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Analytical Methods

Effect of sprouting and roasting processes on some physico-chemical properties and mineral contents of soybean seed and oils

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ABSTRACT

Free fatty acid contents of sprouted soybean oil were found between 1.26% (Adasoy) and 4.20% (Nazlıcan and Türksoy). Peroxide values (PV) of sprouted soybean oils were found between 1.52 meq/kg (Adasoy) and 3.85 meq/kg (A3935), while peroxide values of roasted seed oils were determined between 2.52 meq/kg (Adasoy) and 4.03 meq/kg (Nova). Palmitic, oleic and linoleic acids were found as major fatty acids of soybean genotypes. Oleic acid contents of samples were found between 19.07% (roasted Adasoy) and 35.31% (roasted A3935), linoleic contents of oils ranged between 42.17% (roasted Nazlican) and 54.76% (sprouted A3127). Macro and micro element contents of sprouted, oven roasted and raw (untreated) soybean seeds were determined by Inductively Coupled Plasma Atomic Emission Spectrometry. The potassium contents of soybean seeds ranged between 16,375 mg/kg (raw Adasoy) and 20,357 mg/kg (sprouted A3127, while phosphorus contents of seeds varied from 5427 mg/kg (oven roasted Türksoy) to 7759 mg/kg (sprouted Nova). The micro element contents of samples were found to be different depending on the processing procedures and soybean genotypes.

1. Introduction

Soybean (*Glycine max* L.), belong to Fabaceae family, usually referred to as soybean, is a popular foodstuff and crop plant, used especially in traditional cooking by South Asian people. Soybean is a major source of high quality protein and oil, and soybean seed quality is often determined by seed protein and mineral content (Grieshop & Fahey, 2001; Bellaloui et al., 2010). The quality of soybean seed is important for human and animal nutrition. Oil concentration of soybean seed ranges from 83 g/kg to 279 g/kg with a mean of 195 g/kg (Wilson, 2004). Soybean is a common vegetable oils that contains a significant amount of unsaturated acids: α-linolenic acid, known as omega-3 acid, linoleic, γ-linolenic and arachidonic acid, known as omega-6, oleic acid known as omega-9 acid, very important in the human nutrition (Bressani, 1975; Nikolic, Cakic, Novakovic, Cvetkovic, & Stankovic, 2009; Olguin et al., 2003). Saturated fatty acids, palmitic and stearic acids, in soybean seeds are considered a cardiovascular risk factor in human diets (Kris-Etherton, Derr, & Mitchell, 1993; Wolf & Grundy, 1983). In contrast, oleic, linoleic and linolenic acids reportedly reduce the risk of cardiovascular diseases in humans by reducing the blood serum cholesterol level (Grande, Anderson, & Keys, 1972); Harris, Connor, & McMurry, 1983. However, these unsaturated fatty acids have a negative impact on the flavour and oil stability during frying (O'Brien, Lynn, Clay, Phillip, & Peter, 2005). There is evidence that soybean consumption has a range of beneficial health effects such as cancer prevention, reduced risk of osteoporosis, a valuable role in control/prevention of chronic renal disease, and protection against some cardiovascular disorders (Blair et al., 2002; Grainge, Coupland, Cliffe, Chilvers, & Hosking, 2001; Orhan et al., 2007). Soybean oil is one of the common vegetable oils that contains a significant amount of unsaturated acids: α-linolenic acid, known as omega-3 acid, linoleic, γ-linolenic known as omega-6, oleic acid known as omega-9 acid, which are very important in the human nutrition (Bressani, 1975; Nikolic et al., 2009; Olguin et al., 2003). It is also used for industrial purposes such as the manufacture of paint, printing ink, soap, insecticides (Nikolic et al., 2009). Soybean meal is mainly used for livestock and poultry feed. (Rao, Bhagsari, & Mohamed, 1998). Various soybean speciality products like soymilk, tofu, and natto are rapidly gaining popularity in human nutrition (Endres, 2001). For producing soybean cultivars with high nutritional quality of both grain and soyfood products, and to assure economic returns to farmers, evaluation of both agronomic and nutritional characteristics of soybean genotypes is important.

The aim of this study was to investigate free fatty acids, peroxide values, fatty acid composition, and protein and mineral contents of soybean seed and oils obtained from sprouted, roasted and untreated soybean seeds.

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2. Material and methods

2.1. Material

Seeds of seven soybean genotypes (Nova, Adasoy, Türksoy, Nazlican, A3127, ATEM-7 and A3935) were obtained from Trakya Agriculture Research Institute, Tekirdag, Turkey. Seeds were sprouted, and then dried in oven at 70 °C. The soybean samples were kept at 4 °C prior to analysis.

2.2. Methods

2.2.1. Oven roasted

About 100 g of soybean seeds were roasted at 200 °C for 8 min on an electrically heated tray (Nüve FNO55, Ankara, Turkey). The heating time was selected to avoid any excessive heating of the seed samples.

2.2.2. Sprouting of soybean seeds

Soybean seeds were sprouted in a medium containing 30% water at room temperature (22 °C) for ten days. After sprouting, the seeds were oven dried (70 °C) to 11% moisture.

2.2.3. Oil extraction

The oil from soybean seeds (about 10 g) was extracted using petroleum ether at solvent ratio of 10:1 (v/w plant material) and boiled (60 °C) for 4 h using a soxhlet extractor. After extraction, the solvent was evaporated under vacuum. The experiments were performed in triplicate.

Analyses (peroxide value and free fatty acid) were carried out according to the AOCS (1990). Soybean oil (5 g) was placed in a flask at room temperature (22 °C) and 30 ml acetic acid:chloroform (CH3COOH:CHCl3) (3:2 v/v) was added. The mixture was shaken for five minutes to achieve a homogenous solution. For the determination of peroxide number, saturated solution of KI (1 ml) added. About 30 ml distilled water is added on homogenous solution. The liberated iodine was titrated with sodium thiosulphate solution (0.01 mol/l) in the presence of starch as an indicator (AOCS, 1990). For the determination of peroxide number, saturated solution of KI (1 ml) was added. About 30 ml distilled water was also added to the homogenous solution. The mixture was titrated with 0.1 mol/L NaOH solution by using phenolphthalein as an indicator.

2.2.4. Determination of fatty acids

Fatty acid compositions for soybean seed oil were determined using a modified fatty acid methyl ester method as described by Hışıl (1998). Oil was extracted from 2 g air-dried seed using petroleum ether. The oil samples (50–100 mg) were converted to fatty acid methyl esters (FAME). The methyl esters of the fatty acids (1 μl) were analysed using a gas chromotography (Shimadzu GC-2010) equipped with a flame ionising detector (FID), a fused silica capillary column (60 m × 0.25 mm i.d.; film thickness 0.20 μm).

Conditions of gas chromatograph were:

- Oven temperature program: 90 °C for 7 min (raised to 240 °C at a rate 5 °C/min and then kept at 240 °C for 15 min).
- Injector and detector temperatures: 260 and 260 °C; respectively.
- Carrier gas: nitrogen at flow rate of 1.51 ml/min.
- Split ratio: 1/50 μl/min.

A standard fatty acid methyl ester mixture (Sigma Chemical Co.) was used to identify sample peaks (AOAC, 1990). Quantitative analyses of the fatty acids were performed using the heptadecanoic acid methyl ester as an Internal Standard. The results are mean values of three replicates.

2.2.5. Protein content

Protein content was determined following the Dumas method and using a C/N analyser (TruSpec CN, Leco Co., St Joseph, MI, USA).

2.2.6. Mineral contents

Soybean samples were dried at 70 °C in a drying cabinet with air-circulation. Dried and ground samples (0.5 g) were digested using 5 ml of 65% HNO_3 and 2 ml 35% H_2O_2 in a closed microwave system (Cem-MARS Xpress). The volumes of digested samples were made up to 20 ml with ultra-deionized water and mineral concentrations were determined by inductively coupled plasma-optical emission spectroscopy (ICP-AES; Vista-Pro Axial; Varian Pty Ltd., Australia) (Skujins, 1998). Mineral concentrations were checked using certified values minerals in the reference samples received from the National Institute of Standards and Technology (NIST; Gaithersburg, MD, USA) (Skujins, 1998).

Working conditions of ICP-AES:

Instrument: ICP-AES (Varian-Vista)
RF Power: 0.7–1.5 kw (1.2–1.3 kw for axial)
Plasma gas flow rate (Ar): 10.5–15 L/min. (radial) 15″ (axial)
Auxiliary gas flow rate (Ar):1.5″
Viewing height: 5–12 mm
Copy and reading time:1–5 s (max. 60 s)
Copy time: 3 s (max. 100 s)

2.2.7. Statistical analyses

Results were analysed for statistical significance using analysis of variance by hand (Püskülcü & F İkiz, 1989).

3. Results and discussion

The chemical properties (free fatty acid and peroxide value) of sprouted, roasted and non-roasted soybean seed oils are shown in Table 1.

The free fatty acid (FFA) content of sprouted soybean oil was found to be higher than those of untreated and roasted soybean oils. Free fatty acid ranged from 1.26% (Adasoy) to 4.20% (Nazlican and Türksoy). FFA contents of roasted soybean oil were 0.74% (Türksoy genotype) to 0.84% (Nazlıcan genotype). In addition, FFA content of untreated soybean oil were found between 0.84% (Nazlican) and 3.85% (Adasoy). These differences may be due to enzyme activity during sprouting of soybean seeds ($p < 0.05$). The peroxide values (PV) of non-treated, sprouted and roasted soybean oils are presented in Table 2. According to the variance analysis results, free fatty acid and peroxide values changed in treatment effects at $p < 0.05$ level (Tables 1 and 2). Peroxide values for roasted soybean oils were established as higher than those from untreated

Table 1
Effect of sprouting and roasting processes on free fatty acidity of soybean oil.

Soybean oil samples	Free fatty acidity (oleic acid, %)		
	Untreated	Sprouted	Roasted
A 3935	1.05 ± 0.3b[a]	3.85 ± 0.13a[b]	0.80 ± 0.10c
Adasoy	3.85 ± 0.7a	1.26 ± 0.11b	0.83 ± 0.30c
Nazlıcan	0.84 ± 0.1b	4.20 ± 0.17a	0.84 ± 0.20b
Türksoy	1.47 ± 0.4a	4.20 ± 0.21a	0.74 ± 0.60c
Ataem 7	1.05 ± 0.3ab	1.47 ± 0.90ab	0.84 ± 0.20b
Nova	0.98 ± 0.1ab	1.40 ± 0.70a	0.82 ± 0.20ab
A 3127	1.33 ± 0.9ab	1.33 ± 0.30ab	0.81 ± 0.10c

[A] Mean ± standard deviation.
[b] $p < 0.05$.