycerides, but especially what effects these compounds have on their health (figure no.6).

Figure no.5. The share of consumers who know about omega 3, omega 6, cholesterol or triglycerides of soybean oil



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As regards the health of consumers, they do not have rigorous information about what oils they consume and what are the benefits of oils for their health. Also, from the investigation carried out, consumers do not know the disadvantages of using oils. That's why they can't properly appreciate what a healthy lifestyle means.

4. Conclusions

This study demonstrated that NIRS can be reliably used to determine the fatty acid composition of s seeds. Higher values of R2 were found by the MPLS regression method than the PLS regression method. In addition, he pointed out that NIRS analysis can be a fast and efficient method both in the vegetable oil industry and in the trade and marketing of sunflower seeds.

On the other site, in this stage of evolution the consumers are confusions regarding the selection of healthy oils from unhealthy oils. So that, we recommend a better dissemination of in the bands about the nutritional qualities of beneficial oils for health.

An education on the biochemical composition of oils on the content of good fats and less good fats for consumer health is also needed.

5. References

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