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Effect of Processing and Cooking Methods on the Chemical Composition, Sugars and Phytic Acid of Soybeans

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Abstract The present investigation was conducted to study the effect of processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) on the chemical composition, sugars and phytic of two varieties soybean seeds, Giza, 21 and Giza, 35. The processing and cooking methods caused increase in both protein and crude fiber contents. Meanwhile, crude oil and carbohydrates contents were decreased of the studied soybean seeds. Generally, the processing and cooking methods resulted in a decrease of raffinose, stachyose, verbascose, maltose and sucrose accompanied by an increase in glucose. These resulted revealed that the processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) was more effective in eliminating the contents of oligosaccharides and phytic acid in both varieties soybean seeds.

Keywords Soybeans, Phytic Acid, Sugars, Soaking, Germination, Autoclaving

1. Introduction

Grain legumes are the major sources of dietary proteins in all the developing countries because animal proteins are expensive. Information on the amounts of oligosaccharides extracted from soybean seeds during cooking has been reported by Ku et al. (1976). The traditional method for home preparation of this leguminous seed consists of a water soaking period (usually overnight) followed by cooking of the dehydrated seeds after discarding the soaking water. Beans become edible after prolonged boiling in water or after a shorter time when a pressure cooker is used (Silva and Braga, 1982).

The oligosaccharides, raffinose, stachyose and verbascose, common in legume seeds, are thought be the major producers of flatulence. These saccharides are comprised of one, two and three glactose units respectively joined together with sucrose in α-D linkages. Owing to the lack of α-galactosidases in mammalian digestive system, they pass into the colon where they may produce diarrhea, flatus gas (Co_2, H_2 and small amounts of CH_4 gases) and their inevitable social discomfort (Wagner et al. 1976, Fleming, 1981 and Vijayakumari et al. 1996).

Domestic processing and cooking methods are known to reduce the antinutrients and thus improve the nutritive value of legume grains (Khokhar and Chauhan, 1986 and Sharma and Sehgal, 1992). Germination caused the most significant reduction in phytates. The longer period of germination, led to greater reduction in phytic acid content; germination of seeds for 48 h caused a reduction of 66 to 69%. This reduction was possibly due to activation of phytase during germination (Eskin and Wiebe, 1983 and Sharma and Sehgal, 1992).

Phytic acid, myo – inositol 1, 2, 3, 4, 5, 6– hexa – kis (dihydrogen phosphate) widely distributed in mature legume grains, stores most of the grain phosphorus. Phytic acid has antinutritional properties owing to its ability to chelate several minerals and thereby reduce their bioavaibility (Nolan and Duffin, 1987, and Vijayakumari et al. 1996). The effect of germination conditions on the chemical composition, biochemical constituents and antinutritional factors of soybean was studied (Bau et al. 1997).

Therefore, the present study was undertaken to investigate the effect of various domestic processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) on the chemical composition, sugars and phytic acid of two varieties of soybeans.

2. Materials and Methods

Soybean Giza, 21 and Giza 35 seeds were obtained from the Food Legume Section, Field Crops Research Institute, Agriculture Research Center, Giza, Egypt during 2008/2009. Grains were cleaned and other foreign materials were discarded. The cleaned seeds were stored in polyethylene bags under refrigeration until used.

Chemical Composition

Moisture, crude protein, crude oil, crude fiber and ash contents were determined as described by AOAC (1990). Total

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carbohydrates were calculated by difference.

Extraction and determination of sugars:

Sugars were extracted according to the method of Vijayakumari et al. (1996). 5g of each sample treating with 25ml of 80% ethanol at room temperature by repeated shaking. The extraction was repeated twice. The extracts were pooled and concentrated under vacuum at 4°C. The residue was made up to 5ml with distilled water, and the sugars were separated using ascending thin layer chromatography and the solvent mixture, n-butanol- ethyl acetate- isopropanol - acetic acid - water (35: 100: 60: 35: 30) according to Lato et al.(1968). After development, the plate was visualized by spraying α-naphthol reagent. 10.5 ml α-naphthol (15% solution in 95% ethanol w/v), 6.5 ml concentrated sulfuric acid, 40.5ml 95% ethanol and 40 ml water (Jacin and Mishkin 1965). The isolated sugars were identified according to the Rf values of standard sugars on the same plate. The quantitative analysis of separated chromatographic fractions of sugar was estimated by scanning using Shiuadzu TLC- Scanner (C – S – 910).

Extraction and estimation of phytic acid

Phytic acid content was determined as described by Wheeler and Ferrel (1971). Phytic acid was extracted from 3g seed flour with 50ml of 3% TCA by shaking at room temperature followed by high speed centrifugation. The phytic acid in supernatant was precipitated as ferric phytate by adding excess ferric chloride and centrifuged. The ferric phytate was converted to ferric hydroxide with a few ml of water and 3ml of 1.5N NaOH, and then the iron content present in the sample was estimated. The phytate phosphorus was calculated from the iron results assuming a 4 : 6 iron : phosphorus molecular ratio. The phytic acid was estimated by multiplying the amount of phytate phosphorus by the factor 3.55 based on the empirical formula $C_6 P_6 O_{24} H_{18}$.

Processing and cooking methods

Soaking

Seeds were soaked in tap water, (seeds : water, 1 : 5 w/v) for 6, 12 and 18h at room temperature (30°C). The water left after soaking was discarded. The soaked seeds were washed twice with ordinary water followed by rinsing with distilled water and then dried in a hot air oven at 60°C. (Kaur and Kapoor, 1990). Dried samples were ground to (60 mesh sieve) and then stored in air – tight plastic containers for further chemical analysis.

Germination

The seeds were placed in sterile Petri dishes lined with wet filter paper and kept in an incubator at 30°C for 40 and 60h with frequent watering. The sprouted samples were dried in a hot air oven maintained at 60°C, ground (60 mesh sieve) and stored in glass bottles under refrigeration for further analysis (Kaur and Kapoor, 1990).

Ordinary cooking

The soaked seeds (12h in tap water) and unsoaked seeds were cooked in beakers. The ratio of seeds to water was 1: 5 and 1: 6 (w/v) for soaked and unsoaked seed, respectively. The water was allowed to boil before the addition of seeds. The seeds were cooked until soft as felt between fingers. The cooking time was 10 and 15 min for soaked and unsoaked seeds, respectively. The cooked samples were then mashed and dried in a hot air oven maintained at 60°C and then ground to a fine powder (60 mesh sieve) and stored (Kaur and Kapoor, 1990).

Autoclaving

The soaked seeds for 12h and unsoaked seeds were autoclaved at 1.05 kg/cm^2 for 5 and 10 min, respectively. The ratio of seed to water was 1: 5 (w/v) for unsoaked seeds and 1: 4 (w/v) for soaked seeds. The autoclaved seeds were then mashed, dried at 60°C finely ground (60 mesh sieve) and stored. (Kaur and Kapoor, 1990).

3. Results and Discussion

The effect of processing and cooking methods on chemical composition

The gross chemical composition of soybean; Giza 21 and Giza 35 of processing and cooking methods are shown in Tables (1 and 2). The data showed that, the protein content of soybean Giza 21 (35.55%) and Giza 35 (37.50%).

Processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) caused a slight increase in protein content of tow varieties soybean Giza 21 and Giza 35. Similar findings were reported by Akinlosotu and Akinyele (1991). Lee and karunanithy (1990) observed also an increase in total crude protein content of more than 21% in dehulling germinated soybean compared to ungerminated seeds. Awad – Allah (1996) observed that the protein content was (37.61%) in soybean seed variety "Calland" which was characterized by relatively less lipid content (19.16%). Opposite phenomena was show in the soybean seed variety "Williams" which were 33.83% and 21.04%, respectively.

The crude oil content of soybean; Giza 21 (20.25% and Giza 35 (19.35%) are shown in Tables (1 and 2). The crude oil content was slightly decreased after processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) of soybean seed, Giza 21 and Giza 35. This decrement in oil content might be due to the increasing activity of lipases during soaking and germination (kylen and MeCready, 1975), as well as the breakdown of oil, into glycerol and fatty acids (Igbedioh et al. 1994). The lipid content of soybean seeds gradually diminishes as germination progresses. At the end of 5 days, loss of lipids reached 19.8% compared to ungerminated seeds (Chandrasiri et al. 1990). Mostafa et al. (1987) found also that 6 – day's germination induced a decrease in oil content of soybean seeds.

The crude fiber contents of soybean; Giza 21 and Giza 35 recorded an increase during processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving), Tables (1 and 2). Awad- Allah (1996) found that

the crude fiber of the soybean seed varieties "Williams and Calland" were 7.11% and 7.43%, respectively.

Table 1. The Effect of processing and cooking methods on chemical composition of soybean (Giza 21)

Treatment	Moisture (%)	Crude protein (%) (NX 6.25)	Crude oil* (%)	Ash (%)	Crude fiber (%)	Carbohydrates (%)
Raw (control)	6.15	35.55	20.25	5.80	7.12	31.28
Soaking 6h	55.32	36.70	20.00	5.72	7.80	29.78
12h	56.25	36.80	20.00	5.65	7.95	29.60
18h	56.50	37.25	19.25	5.30	9.20	29.00
Germination						
40h	58.25	37.85	18.35	4.50	9.35	29.95
60h	57.80	38.00	18.20	4.35	9.50	29.85
Ordinary cooking						
Unsoaked	60.75	38.20	17.50	4.00	9.75	30.55
Soaked	61.30	38.55	17.20	3.82	9.83	30.60
Autoclaving						
Unsoaked	60.35	38.85	17.00	3.72	10.20	30.23
Soaked	60.55	38.90	16.80	3.70	10.35	30.25

*On dry weight basis ** Calculated by difference.

Table 2. The Effect of processing and cooking methods on chemical composition of soybean (Giza 35)

Treatments	Moisture (%)	Crude protein (%) (NX 6.25)	Crude oil (%)	Ash (%)	Crude fiber (%)	Carbohydrates** (%)
Raw (control)	7.32	37.50	19.35	6.80	9.30	27.05
Soaking 6h	50.20	37.80	19.25	6.65	9.35	26.95
12h	52.30	38.20	19.00	6.35	9.72	26.73
18h	53.25	38.52	18.32	6.20	11.00	25.96
Germination						
40h	60.35	38.75	18.20	5.80	11.30	25.95
60h	60.80	39.33	18.10	5.55	11.52	25.50
Ordinary cooking						
Unsoaked	61.20	40.15	17.52	5.33	11.70	25.30
Soaked	62.33	40.25	17.35	5.25	11.95	25.20
Autoclaving						
Unsoaked	62.72	40.80	16.60	4.30	13.20	25.10
Soaked	62.80	41.25	16.45	4.00	13.35	24.95

*On dry weight basis ** Calculated by difference.

The ash content of soybean seeds; Giza 21 and Giza 35, are shown in Tables (1 and 2) respectively. Data in Tables (1 and 2) revealed that the ash contents were decreased during processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving).

The processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) caused a slight decrease of carbohydrates of soybean; Giza 21 and Giza 35 (Tables, 1 and 2).

From the abovementioned results it could be concluded that the soybean seeds Giza 21 and Giza 35 were rich sources of protein, lipids and carbohydrates reaching average about 35.55% - 37.50%, 20.25% - 19.35% and 31.28% - 27.05%, respectively.

The effect of processing and cooking methods on sugars

Sugars content of the studied soybean seeds as affected by processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) are illustrated in Tables (3 and 4). The raffinose content of soybean seed Giza 21 had higher than that of soybean seed, Giza 35. The processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) recorded that the decreasing of raffinose content of soybean seeds, Giza 21 and Giza 35. Vijayakumari et al. (1996) observed that the soaking in distilled water of germplasm does not result in significant reduction in the content of raffinose which agrees with an earlier study in Dolichos lablab (Revilleza et al. 1990).

Untreated (raw) and all treated and cooked methods soybean seeds (Giza 21) had higher raffinose content than that of (Giza 35).

Moreover, stachyose and verbascose levels were higher in raw and treated Giza 35 seeds than that of Giza 21. Data also revealed that soaking, germination and cooking methods led to little reduction in raffinose, stachyose and verbascose levels in the studied soybean seed varieties. Saini (1988) reported that the stachyose content was similar in lupin and soybean, while cowpea was higher that adzuki beans. Vijayakumari et al. (1996) reported that the during of soaking in distilled water, significant reduction has been observed in the levels of stachyose, followed by verbascose and raffinose contents in both the germplasms studied. Akinyele and Akinlosotu (1991) mentioned that the decreasing rate of verbascose of cowpea was 49.38 and 76.43% during soaking in water for 4h and dehulling processes, respectively.

The sucrose content of soybean seed Giza 21 had highest (35.55%) than that the soybean seed Giza 35 (28.75%) (Tables, 3 and 4). The processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) caused slight decreased of sucrose content of soybean seeds Giza 21 and Giza 35. Onigbinde and Akinyele (1983) reported that the sucrose levels of raw and dehulled cowpea were 0.87% and 0.88%, respectively. In general, the soybean seeds, Giza 21 and Giza 35 are considered as good sources of sugar fractions. All samples of soybean (Giza 21) seeds recorded higher sucrose and lower maltose contents than that of (Giza 35) seeds. The

glucose content of soybean Giza 35 had highest (10.20%) than that the soybean seed Giza 21 (8.30%). The processing and cooking methods caused a gradual increase of glucose. Akinlosotu and Akinyele (1991) showed that there was a gradual decrease in oligosaccharide content with germination, while the level of monosaccharide increased.

Table 3. The Effect of processing and cooking methods on sugars of soybean (Giza 21)

Treatments	Sugar fractions*					
	Raffinose	Stachyose	Verbascose	Sucrose	Maltose	Glucose
Raw (control)	7.65	7.25	0.78	35.55	40.47	8.30
Soaking 6h	7.10	6.70	0.22	35.25	40.15	10.58
12h	7.05	6.62	0.20	34.95	40.13	11.05
18h	6.88	6.60	0.19	34.65	40.10	11.58
Germination						
40h	6.80	6.50	0.18	34.37	39.80	12.35
60h	6.75	6.52	0.13	34.07	39.50	13.03
Ordinary cooking						
Unsoaked	6.72	6.45	0.10	33.77	39.30	13.66
Soaked	6.68	6.35	0.09	33.47	39.00	14.41
Autoclaving						
Unsoaked	6.65	6.30	0.08	33.17	38.70	15.10
Soaked	6.50	6.23	0.07	32.87	38.40	15.93

* = % of the total Sugars.

Table 4. The Effect of processing and cooking methods on sugars of soybean (Giza 35)

Treatments	Sugar fractions*					
	Raffinose	Stachyose	Verbascose	Sucrose	Maltose	Glucose
Raw (control)	6.30	8.20	0.80	28.75	45.75	10.20
Soaking 6h	5.80	7.68	0.30	28.45	45.20	12.64
12h	5.70	7.65	0.25	28.15	45.13	13.12
18h	5.68	7.63	0.22	27.85	45.12	13.50
Germination						
40h	5.65	7.60	0.20	27.55	45.10	13.90
60h	5.62	7. 55	0.22	27.25	45.08	14.28
Ordinary cooking						
Unsoaked	5.60	7.50	0.20	27.00	44.78	14.92
Soaked	5.50	7.53	0.18	26.70	44.48	15.51
Autoclaving						
Unsoaked	5.50	7.45	0.17	26.40	44.18	16.30
Soaked	5.53	7.30	0.15	26.10	44.00	16.92

* = % of the total

Sugars.Generally, the processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving) resulted in a decrease of raffionse, stachyose, verbascose maltose and sucrose accompanied by an increase in glucose. Reddy et al. (1984) who reported that the raffinose, stachyose and verbascose are soluble in water. Therefore, soaking beans in water and discarding the water will remove most of these sugars from beans.

The effect of processing and cooking methods on phytic acid

The phytic acid content of soybean, Giza 21 had highest (0.625%) than that the soybean, Giza 35 (0.463%) in Table (5). The soybean, Giza 21 and Giza 35 recorded markedly decreased of phytic acid during processing (soaking and germination) and cooking methods (ordinary cooking and autoclaving). These findings are in the line with Eskin and Wiebe (1983). Igbedioh et al. (1994) mentioned that the boiling of soaked pigeon seeds showed a further lowering of the phytic acid content. Vijayakumari et al. (1996) found that the percentage loss of phytic acid higher with distilled water soaking compared to salt water soaking in kerala germplasm.

Table 5. The Effect of processing and cooking methods on phytic acid (%) of soybean, Giza 21 and Giza 35[a].

Treatments	Soybean Giza 21	Soybean Giza 35
Raw (control)	0.625	0.463
Soaking 6h	0.535	0.452
12h	0.520	0.450
18h	0.500	0.435
Germination		
40h	0.485	0.420
60h	0.470	0.415
Ordinary cooking		
Unsoaked	0.465	0.382
Soaked	0.460	0.373
Autoclaving		
Unsoaked	0.435	0.350
Soaked	0.423	0.335

a All values of three determination and expressed on a dry weight basis.

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