EFFECT OF SOAKING AND BOILING ON CHEMICAL AND FUNCTIONAL PROPERTIES OF SOYBEAN CULTIVARS

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ABSTRACT

Variations among soybean cultivars in their chemical compositions were detected in the present work. By using both boiling and / or soaking methods, it was found that Giza 83 had highest protein content than another seed cultivars. Fat content of whole soybean seed cultivars ranged from 19.70 to 22.25. The cultivar of clark had lowest content of trypsin inhibitor but highest content of phytic acid and tanninis. Soaking and boiling treatments decreased the content of protein, fat, ash and crude fiber contents both using water or 0.5% $NaHCO_3$. The antinutritional factors in soybean seeds were reduced by soaking and boiling processes either by water or 0.5% $NaHCO_3$. Concerning soybean cultivars, Giza 83 ranked as the most cultivars having the highest foaming capacity followed by Clark, Giza 35 and Giza 22. Defatting soybean was the most treatment produced the higher functional properties than whole soybean seeds in all cultivars and all treatments.

INTRODUCTION

It is well established that soybean as a food legume crop has a desirable effects on health, diet and consider as an excellent sources for human and animal nutrition (Wolf and Cawon, 1975; Fomon and Ziegler, 1979 and Mesina and Mesina, 1991). Breeding of soybean cultivars for high quality is the principle aim for man investigators (Greater *et al.*, 2000 and Orf and Denny, 2000) Protein, carbohydrates, fat, fiber, phytic acid and typsin are the most important compounds desirable in soybean (Scrimshaw and Young, 1979).

Therefore, selections for soybean cultivars for such compounds are the safe, economic and stable method. Geater and Fehr, (2000) found variation among 23 soybean cultivars in total sugar, protein, oil and fiber. Also, Orf and Denny (2000) found that the new soybean cultivars MN 1401 exhibited over 11 g /kg higher in protein and 4g/kg lower in oil than seeds of parker cultivar.

Legume proteins are major components of the diet of food-producing animals and are increasingly important in human nutrition. Soybean is the most important legume in relation to total world grain production and the most frequently used because of its high protein content and relative cheapness (Wolf, 1970).

To utilize the dietary protein as ingredients in food industry, it is necessary to investigate the functional and other properties of the proteins. There are several reports concerning the functional properties of soy protein products (BWP) however, some functional properties of the proteins produced by different processing are inconsistent. The term functionality as applied to food ingredients is defined as any property, aside from nutritional attributes, that influences ingredients usefulness in food. Most functional properties affect the sensory characters of food (especially their texture attributes) but also play major role in the physical behaviour of foods or food ingredients during their preparation, processing, or storage (Fox, 1982; Kinsella, 1982 and Acton *et al.,* 1983).

The present investigation under taken to compare five introduced and local soybean cultivars in their chemical composition i.e. protein, carbohydrate, fat, fiber, ash, phytic acid, tannins and trypsin inhibitor. Different methods of treatments were applied.

MATERIALS AND METHODS

Source of samples:

Soybean seeds (Clark Giza-35, Giza-83, Giza-22 and Giza-111) varieties were obtained from Legume Research Department, Field Crops Research Institute, Agricultural Research Center.

Preparation of samples:

Preparation of defatted soybean

Soybean seeds were cleaned then dehulled using Yakushin (Hibean) Model Yk-20 BD.The soybean were milled by using a laboratory blenders, then the contained oil was extracted by n-Hexane using Soxhlet apparatus . The obtained defatted soybean was milled by MDY mill to obtain flour. The defatted meal was air – dried for 24 hour at room temperature.

Soaking and boiling of whole soybean:

300 gm whole soybean was soaked in 1.2L both by water or 0.5% $NaHCO_3$ for 8 hr, then drain and weigh were measured.

300 gm whole soybean was blenched 1.2L boiling both by water or 0.5% $NaHCO_3$ for 30min, then drain and weigh were measured.

Chemical analysis:

The prepared samples, whole soybean, and whole soybean defatted, were conducted to the following chemical analysis: moisture, crude protein, crude fiber, fat and ash contents according to A.O.A.C. (1985). While, carbohydrate content was determined by difference.

Antinutritional factors:

Tannins (as tannic acid):

Total tannins were determined colorimetrically as described in the AOAC (1985). One gram of sample was mixed with 50 ml methanol in quiet closed conical flask and left for 20 hr at room temperature (25 ± 2°C). The mixture was centrifuged for 30 min at 3000 *xg*. the tannins in the supernatant were estimated using Folin-Deins reagent. Spectrophotometer (Bausch and Lomb spectronic 2000) was used to measure the formed blue colour. Tannic acid was used to prepare the standard curve.

Phytic acid:

The level of phytic acid was determined according to the method of Wheeler and Ferrel (1971). The flour sample was extracted for 1 hr with 3% TCA by mechanical shaking at room temperature. The phytate content was precipitated by adding 2 mg of Fe^{+++} ($FeCl_3$) in 3% TCA then removed by centrifugation for 30 min at 3000 *xg* and digested by concentrated HNO_3 and $HClO_4$ (1 : 1, v / v) for two hours (up to colourless). The phosphorus content was determined in the digested solution according to the method of Taussky and Shorr (1953). Phytic acid was calculated from the phosphorus: phytic acid molecular ratio assuming that 660.08 is the molecular weight and $C_6 H_{18} O_{24} P_6$ .the structural formula of phytic acid.

Determination of trypsin inhibitor activity:

The trypsin inhibitor activity of flour samples was determined according to the method of Kakade *et al.* (1969).

Functional properties methods

Water absorption:

It was measured according to the procedure of Sosulski (1962). To 2 gram of the flour sample in a weighed centrifuge tube, 15 ml of distilled water were added and the material suspended in water using Vortex mixer for 1 min. After holding a period of 30 min, the tube was centrifuged for 30 min at 3000 *xg*. The supernatant liquid was discarded and the tube kept mouth down at an angle of 15 to 20 min in an electric forced draught air oven at 50°C. It was allowed to drain and dry for 25 min. Then it was kept in a desicator at 25 ± 2°C and subsequently weighed. Water absorption is expressed as the amount of water retained by 100 gm of flour or protein.

Fat absorption:

The method of Sosulski *et al.* (1976) was followed. It was performed as water absorption capacity using 10 ml of refined corn oil instead of distilled water. The results are expressed as ml of oil absorbed by 100 gm of flour.

RESULTS AND DISCUSSION

1. Chemical composition and antinutritional factors

Data in Table (1) show the proximate composition of whole soy seed and their flours for different cultivars (Clark, Giza 35, Giza 83, Giza 22 and Giza 111). Giza 83 and its flour had highest protein content than another seed and its flour. But, the cultivar Clark had lowest protein content than another cultivars. The fat content of whole soybean seed cultivars ranged from 19.70 to 22.25 %. Ash content of soybean cultivars was almost the same. However, Giza 111 cultivar seed flour had lower ash than other seeds. Moreover, in all soy been cultivars tested, whole soybean has lowest content than its flour accepted the total carbohydrate content.

Table (1) illustrates some antinutritional factors found in the different cultivars (Clark, Giza 35, Giza 83, Giza 22 and Giza 111) seeds and defatted flours. phytic acids content was in the range of 1.68 for Giza 22 to 1.92 g/100gm for cultivar of Clark. Generally, the defatting and dehulling of soybean had decreased values of the total phytic acid, tannins and trypsin inhibitor content. They found that, the cultivar of clark had lower content of trypsin inhibitor but higher content of phytic acid and tanninis. Meanwhile, the cultivar of Giza 22 had lower content of phytic acid and tanninis but higher content of trypsin inhibitor.

Table (1) Chemical composition and antinutritional factors of different cultivars of soybean seed and defatted flours.

Soy bean Cultivars		Chemical Composition % (on dry weight)					Antinutrition factors		
		Protein	Fat	Ash	Crude fiber	Carbohydrate*	Phytic acid (g/100g)	Tanins (mg/100g)	Trypsin (TIU/g)**
Clark	Whole	36.57	21.47	6.40	7.81	27.75	1.92	42.32	7.15
	Defatted	51.34	1.04	6.97	8.24	32.41	1.53	30.52	6.84
G_{35}	Whole	37.02	22.25	5.80	8.01	26.92	1.79	39.65	8.22
	Defatted	51.25	0.95	6.14	8.75	31.91	1.39	26.37	7.94
G_{83}	Whole	40.40	19.91	5.18	6.61	27.92	1.80	40.12	8.48
	Defatted	52.20	0.78	5.97	7.12	33.93	1.42	30.57	8.01
G_{22}	Whole	38.81	20.59	5.20	6.24	29.16	1.68	35.66	9.31
	Defatted	51.60	1.06	5.83	6.95	34.56	1.32	24.81	8.97
G_{111}	Whole	37.93	19.70	4.50	5.78	32.03	1.80	41.85	8.19
	Defatted	51.70	0.77	5.24	6.35	35.94	1.50	29.97	7.83

* total carbohydrate by difference
** TIU: Trypsin inhibtor unit

Effect of Soaking on chemical composition of soybean cultivars

Chemical compositions of raw and soaked soybean seeds and their flour are presented in Table (2). Soaking treatments decreased the protein, fat, ash and crude fiber contents using either in water or 0.5% $NaHCO_3$ treatment. but the level of decreases by soaking in water was lower than that of soaking in 0.5% $NaHCO_3$. These decreases might be attributed to their diffusion into the soaking water. Total carbohydrates of all cultivars were increased by soaking by both of water or 0.5% $NaHCO_3$. The differences in total protein or total carbohydrate contents were observed among cooking processes of soybean seeds. These observations are in agreement with those reported by Bau et al. (1997) for soybeans.

Effect of boiling on chemical composition of soybean cultivars

Chemical compositions of raw and boiled soybean seeds and their flour are presented in Table (3). Boiling treatments decreased the protein, fat, ash and crude fiber contents by both of the water or 0.5% $NaHCO_3$. The trend of the results obtained from soaking methods

(Table 2) was almost similar to that obtained from boiling. With minor differences in the rank when Clark ranked the first followed by G35 and G83 while, G22 and G111 were the lowest. In this line, Orf and Denny (2000) found that MN1401 soybean cultivar exhibited high amount of protein than Parker cultivar.

Table (2) Effect of soaking on chemical composition of soy bean cultivar flours. (on dry weight)

Soy bean Cultivars		Protein			Fat			Ash			Crude fiber			Carbohydrate*		
		Raw	Sod*	W**	Raw	Sod	W	Raw	Sod	W	Raw	Sod	W	Raw	Sod	W
Clark	Whole	36.57	35.42	36.04	21.47	20.12	21.15	6.40	6.35	6.24	7.81	7.25	7.56	27.75	33.86	29.01
	Defatted	51.34	49.04	50.17	1.04	0.95	1.00	6.97	6.88	6.58	8.24	7.85	7.98	32.41	35.28	34.27
G_{35}	Whole	37.02	35.46	36.45	22.25	21.65	22.03	5.80	5.65	5.70	8.01	7.68	7.98	26.92	29.56	27.84
	Defatted	53.25	51.64	52.09	0.95	0.75	0.78	6.14	6.21	6.05	8.75	8.54	8.61	30.91	32.86	32.47
G_{83}	Whole	40.40	39.25	39.98	19.91	18.32	19.3	5.18	5.00	5.10	6.61	6.43	6.15	27.92	31.00	29.47
	Defatted	52.20	50.71	51.25	0.78	0.66	0.74	5.97	5.90	5.95	7.12	7.00	7.05	33.93	35.73	35.01
G_{22}	Whole	38.81	37.35	37.93	20.59	19.58	19.87	5.20	5.00	5.12	6.24	6.05	6.20	29.16	32.02	30.88
	Defatted	53.60	51.35	51.99	1.06	0.84	0.80	5.83	5.75	5.80	6.95	6.72	6.85	32.56	35.37	34.56
G_{111}	Whole	37.93	36.6	37.21	19.70	19.00	19.36	4.50	4.03	4.34	5.78	5.35	5.56	32.03	35.05	33.53
	Defatted	51.70	49.98	50.34	0.77	0.50	0.65	5.24	5.37	5.10	6.35	6.05	6.18	35.94	38.10	37.73

* Sod: Sodium bicarbonate $NaHCO_3$ 0.5%
** W: water

Table (3) Effect of boiling on chemical composition of soy bean cultivar flours. (on dry weight)

Soy bean Cultivars		Protein			Fat			Ash			Crude fiber			Carbohydrate*		
		Raw	Sod	W	Raw	Sod	W	Raw	Sod	W	Raw	Sod	W	Raw	Sod	W
Clark	Whole	36.57	33.25	33.92	21.47	20.36	20.84	6.40	6.32	6.25	7.81	7.13	7.24	27.75	32.94	31.75
	Defatted	51.34	48.04	48.75	1.04	0.83	0.90	6.97	6.90	6.62	8.24	7.80	7.81	32.41	36.43	35.92
G_{35}	Whole	37.02	35.12	36.11	22.25	20.96	21.13	5.80	5.76	5.64	8.01	7.86	7.95	26.92	30.30	29.17
	Defatted	53.25	50.24	50.89	0.95	0.71	0.88	6.14	6.01	6.02	8.75	8.45	8.51	30.91	34.59	33.77
G_{83}	Whole	40.40	38.75	39.36	19.91	18.01	18.25	5.18	5.02	5.14	6.61	6.38	6.47	27.92	31.84	30.78
	Defatted	52.20	50.16	50.25	0.78	0.69	0.69	5.97	5.81	5.73	7.12	6.85	6.95	33.93	36.49	36.38
G_{22}	Whole	38.81	36.60	37.04	20.59	18.14	18.46	5.20	5.14	5.10	6.24	6.01	6.18	29.16	34.11	31.82
	Defatted	53.60	50.35	51.18	1.06	0.82	0.82	5.83	5.62	5.82	6.95	6.75	6.80	32.56	36.46	35.38
G_{111}	Whole	37.93	36.27	36.81	19.70	18.51	18.8	4.50	4.41	4.33	5.78	5.46	5.65	32.03	34.90	34.41
	Defatted	51.70	47.65	48.34	0.77	0.64	0.65	5.24	5.27	5.20	6.35	6.05	6.18	35.94	40.39	39.63

* Sod: Sodium bicarbonate 0.5%
** W: water

Effect of soaking and boiling on antinutritional factors of soybean cultivars

The antinutritional factors of raw and processed soybean seeds and their defatted flour are shown in Table (4). Tannins and phytic acid in soybean seeds were reduced by soaking and boiling processes by both of water or 0.5% $NaHCO_3$. Similar results were obtained by Vijayakumari et al. (2007) for *Vigna aconitifolia* and *Vigna sinensis*. Dehulling and soaking processes were less effect than boiling processes in reducing phytic acid and tannins. The highest reduction of tannin and phytic acid have in cultivar G22. Trypsin inhibitor activities were decreased by soaking and dehulling processes were similarly completely destroyed by boiling processes. The effect of soaking or boiling in 0.5% $NaHCO_3$ was higher effect than water. Khalil and Mansour (1995) reported that boiling and autoclaving of faba bean seeds completely eliminated trypsin inhibitor and hemagglutinin activity. The destruction of the trypsin inhibitor or reduction of tannins and phytic acid improved the digestibility of protein. The antinutritional activity of tannins can be reduced by processing or through breeding programms for low tannins. Aw and Swanson (1985).

Table (4) Effect of soaking and boiling on antinutritional factors of soy bean cultivar flours.

Soy bean Cultivars		Phytic acid (g/100g)					Tanins (mg/100g)					Trypsin(TIU/g)				
		Raw	Soaking		Boiling		Raw	Soaking		Boiling		Raw	Soaking		Boiling	
			Sod	W	Sod	W		Sod	W	Sod	W		Sod	W	Sod	W
Clark	Whole	1.92	1.28	1.35	1.01	1.20	42.32	29.05	30.00	23.45	25.34	7.15	4.32	4.95	0.64	0.87
	Defatted	1.53	1.14	1.21	0.98	1.10	30.52	16.50	17.03	12.65	15.64	6.84	3.15	4.53	0.10	0.25
G_{35}	Whole	1.79	1.21	1.30	1.05	1.15	39.65	25.23	26.53	20.17	22.87	8.22	5.03	6.47	0.53	0.75
	Defatted	1.39	0.98	1.05	0.87	0.98	26.37	13.64	14.39	10.68	12.36	7.94	4.36	5.68	0.21	0.40
G_{83}	Whole	1.80	1.25	1.32	1.03	1.15	40.12	27.25	28.50	21.87	23.55	8.48	5.41	6.85	0.65	0.96
	Defatted	1.42	0.96	1.08	0.75	0.95	30.57	16.38	17.01	12.61	15.96	8.01	5.16	6.68	0.30	0.52
G_{22}	Whole	1.68	1.07	1.15	0.86	0.96	35.66	21.95	22.43	17.69	19.01	9.31	6.45	7.55	0.85	0.98
	Defatted	1.32	0.85	1.00	0.75	0.90	24.81	11.36	12.55	9.00	10.36	8.97	3.56	4.96	0.30	0.56
G_{111}	Whole	1.80	1.24	1.09	1.01	1.25	41.85	27.05	28.65	21.85	24.23	8.19	5.24	6.56	0.82	1.00
	Defatted	1.50	1.05	1.15	0.82	0.94	29.97	16.55	17.28	12.41	15.30	7.83	4.75	6.01	0.35	0.68

* Sod: Sodium bicarbonate 0.5%

** W: water

Effect of soaking and boiling on water absorption and foam capacity of soy bean cultivars

Water binding or absorption is defined as the amount of water (gm) which is retained by protein following filtration and application of mild pressure or centrifugal force (Sosulski, 1962). Data in Table (5) shows the properties of water absorption and foam capacity of the tested cultivars. Differences among the treatments were noted. The cultivar of Giza 83 seed flour had highest of water absorption capacity, meanwhile the lowest value for water absorption was for cultivar Clark seed flour. The values for Giza 83 seed and defatted flour were 4.15 and 5.64gm H_2O/gm flour, respectively. In addition, may be the conformational features of the proteins caused these differences in water absorption capacity, also some other chemical compounds rather than protein particularly starch and crude fibre may take place in water binding capacity.

Foaming or whipping, i.e. the ability to form stable foams with air, is an important functional property of proteins desirable in several products such as cakes, sponge cakes, confectioneries, candy, beverages..... etc (Kinsella, 1976). Concerning soybean cultivars, Giza 83 ranged as the most cultivars having the highest foaming capacity followed by Clark, Giza 35 and Giza 22. Soybean defatted were the most treatment having the higher foaming capacity than whole soybean seeds in all cultivars and all treatments.

Table (5) Effect of soaking and boiling on water absorption and foam capacity of soy bean cultivar flours.

Soy bean Cultivars		Water absorption (gm/gm)					Foam capacity (% volume increase)				
		Raw	Soaking		Boiling		Raw	Soaking		Boiling	
			Sod	W	Sod	W		Sod	W	Sod	W
Clark	Whole	3.25	3.15	3.22	2.85	2.96	70	69	68	68	67
	Defatted	4.46	4.25	4.38	3.98	4.02	93	91	90	90	89
G_{35}	Whole	3.44	3.30	3.48	3.14	3.20	68	67	66	66	66
	Defatted	4.86	4.55	4.80	4.16	4.42	91	91	90	88	88
G_{83}	Whole	4.15	4.02	4.02	3.86	3.88	73	70	70	68	68
	Defatted	5.64	5.46	5.50	5.12	5.22	97	95	95	91	92
G_{22}	Whole	3.95	3.78	3.72	3.40	3.52	67	64	65	63	61
	Defatted	5.34	5.00	5.12	4.98	4.90	87	87	85	87	84
G_{111}	Whole	3.88	3.65	3.65	3.42	3.50	66	61	60	59	59
	Defatted	4.75	4.50	4.54	4.22	4.34	79	75	72	74	70

* Sod: Sodium bicarbonate 0.5%
** W: water

Effect of soaking and boiling on fat absorption

Data in Table (6) shows the properties of fat absorption and emulsification capacity of the tested cultivars. The high oil absorption capacity for Giza 83 followed by Giza 22, Giza 111, Giza 35 and Clark. The treatments by soaking or boiling decreased the value of fat absorption, the effect of treatment by 0.5 % $NaHCO_3$ was lower effect than water on fat absorption. The oil absorption capacity is affected by several factors, such as the protein content, the surface area, the hydrophobicity, the charge and topography, the liquidity of the oil and the method used. Also, oil absorption capacity of protein may depend on its capacity to entrap the oil (Kinsella, 1976). The ability of protein to bind fat is very important for such applications as meat replacers because it enhances flavour retention and improves mouthfeel (Lin *et al.,* 1974).

Table (6) Effect of soaking and boiling on fat absorption and emulsification capacity of soy bean cultivar flours.

Soy bean Cultivars		Fat absorption (ml oil/gm)				
		Raw	Soaking		Boiling	
			Sod	W	Sod	W
Clark	Whole	2.65	2.58	2.00	2.43	2.14
	Defatted	3.36	3.00	2.68	3.04	2.12
G35	Whole	2.92	2.44	2.15	2.65	2.00
	Defatted	3.52	3.25	3.02	3.16	2.98
G83	Whole	3.24	2.96	2.68	2.98	2.44
	Defatted	4.25	4.02	3.84	4.12	3.76
G22	Whole	3.05	2.96	2.65	3.00	2.54
	Defatted	4.00	3.58	3.24	3.75	3.05
G111	Whole	2.95	2.64	2.16	2.84	2.04
	Defatted	3.86	3.56	3.05	3.54	3.00

* Sod: Sodium bicarbonate 0.5%
** W: water

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تأثير النقع والغليان على التركيب الكيماوي والخصائص الوظيفية لأصناف فول الصويا المختلفة

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وجدت اختلافات في التحليل الكيماوي لأصناف الصويا أثناء عملية النقع والغليان وقد وجد أن صنف جيزة 83 يحتوى على أعلى قيمة فى البروتين أكثر من الأصناف الأخرى وان نسبة الدهون فى أصناف الصويا المستخدمة تراوحت بين 17.7 إلى 22.25% بينما صنف كلارك يحتوى على اقل قيمة من مثبط التربيسين وأعلاهم في حامض الفيتك والتانين ووجد ان معاملة النقع والغليان أدت إلى نقص البروتين والدهون والرماد وكذا الألياف كما حدث اختزال لقيمة مضادات التغذية في أصناف الصويا التي تم نقعها وغليها في كل من الماء اما عند النقع فى 5% بيكربونات الصوديوم فقد اعطى صنف جيزة 83 أعلى رغوة يليه كلارك وجيزة 35 جيزة 22. وجد أن أصناف الصويا المنزوعة الدهن سجلت أعلى نتائج فى الخصائص الوظيفية مقارنة بالحبة الكاملة لنفس الأصناف في كل المعاملات.