Pol. J. Food Nutr. Sci., 2011, Vol. 61, No. 3, pp. 181-186
http://journal.pan.olsztyn.pl
Original Paper
Section: Food Technology
DOI: 10.2478/v10222-011-0019-3

Effects of Various Hydrothermal Treatments on Selected Nutrients in Legume Seeds

Agnieszka Filipiak-Florkiewicz[1], Adam Florkiewicz[1], Ewa Cieślik[1], Izabela Wałkowska[1], Maria Walczycka[2], Teresa Leszczyńska[3], Joanna Kapusta-Duch[3]*

[1]The Malopolska Centre of Food Monitoring and Certification, [2]Department of Animal Product Technology, [3]Department of Human Nutrition; University of Agriculture in Krakow, ul. Balicka 122, 30–149 Krakow, Poland

Key words: soya bean, kidney-bean, hydrothermal treatment, protein, fat, mineral compounds

The aim of this study was to assess the influence of different soaking and cooking methods on contents of selected nutrients in legume seeds. The experimental material were dried kidney-bean seeds and soya bean seeds originating from the collection of Krakow's Plants and Seeds Horticulture POLAN LTD. Technological treatment of seeds was performed in two stages: (1) cold and hot soaking, (2) cooking with three different devices: electric and induction stoves and microwave apparatus. The experimental material was determined for contents of: dry matter, protein, fat, ash, carbohydrates and selected mineral compounds (Ca, Mg, Na, K). The soaking and cooking of the seeds were observed to affect an increase in contents of protein, fat, ash, calcium and sodium in dry matter as well as a decrease in contents of digestible carbohydrates, potassium and magnesium. A more favorable method of soaking kidney bean seeds turned out to be hot soaking, which caused smaller losses of nutrients and shortened significantly the whole process. Cooking soya bean and kidney bean seeds with electric and induction stoves facilitated better protein preservation in comparison to the thermal treatment performed in a combined microwave oven.

INTRODUCTION

Seeds of legumes such as bean, soya bean, kidney bean, broad bean and others are one of the basic food products, especially for individuals restricting the consumption of meat (vegetarians). Legumes are a very valuable source of plant protein, fat (soya bean), complex carbohydrates, mineral compounds, fiber and vitamins [Fıratlıgil-Durmuş *et al.*, 2010]. They exceed other vegetables in phosphorus, potassium, calcium and magnesium contents [Ximenez--Embun, 2004]. Also the content of iron and group B vitamins, such as thiamine and riboflavin, in these seeds is rather high [Iqbal *et al.,* 2006; Kołota *et al.,* 2007]. The chemical composition of individual species and varieties of legumes is very differentiated both in quantity and quality aspects. It is not only influenced by genetic differentiation but also by environmental factors, mainly courses of the weather [Jasińska & Kotecki, 1993]. A high nutritive value of legume seeds is restricted by a few anti-nutritive factors (*e.g.* trypsin inhibitors, tannins, phytic acid, flatulence-causing oligosaccharides) [Khattab & Arntfield, 2009]. They occur mainly in raw seeds, but also in seeds subjected to technological and culinary treatments. Culinary treatment of seeds usually involves two stages, *i.e.* soaking and cooking. The most popular method of soaking is to spill them over with water of ambient temperature, in a ratio of 1:4 and to leave them in that state for about 12 h. The alternative way of soaking can be "hot " soaking. The dry seeds are spilled over with boiling water, in volume ratio four times greater than the volume of seeds, and left at ambient temperature for about 2–3 h. The seeds soaked in that way are suitable for further thermal treatment.

The aim of this study was to assess the influence of different soaking and cooking methods on contents of selected nutrients (*i.e.* protein, fat, total and digestible carbohydrates, Ca, Mg, Na, and K) in legume seeds.

MATERIAL AND METHODS

The experimental material were dry legumes seeds, *i.e.* kidney bean and soya bean originating from the collection of Krakow's Plants and Seeds Horticulture POLAN LTD.

The technological treatment was conducted in two stages:

1. Soaking:
   - "cold" – traditional – spilling the seeds over with water of ambient temperature (ratio 1:4) and leaving them for 12 h,
   - "hot" – spilling the seeds over with hot water – temp. of about 95°C (ratio 1:4) and leaving them for 2 h,
2. Cooking (without addition of sodium chloride) to ready-to-eat softness with:
   - electric stove (with cast iron hotplate, Mastercook 5E1/0/4A type),

* Corresponding author: Tel.: +4812 662 48 29; fax: +4812 662 48 25; E-mail: *afilipiak-florkiewicz@ar.krakow.pl* (A. Filipiak-Florkiewicz)

- combined microwave oven (Panasonic NN-C703/C753 type),
- induction stove (with glass-ceramic hotplate, STALGLAST , BT-180K type).

The hydrothermal processes were conducted in duplicate. Determinations were made for: dry matter content by drying method [PN-ISO 712:2002]; protein content by Dumas method (TruSpec, Leco) according to PN-EN ISO 16 634–1:2008; fat content by extraction method in overcritical CO_2 state [TFE 2000, Leco]; ash content by burning in a muffle stove, according to PN-ISO 2171:1994; selected mineral components – Ca, Mg, Na, K – by atomic absorption spectrophotometer (Varian AA240FS, Varian), according to PN-EN ISO 6869:2002. The amount of digestible carbohydrates was calculated from the difference between the total carbohydrates content and dietary fibre content determined according to AOAC (Fibertech, Foss) [Kunachowicz *et al.,* 2005]. Because this work concerns only nutritional compounds of legume seeds, the dietary fibre levels are presented in a separate paper. All mentioned analyses were performed in triplicate after each type of soaking and cooking. There was also estimated the dynamics and magnitude of water absorption during soaking and the efficiency of cooking process (change of seeds mass expressed in percentages). There were compared also other parameters of the technological process, *i.e.* time, work consumption *etc*. Results obtained were expressed as means and standard deviation and were subjected to a statistical analysis (Statistica v. 7.0 software). The significance of differences between means was estimated with post hoc Duncan test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Soaking and cooking of soya bean and kidney bean seeds affected a decrease in dry matter content. The dry matter content in raw soya bean seeds was 90.5 g/100 g and in raw kidney bean seeds 81.9 g/100 g (Table 1). The "hot" soaked seeds of both legume species were characterised by lower dry matter content, reaching 38.1 g/100 g for soya bean and 38.3 g/100 g for kidney bean. The statistical analysis did not show any significant differences in dry matter contents of soya bean, for both methods of soaking. Such a dependency was, in turn, observed for kidney bean seeds. The "hot" soaked kidney bean was characterised by a significantly lower dry matter content (38.3 g/100 g) in comparison to the traditionally-soaked seeds (45.3 g/100 g). Among the cooked soya bean seeds the highest dry matter content was found in the electric stove-cooked seeds that had earlier been "cold" soaked (38.2 g/100 g), whereas the lowest one in the seeds cooked in an induction stove and soaked with both methods (36.3 g/100 g for "hot" soaked seeds and 36.1 g/100 g for "cold" soaked seeds), (Table 1). Also "cold" soaked and cooked in an electric stove kidney bean seeds contained the highest level of dry matter (41.1 g/100 g). The lowest content of dry matter was determined in "hot" soaked kidney bean seeds cooked in a combined microwave oven (34.7 g/100 g). Kalogeropoulos *et al.* [2010] reported the content of dry matter in cooked legume seeds at levels of 23.5–36.1 g/100 g. A research by Judprasong *et al*. [2006] showed that the loss of dry matter in legume seeds during cooking might reach 40%. The contribution of individual components in the total solids of soya bean was observed to change upon the hydrothermal processes applied. The soaking of soya seeds in hot water caused a significant increase in protein content (48.1 g/100 g), (Table 2). Also cooking of those seeds resulted in increased protein content (44.5–46.4 g/100 g) of dry matter in comparison to the dry seeds (37.2 g/100 g). In turn, the microwave cooking of soya bean was observed to significantly lower the content of that component in comparison to the "hot" soaked seeds. When analysing changes in protein content of dry matter of kidney bean seeds as a result of soaking, no significant differences were noticed in that component levels (22.5–23.2 g/100 g d.m.) in comparison to dry seeds (22.7 g/100 g d.m.). Among seeds submitted to thermal treatment the highest protein content was found in seeds cooked with an induction stove after former "hot" soaking (27.3 g/100 g d.m.), and the lowest content in seeds "cold" soaked and then cooked in a combined microwave oven (19.8 g/100 g d.m.) (Table 2). Many authors stated that soaking of kidney bean and also its cooking did not influence significantly protein content [Aguilera *et al.,* 2009; Khali & Mansour, 1995; Zia-ur Rehman & Shah, 2005]. Winiarska-Mieczan & Koczmara [2006] reported a relatively low increase in the total protein content of dry matter (by 6%) in raw kidney bean. It could be caused by solubilization of some easy hydrolysing components and their migration to water and also by enhanced activity of enzymes, *i.e.* lipases. The long-term soaking may also result in microbiological changes occurring in seeds, which is connected with the multiplication of microflora and may affect an increase in protein content. As shown by Winiarska-Mieczan & Koczmara [2006], the soaking of seeds for two days caused a decrease (by 1/7%) in protein concentration in kidney bean seeds in comparison to the seeds soaked for 1 day. The content of protein after 2 days of soaking in those seeds was significantly lower than in the raw seeds. A slight increase in protein content of seeds soaked for 1 day and then cooked was also reported by Pir-

TABLE 1. Influence of hydrothermal processes on dry matter content of soya bean and kidney bean (g/100 g).

Hydrothermal processing		Soya bean (g/100 g)	Kidney bean (g/100 g)
Raw material (dry seeds)		$90.5^{c}\pm0.14$	$81.9^{e}\pm0.32$
„Hot" soaked		$38.1^{b}\pm0.26$	$38.3^{c}\pm0.09$
„Cold" soaked		$38.2^{b}\pm0.21$	$45.3^{d}\pm0.34$
„Hot" soaked	electric stove cooking	$37.2^{ab}\pm1.39$	$38.6^{c}\pm0.33$
	combined microwave oven cooking	$36.9^{ab}\pm0.16$	$34.7^{a}\pm0.72$
	induction stove cooking	$36.3^{a}\pm0.62$	$38.9^{c}\pm0.55$
„Cold" soaked	electric stove cooking	$38.2^{b}\pm0.23$	$41.1^{d}\pm0.18$
	combined microwave oven cooking	$37.0^{ab}\pm0.06$	$39.2^{c}\pm0.13$
	induction stove cooking	$36.1^{a}\pm0.15$	$36.3^{b}\pm0.22$

Values in the same columns denoted with different letters: a,b,c,d,e differ statistically significantly at $p \leq 0.05$.

TABLE 2. Influence of hydrothermal processes on chemical composition of soya bean and kidney bean (g/100 g dry matter).

Hydrothermal processing		Protein		Fat		Ash		Total carbohydrates		Digestible carbohydrates	
		soya bean	kidney bean	soya bean	kidney bean	soya bean	kidney bean	soya bean	kidney bean	soya bean	kidney bean
Raw material (dry seeds)		37.2^{a}±0.1	22.7^{ab}±0.5	19.1^{a}±0.1	2.2^{bc}±0.1	6.5^{a}±0.0	4.6^{b}±0.0	37.2^{c}±0.74	70.5^{b}±0.12	15.5^{g}±0.1	47.5^{b}±2.3
„Hot" soaked		48.1^{c}±0.2	22.5^{ab}±1.1	19.9^{a}±0.2	1.7^{a}±0.1	8.4^{d}±0.1	5.2^{cd}±0.1	23.7^{a}±0.11	70.6^{b}±0.31	8.7^{f}±0.1	48.4^{b}±1.2
„Cold" soaked		38.4^{a}±0.5	23.2^{b}±1.2	19.7^{a}±0.3	1.9^{ab}±0.0	8.3^{d}±0.1	3.8^{a}±0.0	25.7^{b}±0.68	71.2^{bc}±0.68	4.7^{c}±0.0	57.1^{c}±2..6
„Hot" soaked	electric stove cooking	46.4^{bc}±1.0	22.7^{ab}±0.9	22.9^{b}±0.9	2.0^{b}±0.0	7.3^{bc}±0.0	5.2^{cd}±0.0	23.5^{a}±0.29	70.1^{b}±0.23	6.2^{d}±0.1	48.1^{b}±3.6
	combined microwave oven cooking	44.6^{b}±0.8	19.8^{a}±1.2	22.5^{b}±0.5	2.3^{c}±0.1	7.0^{ab}±0.1	5.5^{d}±0.1	28.5^{b}±0.03	64.9^{a}±1.06	7.4^{e}±0.2	41.1^{a}±2.4
	induction stove cooking	44.9^{bc}±0.3	27.3^{c}±0.8	19.8^{a}±0.4	2.0^{b}±0.1	7.4^{bc}±0.0	4.7^{b}±0.1	36.3^{c}±0.53	73.5^{c}±0.96	8.9^{f}±0.2	50.8^{bc}±2.0
„Cold" soaked	electric stove cooking	45.9^{bc}±0.5	23.8^{b}±0.6	24.1^{b}±0.9	1.6^{a}±0.0	6.8^{a}±0.1	3.7^{a}±0.0	23.2^{a}±0.28	70.8^{b}±0.56	0.7^{a}±0.1	55.1^{c}±1.3
	combined microwave oven cooking	44.5^{b}±0.2	23.6^{b}±0.5	22.7^{b}±0.1	1.6^{a}±0.0	7.0^{a}±0.2	3.8^{a}±0.0	25.7^{b}±0.91	71.0^{b}±0.29	2.6^{b}±0.0	58.4^{c}±3.5
	induction stove cooking	45.4^{bc}±0.3	23.9^{b}±1.2	23.7^{b}±0.3	1.9^{ab}±0.0	7.7^{c}±0.2	4.1^{ab}±0.0	23.5^{a}±0.15	70.1^{b}±0.36	0.9^{a}±0.0	48.1^{b}±4.5

Values in the same columns denoted with different letters: a,b,c,d,e f,g, differ statistically significantly at p≤0.05.

man & Stibilj [2001]. Observed by various authors different results concerning the influence of hydrothermal treatment on protein content in legumes seeds may be due to species and varietal differences and also to tillage conditions and different methods of hydrothermal treatment. The content of fat in dry matter of cooked soya bean seeds was growing significantly in comparison to dry and soaked seeds. The cooking of "cold" soaked kidney bean seeds did not influence changes in fat content of dry matter in comparison to "hot" soaked seeds. Significantly more fat was found in dry matter of "hot" soaked seeds cooked in a combined microwave oven or in raw material. The ash content of dry matter was significantly differentiated as affected by the method of thermal treatment. The content of ash in dry matter of not treated soya bean and kidney bean seeds was 6.5 g/100 g and 4.6 g/100 g, respectively. The average content of ash in raw kidney bean seeds was corresponding to values obtained by Winiarska-Mieczan & Koczmara [2006] and Berrios *et al.* [1999], who reported the content of ash to reach 44.4 g/kg and 4.65 g/100 g, respectively. In turn, Khali & Mansour [1995] and Korus *et al.* [2005] obtained a slightly lower ash content – 4.2 g/100 g d.m. Holse *et al.* [2010] when analysing 16 lots of beans, obtained ash levels of 2.5–4.6 g/100 g d.m. Similar results were presented by de Almeida Costa *et al.* [2006] and Khattab *et al.* [2009]. The experimental "hot" soaked legume seeds contained significantly higher levels of that component (29 and 13%). Such interchangeable tendency was not observed in the case of the traditional soaking method. The "cold" soaked soya bean seeds were characterised by a higher ash content (8.3 g/100 g) than the untreated seeds (6.5 g/100 g), whereas the traditionally-soaked kidney bean seeds had significantly lower ash content (3.8 g/100 g) than the dry kidney bean (4.6 g/100 g). As expected, during cooking, the diffusion of some mineral compounds from seeds to a solution occurred, which caused the loss of ash. Its decrease, in soya bean seeds because of their cooking (irrespective of the technique applied), was significant. Cooking the "cold" soaked kidney bean seeds did not cause any significant changes in ash content in comparison to the "hot" soaked seeds. Khatoon & Prakash [2006] noticed that the cooking process may reduce ash content by 7–13% in comparison to dry seeds. The greater loss of ash content (even by 50%) as a result of seeds cooking was obtained by Pysz *et al.* [2001]. A research concerning the effect of hydrothermal treatment on ash content was also conducted by Khali & Mansour [1995]. The authors did not show any significant differences in its content in seeds submitted to processes of cooking, sterilization and sprouting. Krupa & Soral-Śmietana [2005] showed that the average content of mineral compounds in seeds of the analysed kidney bean varieties (Aura & Eureka) reached *ca.* 4% d.m. As a result of water-cooking treatment applied (sterilization and microoven) a small decrease was observed in the content of total mineral compounds. The conducted hydrothermal treatment of soya bean seeds caused a decrease in the total carbohydrates (average at about 30%) and in digestible carbohydrates (68%). The lowest losses of those components were observed for seeds cooked with an induction stove with initial "hot" soaking, *i.e.* 3% and 43%, respectively. Such obvious changes were not observed for kidney bean seeds. In kidney

TABLE 3. Influence of hydrothermal processes on calcium, magnesium, potassium and sodium content of soya bean and kidney bean (mg/100 g dry matter).

Hydrothermal processing		Ca		Mg		K		Na	
		soya bean	kidney bean	soya bean	kidney bean	soya bean	kidney bean	soya bean	kidney bean
Raw material (dry seeds)		212.2^{b}±9.3	227.1^{c}±15.6	234.9^{d}±12.3	204.1^{e}±10.5	1660.4^{g}±53.6	1929.9^{i}±56.8	4.8^{a}±0.1	4.5^{b}±0.0
„Hot" soaked		280.3^{c}±8.5	206.0^{b}±12.5	206.0^{c}±16.2	185.2^{de}±9.5	1135.0^{e}±69.3	1489.0^{g}±26.4	7.7^{ef}±0.2	9.5^{h}±0.2
„Cold" soaked		263.0^{c}±3.9	414.1^{e}±16.5	221.5^{cd}±11.2	168.2^{bc}±8.4	1367.5^{f}±50.2	743.3^{b}±35.4	5.9^{b}±0.1	8.7^{g}±0.2
„Hot" soaked	electric stove cooking	490.9^{de}±11.2	229.3^{c}±9.5	174.1^{b}±9.6	130.5^{ab}±5.4	440.4^{a}±49.3	997.3^{d}±41.7	8.0^{fg}±0.1	4.8^{c}±0.0
	combined microwave oven cooking	471.4^{d}±10.5	297.8^{d}±8.2	190.0^{bc}±8.2	192.2^{de}±11.5	680.2^{c}±36.5	1427.8^{f}±50.8	6.7^{c}±0.1	3.2^{a}±0.0
	induction stove cooking	516.8^{e}±9.1	172.6^{a}±11.6	179.7^{b}±14.9	115.9^{a}±6.5	606.5^{b}±51.2	869.7^{c}±19.7	7.3^{de}±0.2	6.3^{e}±0.1
„Cold" soaked	electric stove cooking	277.7^{c}±12.5	417.2^{e}±20.8	164.4^{a}±6.9	175.6^{cd}±12.4	833.6^{d}±52.4	661.9^{a}±23.5	7.1^{d}0.1±	6.8^{f}±0.1
	combined microwave oven cooking	173.5^{a}±14.2	236.8^{c}±9.6	176.9^{b}±8.5	164.8^{bc}±11.7	1762.7^{h}±89.5	1540.7^{h}±69.8	8.2^{g}±0.2	5.6^{d}±0.1
	induction stove cooking	258.5^{c}±9.6	239.0^{c}±8.2	152.4^{a}±9.8	146.5^{b}±8.6	1339.9^{f}±56.8	1288.9^{e}±71.2	7.3^{de}±0.1	3.4^{a}±0.0

Values in the same columns denoted with different letters: a,b,c,d,e f,g,h i, differ statistically significantly at p≤0.05.

TABLE 4. Time and efficiency of soaking and cooking processes of soya bean and kidney bean.

Hydrothermal processing		Time of process (min)		Total time of technological process (soaking + cooking) (min)		Process efficiency (%)	
		soya bean	kidney bean	soya bean	kidney bean	soya bean	kidney bean
„Hot" soaked		120^{d}	120^{d}			223.5^{e}	196.2^{f}
„Cold" soaked		720^{e}	720^{e}			222.4^{c}	198.0^{f}
„Hot" soaked	electric stove cooking	82^{c}	60^{c}	202^{b}	180^{b}	104.0^{ab}	112.0^{de}
	combined microwave oven cooking	50^{a}	40^{a}	170^{a}	160^{a}	104.0^{ab}	96.0^{a}
	induction stove cooking	63^{b}	45^{a}	183^{ab}	165^{a}	118.0^{b}	116.0^{e}
„Cold" soaked	electric stove cooking	90^{c}	60^{c}	810^{d}	780^{c}	100.0^{a}	110.7^{cd}
	combined microwave oven cooking	50^{a}	40^{a}	770^{c}	760^{c}	104.0^{ab}	113.8^{b}
	induction stove cooking	64^{b}	55^{b}	784^{c}	775^{c}	104.0^{ab}	117.1^{bc}

Values in the same columns denoted with different letters: a,b,c,d,e, f, differ statistically significantly at p≤0.05.

bean seeds "hot" soaked and then cooked with an induction stove, the content of total carbohydrates of dry matter was noticed to increase by 4%. The greatest increase in digestible carbohydrates in dry matter was observed during "cold" soaking of the seeds (20%). A research by Aguilera *et al.* [2009] showed a decrease in the total carbohydrates in dry matter of legume seeds during their soaking and cooking.

The dry soya bean and kidney bean seeds contained considerable amounts of calcium 212.2 mg/100 g and 227.1 mg/100 g, respectively (Table 3). The results obtained are consistent with the findings of Khalil & Mansour [1995], Ghavidel & Prakash [2007] and Sandberg [2002], who reported calcium content to reach 220, 222 and 197 mg/100 g of dry matter, re spectively. A lower calcium content, accounting for 163 mg/100 g of dry seeds of White Kidney, was reported by Kunachowicz *et al.* [2005]. Much lower content of that element was found by Alonso *et al.* [2001], Viadel *et al.* [2006] and Pirman & Stibilj [2001]. Whereas ElMaki *et al.* [2007] and Sangronis & Machado [2007] reported significantly higher contents of calcium in dry kidney bean seeds, *i.e.* 350 mg/100 g of dry matter on average. The contents of magnesium and potassium in not treated soya bean seeds were also high and reached 234.9 and 1660 mg/100 g, respectively. Also the kidney bean seeds were characterised by a high content of those minerals (204.1 and 1929.9 mg/100 g). When analysing changes in the contents of the assessed mineral components during cooking of soya bean seeds, an increase was noted in contents of calcium and sodium (with exception of "cold" soaked and microwaved seeds) in dry matter with parallel decrease in magnesium and potassium levels. Estimation of hydrothermal treatment influence on changes in the contents of mineral components enabled concluding that the "cold" soaked seeds and seeds cooked with all methods (after former "cold" soaking) were characterised by higher calcium content than the seeds "hot" soaked and coked. ElMaki *et al.* [2007] determined the influence of soaking and cooking on contents of mineral compounds in three varieties of kidney bean showed that the seeds soaked for 1, 2, and 3 days were characterised by continuous losses of calcium, magnesium, potassium and sodium, with the losses being greater along with the longer soaking time. The cooking of soaked seeds caused further loss of calcium. According to Khali & Mansour [1995] and Pirman & Stibilj [2001], hydrothermal treatment reduced significantly the contents of the examined macroelements in legume seeds. All applied techniques of soya bean and kidney bean cooking affected a decrease in digestible carbohydrates content in comparison to dry seeds and "hot" soaked seeds (with exception of soya bean "hot" soaked and cooked with an induction stove).

Further analyses involved the comparison of time and efficiency of different hydrothermal treatments of soya bean and kidney bean seeds. Analysis of the influence of different soaking and cooking methods on the time and yield of the applied process demonstrated that the cooking of both "cold" and "hot" soaked soya bean with an induction stove and with a combined microwave oven significantly shortened the time of the culinary process (50–64 min) in comparison to cooking with an electric stove (82–90 min), (Table 4). The total time of the technological treatment for "hot" soaked seeds was shorter (despite the cooking technique) in comparison to the "cold" soaked seeds. The statistical analysis did not show any significant differences in the process efficiency as affected by the soaking method for both soya bean (222.4–223.5%) and kidney bean seeds (196.2–198.0%), (Table 4). The cooking of kidney bean seeds formerly "hot" soaked was characterised by a higher yield in comparison to the cooking of seeds with a combined microwave oven (irrespective of the method of their soaking).

CONCLUSIONS

1. Dry matter of soya bean and kidney bean seeds was characterised by high contents of basic nutritive compounds.

2. The soaking and cooking of seeds (irrespective of species) increased contents of protein, fat, calcium and sodium in dry matter and decreased those of digestible carbohydrates, potassium and magnesium.

3. The favorable method of soaking of kidney bean turned out to be "hot" soaking, which caused smaller losses of nutrients.

4. Cooking soya bean and kidney bean seeds with electrical or induction stove facilitated better protein preservation.

5. The shorter total time of technological treatment including soaking and cooking was typical of the "hot" soaked soya and kidney bean seeds.

6. The application of modern hydrothermal treatment methods, *i.e.* "hot" soaking, and the use of an induction stove can be a successive alternative in preparation of meals from legumes seeds.

7. Taking into account all analysed aspects of the technological process and changes in the composition of soya and kidney bean seeds cooked in a combined microwave oven it has been concluded that it is not the proper method for hydrothermal treatment of those beans.

REFERENCES

1. Aguilera Y., Martin-Cabrejas M. A., Benitez V., Mollá E., López-Andréu F. J., Esteban R. M., Changes in carbohydrate fraction during dehydration process of common legumes. J. Food Comp. Anal., 2009, 22, 678–683.
2. Alonso R., Rubio L.A., Muzquiz M., Marzo F., The effect of extrusion cooking on mineral bioavailability in pea and kidney beans seed meals. Anim. Feed Sci. Technol., 2001, 94, 1–13.
3. Berrios J.J., Swanson B.G., Cheong W.A., Physico-chemical characterization of stored black beans (*Phaseolus vulgaris* L.). Food Res. Int., 1999, 32, 669–676.
4. de Almeida Costa G.E., da Silva Queiroz-Monici K., Reis A.M.P.M., de Oliveira A.C., Chemical composition, dietary fibre and resistant starch contents of raw and cooked pea, common bean, chickpea and lentil legumes. Food Chem., 2006, 94, 327–330.
5. ElMaki H.B., AbdelRahaman S.M., Idris W.H., Hassan A.B., Babiker E.E., ElTinay A.H., Content of antinutritional factors and HCl-extractability of minerals from white bean (*Phaseolus vulgaris*) cultivars: Influence of soaking and/or cooking. Food Chem., 2007, 100, 362–368.
6. Fıratlıgil-Durmuş E., Šárka E., Bubnik Z., Schejbal M., Kadlec P., Size properties of legume seeds of different varieties using image analysis. J. Food Eng., 2010, 99, 445–451.
7. Ghavidel R.A., Prakash J., The impact of germination and dehuling on nutrients, antinutrients, *in vitro* iron and calcium bioavailability and *in vitro* starch and protein digestibility of some legume seeds. Food Sci. Technol./LWT, 2007, 40, 1292–1299.
8. Holse M., Husted S., Hansen A., Chemical composition of marama bean (*Tylosema esculentum*) – A wild African bean with unexploited potential. J. Food Comp. Anal., 2010, 23, 648–657.
9. Iqbal A., Khalil I.A., Ateeq N., Kha, M.S., Nutritional quality of important food legumes. Food Chem., 2006, 97, 331–335.
10. Jasiński Z., Kotecki A., Szczegółowa uprawa roślin. 1999, Wydawnictwo Akademii Rolniczej, Wrocław, Poland, pp. 48–62 (in Polish).
11. Judprasong K., Charoenkiatkul S., Sungpuag P., Vasanachitt K., Nakjamanong Y., Total and soluble oxalate contents in Thai vegetables, cereal grains and legume seeds and their changes after cooking. J. Food Comp. Anal., 2006, 19, 340–347.
12. Kalogeropoulos N., Chiou A., Ioannou M., Karathanos V. T., Hassaidou M., Andrikopoulos N. K., Nutritional evaluation and bioactive microconstituents (phytosterols, tocopherols, polyphenols, triterpenic acids) in cooked dry legumes usually consumed in the Mediterranean countries. Food Chem., 2010, 121, 682–690.
13. Khalil A.H., Mansour E.H., The effect of cooking, autoclaving and germination on the nutritional quality of faba beans. Food Chem., 1995, 54, 177–182.
14. Khatoon N., Prakash J., Nutrient retention in microwave cooked germinated legumes. Food Chem., 2006, 97, 115–121.
15. Khattab R.Y., Arntfield S.D., Nutritional quality of legume seeds as affected by some physical treatments, Part 2. Antinutritional factors. Food Sci. Technol./LWT, 2009, 42, 1113–1118.
16. Khattab R.Y., Arntfield S.D., Nyachoti C.M., Nutritional quality of legume seeds as affected by some physical treatments, Part 1: Protein quality evaluation. Food Sci. Technol./LWT, 2009, 42, 1107–1112.
17. Kołota E., Orłowski M., Biesiada A., Warzywnictwo. 2007, Wydawnictwo Uniwersytetu Przyrodniczego, Wrocław, Poland, pp. 405–413 (in Polish).

18. Korus J., Gumul D., Achremowicz B., Chemical composition of five new kidney bean (*Phaseolus vulgaris* L.) cultivars. Żywność, 2005, 45, 81–86 (in Polish, English abstract).
19. Krupa U., Soral-Śmietana M., Bean seeds – a source of nutritious and non-nutritious macro-components. Żywność, 2003, 35, Suppl., 98–108 (in Polish, English abstract).
20. Kunachowicz H., Nadolna I., Przygoda B., Iwanow K., Food Composition Tables. 2005, PZWL, Warsaw, Poland, pp. 236–243.
21. Pirman T., Stibilij V., Chemical composition of 3 varieties of common beans (*Phaseolus vulgaris* L.) and lentil (*Lens esculenta var. Puyensis*). Żyw. Człow. Metab., 2001, 28, 187–197.
22. Polish Standard, PN-EN ISO -16634–1:2008. Food products – Determination of the total nitrogen content bt combustion according to the Dumas principle and calculation of the crude protein content – Part 1. Oilseeds and animal feeding stuffs (ISO 16634–1:2008) (in Polish).
23. Polish Standard, PN-EN ISO 6869:2002. Animal feeding stuffs – Determination of the contents of calcium, copper, iron, magnesium, manganese, potassium, sodium and zinc – Method using atomic absorption spectrometry (in Polish).
24. Polish Standard, PN-ISO -712:2002. Cereals and cereals products – Determination of moisture content – Routine reference method (in Polish).
25. Polish Standard, PN-ISO 2171:1994. Cereals and milled cereal products – Determination of total ash (in Polish).
26. Pysz M., Bieżanowska R., Pisulewski P.M., The effect of thermal processing and germination on chemical composition, non-nutritional factors, and nutritive value of pea and soybean seeds. Żywność, 2001, 26, 85–92 (in Polish, English abstract).
27. Sandberg A.S., Bioavailability of minerals in legumes. Br. J. Nutr., 2002, 88, Suppl. 3, 281–285.
28. Sangronis E., Machado C.A., Influence of germination on the nutritional quality of *Phaseolus vulgaris* and *Cajanus cajan*. Food Sci. Technol./LWT, 2007, 40, 116–120.
29. TFE 2000, Leco, Manual (method applied in accordance with instruction given by apparatus producer) (in Polish).
30. Viadel B., Barberá R., Farré R., Effect of cooking and legume species upon calcium, iron, and zinc uptake by Caco-2 cells. J. Trace Elem. Med. Biol., 2006, 20, 115–120.
31. Winiarska-Mieczan A., Koczmara K., Effect of soaking on the nutritional value of kidney bean (*Phaseolus Vulgaris*), soybean (*Glycine Max*) and lentil (*Lens Culinaris*) seeds. Acta Agrophysica, 2006, 8, 537–543 (in Polish, English abstract).
32. Ximenez-Embun P., Alonso I., Madrid-Albarrany Y., Camara C., Establishment of selenium uptake and species distribution in lupine, Indian mustard and sunflower plants. J. Agric. Food Chem., 2004, 52, 832–838.
33. Zia-ur Rehman, Shah W.H., Thermal heat processing effects on antinutrients, protein and starch digestibility of food legumes. Food Chem., 2005, 91, 327–331.

Received March 2010. Revision received April and accepted August 2010.