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Original Article

Nutritional composition of chickpea (*Cicer arietinum* L.) as affected by microwave cooking and other traditional cooking methods

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Abstract

The effects of microwave cooking and other traditional cooking methods such as boiling and autoclaving on the nutritional composition and anti-nutritional factors of chickpeas (*Cicer arietinum* L.) were studied. Cooking treatments caused significant ($P<0.05$) decreases in fat, total ash, carbohydrate fractions (reducing sugars, sucrose, raffinose and stachyose, while verbascose was completely eliminated after cooking treatments), antinutritional factors (trypsin inhibitor, haemagglutinin activity, tannins, saponins and phytic acid), minerals and B-vitamins. Cooking treatments decreased the concentrations of lysine, tryptophan, total aromatic and sulfur-containing amino acids. However, cooked chickpeas were still higher in lysine, isoleucine and total aromatic amino acid contents than the FAO/WHO reference. The losses in B-vitamins and minerals in chickpeas cooked by microwaving were smaller than those cooked by boiling and autoclaving. In-vitro protein digestibility, protein efficiency ratio and essential amino acid index were improved by all cooking treatments. The chemical score and limiting amino acid of chickpeas subjected to the various cooking treatments varied considerably, depending on the type of treatment. Based on these results, microwave cooking is recommended for chickpea preparation, not only for improving nutritional quality (by reducing the level of antinutritional and flatulence factors as well as increasing in-vitro protein digestibility and retention rates of both B-vitamins and minerals), but also for reducing cooking time.

Keywords: Chickpea seeds; Boiling; Autoclaving; Microwave cooking; Antinutritional factors; Nutritional composition

1. Introduction

Chickpeas (*Cicer arietinum* L.) are one of the oldest and most widely consumed legumes in the world, particularly in tropical and subtropical areas. Kabuli chickpea seeds are grown mainly in the Mediterranean area, the Near East, Central Asia and America (Singh et al., 1991). The seeds are large in size, salmon-white in color, and contain high levels of carbohydrate (41.10–47.42%) and protein (21.70–23.40%). Starch is the major carbohydrate fraction, representing about 83.9% of the total carbohydrates (Rincón et al., 1998).

Generally, legumes have been reported to have low nutritive value because of low amounts of sulfur-containing amino acids, low protein digestibility and the presence of anti-nutritional factors. Legumes are usually cooked before being used in the human diet. This improves the protein quality by destruction or inactivation of the heat labile anti-nutritional factors (Chau et al., 1997; Wang et al., 1997; Vijayakumari et al., 1998). However, cooking causes considerable losses in soluble solids, especially vitamins and minerals (Barampama and Simard, 1995).

In Egypt, chickpea seeds are usually consumed at the raw green and tender stage (unripe stage), called *Malana*, or in the form of mature dry seeds after parching as a popular snack food. The dry seeds can also be consumed as whole or decorticated after cooking and processing in different ways. In addition to these uses, the flour of decorticated chickpea seeds is used in several dishes and as a supplement in weaning food mixes, bread and biscuits (van der Maesen, 1972). The chemical composition and oligosaccharides of raw and germinated chickpea seeds were reviewed by Singh et al. (1991). The effect of cooking on the constituents of chickpea seeds has been reported by Attia et al. (1994). Increasing the time and temperature of

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processing has been reported to reduce the nutritive value and available lysine of legumes (Chau et al., 1997; Kon and Sanshuck, 1981).

Cooking of chickpea by microwave has not been extensively studied but it has been shown to reduce antinutritive agents in soybean (Rajko et al., 1997) and have positive effects on protein digestibility (Khatoon and Prakash, 2004) in eight whole legumes. A study on chickpea cooked by microwave is thus needed to know whether this treatment could improve nutritional quality and eventually replace traditional cooking methods, which are not only costly in energy but also cause important losses in soluble solids. This experimental study was therefore carried out to determine the effect of boiling, autoclaving and microwave cooking on the nutritional composition and nutritive value of chickpea seeds.

2. Materials and methods

2.1. Materials

One batch (10 kg) of local chickpea seeds (*Cicer arietinum* L.) were purchased from the local market (Menofiya Governorate, Egypt) during the summer season (August) of 2003. The seeds were hand-sorted to remove wrinkled, moldy seeds and foreign material, then stored in polyethylene bags in the refrigerator (4 °C ± 1) until used.

2.2. Processing: cooking treatments

Chickpea seeds were soaked in distilled water (1:10, w/v) for 12 h at room temperature (~25 °C). The soaked seeds were drained and rinsed three times with 600 mL distilled water, then cooked by the methods described below:

- *Boiling*: The rinsed soaked seeds were cooked in tap water (100 °C) in the ratio of 1:10 (w/v) on a hot plate until they became soft when felt between the fingers (90 min).
- *Autoclaving*: The rinsed soaked seeds were autoclaved using vertical autoclave (Systec, Model Systec V-150, Wettenberg, Germany) at 15 lb pressure (121 °C) in tap water (1:10, w/v) until 50% of the seeds were soft when felt between the fingers (35 min).
- *Microwave cooking*: The rinsed soaked seeds were placed in a glass beaker (Type Birex, England) with tap water (1:10, w/v), then cooked in a microwave oven (Goldstar, Model ER-50540, 2450 MHz, Egypt) on high for 15 min (about 50% of the seeds were soft when felt between the fingers). The cooked seeds were dried in an electric air draught oven (VEB MLW Medizinische, Geräte, Berlin, Germany) at 50 °C for 20 h.

Cooking treatments were replicated three times. Raw and processed chickpea seeds were ground in an electric mill equipped with stainless steel blades (Braun, Model 1021, Germany) to pass through a 60 mesh (British standard screen) nylon sieve.

2.3. Analytical methods

Chemical composition. Moisture (14.004), fat (14.018), ash (14.006), crude fiber (14.020) and protein $N \times 6.25$ (14.026) were determined as described by AOAC (1990). The crude fiber was determined in the portion of the moisture and fat-free sample that remained after digestion with weak acid and base; it is of low digestibility and composed of cellulose, hemi-cellulose and some lignins. Non-protein nitrogen was measured as soluble nitrogen in 30% trichloro-acetic acid using method of Patel et al. (1990). The content of reducing sugars was determined in the 70% ethanol extracts by the phenol–sulphuric acid method used by Dubois et al. (1956). Starch content was determined as reducing sugars after complete acid hydrolysis. Flatulence factors (stachyose, raffinose and verbascose) and sucrose were determined according to Tanaka et al. (1975) using thin layer chromatography.

B-vitamins. B-vitamins were determined microbiologically using *Lactobacillus plantarum* ATCC 8014 for niacin, *Lactobacillus casei* ATCC 7469 for riboflavin, *Lactobacillus fermentum* ATCC 9338 for thiamin and *Saccharomyces calsbergensis* (obtained from National Research Center, Cairo, Egypt) for pyridoxine, according to the methods described by György and Pearson (1967).

Minerals. Minerals were determined after wet ashing by concentrated nitric acid and perchloric acid (1:1, v/v). Na, K and Ca were determined by flame photometer (Corning 410, England), while Mg, Mn, Zn, Fe and Cu were determined using an atomic absorption spectrophotometer (Perkin–Elmer, Model 2380, USA). Phosphorus was estimated photometrically via the phosphorus molybdate complex described by Taussky and Shorr (1953).

Antinutritional factors. Total tannins (9.098) were determined colorimetrically as described in AOAC (1990). Phytic acid was determined according to the method of Wheeler and Ferrel (1971). Trypsin inhibitor activity was determined according to the method of Kakade et al. (1969) using benzoyl-DL-arginine-P-nitroanalide hydrochloric as the substrate. Haemagglutinin activity was estimated according to the method of Liener and Hill (1953). Saponin content was assayed by the hemolysis test described by Rodriguez et al. (1986) using red cells from sheep blood.

Amino acids. Amino acids were determined using a Mikrotechna AAA 881 automatic amino acid analyzer (Model 118/119 CL, Czech Republic) according to method of Moore and Stein (1963). Hydrolysis of the samples was performed in the presence of 6 M HCl at 110 °C for 24 h under a nitrogen atmosphere. Sulfur-containing amino acids were determined after performic acid oxidation. Tryptophan was chemically determined by the method of Miller (1967).

In-vitro protein digestibility (IVPD). IVPD was determined as described by Salgó et al. (1984) measuring the change in the sample solution pH after incubation at 37 °C with trypsin-pancreatin enzyme mixture for 10 min.

Biological values (BV). Biological values of raw and treated chickpea seed flour were determined on the basis of amino acid profile. Chemical score of amino acids was calculated using the FAO/WHO (1973) reference pattern. Essential Amino Acid Index (EAAI) was calculated according to Oser (1959) using the amino acid composition of the whole egg protein published by Hidvégi and Békés (1984). Protein efficiency ratio (PER) was estimated according using the regression equation proposed by Alsmeyer et al. (1974):

PER = −0.468 + 0.454 (leucine)−0.105 (tyrosine).

Statistical analysis. Results are expressed as the mean value ± standard deviation (S.D.) of three replicates (each replicate was presented by a mean of three determinations), except for the minerals and amino acid contents, which were determined in duplicate. Data were statistically analyzed using analysis of variance and least significant difference using SAS (1985). Significant differences were determined at the $P<0.05$ level.

3. Results and discussion

3.1. Chemical composition

Chemical compositions of raw and treated chickpea seeds are presented in Table 1. No significant ($P>0.05$) differences in total protein and moisture contents were observed between cooked treatments of chickpea seeds. These observations are in agreement with those reported by Barampama and Simard (1995) for cooked common beans (*Phaseolus vulgaris*). Also, Khatoon and Prakash (2004) reported that microwave cooking and pressure cooking do not affect the nutrient composition of eight legumes. Cooking treatments significantly ($P<0.05$) decreased the non-protein nitrogen, ash and fat contents. These decreases might be attributed to their diffusion into cooking water. Crude fiber was significantly ($P<0.05$) increased by cooking treatments. This increase could have been due to protein-fiber complexes (Bressani, 1993) formed after possible chemical modification induced by the soaking and cooking of dry seeds.

3.2. Carbohydrate fractions

Table 2 shows carbohydrate fractions of raw and treated chickpea seeds. Reducing sugars, sucrose, raffinose and stachyose were significantly ($P<0.05$) reduced, while verbascose was completely eliminated after cooking treatments. These reductions are presumably due to their diffusion into cooking water. No publications were found regarding the effect of microwave cooking on the flatulence factors (raffinose, stachyose and verbascose) content of legumes. These observations are in agreement with that reported by Khalil and Mansour (1995) for faba bean cooked by boiling and autoclaving.

3.3. Antinutritional factors

The antinutritional factors of raw and treated chickpea seeds are shown in Table 3. Trypsin inhibitor activity was significantly ($P<0.05$) decreased by cooking treatments. The highest reduction was noted after autoclaving

Table 1
Effect of different cooking methods on the chemical composition of chickpea seeds (g/100 g dry weight basis)

Treatment	g/100 g-dry weight basis					Moisture
	Total protein	Non-protein nitrogen	Ash	Fat	Crude fiber	
Raw	$23.64^a \pm 0.50$	$1.82^b \pm 0.10$	$3.72^b \pm 0.04$	$6.48^b \pm 0.08$	$3.82^a \pm 0.13$	$10.35^a \pm 0.31$
Boiling	$23.21^a \pm 0.36$	$1.42^a \pm 0.12$	$3.52^a \pm 0.07$	$6.22^a \pm 0.09$	$4.62^b \pm 0.12$	$10.55^a \pm 0.29$
Autoclaving	$23.15^a \pm 0.47$	$1.38^a \pm 0.07$	$3.56^a \pm 0.06$	$6.17^a \pm 0.06$	$4.96^c \pm 0.10$	$10.48^a \pm 0.33$
Microwave cooking	$23.16^a \pm 0.50$	$1.51^a \pm 0.10$	$3.51^a \pm 0.10$	$6.21^a \pm 0.07$	$4.82^{bc} \pm 0.12$	$10.39^a \pm 0.35$

Means in the same column with different letters are significantly ($P<0.05$) different.
Means ± standard deviation of three determinations.

Table 2
Effect of different cooking methods on the carbohydrate fractions of chickpea seeds (g/100 g dry weight basis)

Treatment	Reducing sugars	Sucrose	Raffinose	Stachyose	Verbascose	Starch
Raw	$0.97^b \pm 0.04$	$1.89^b \pm 0.08$	$1.45^b \pm 0.07$	$2.56^b \pm 0.08$	$0.19^b \pm 0.06$	$36.91^a \pm 0.60$
Boiling	$0.60^a \pm 0.05$	$1.23^a \pm 0.08$	$0.76^a \pm 0.05$	$1.52^a \pm 0.07$	$0.00^a \pm 0.00$	$36.51^a \pm 0.40$
Autoclaving	$0.63^a \pm 0.04$	$1.19^a \pm 0.11$	$0.81^a \pm 0.09$	$1.46^a \pm 0.06$	$0.00^a \pm 0.00$	$36.69^a \pm 0.29$
Microwave cooking	$0.67^a \pm 0.05$	$1.36^a \pm 0.11$	$0.71^a \pm 0.08$	$1.47^a \pm 0.07$	$0.00^a \pm 0.00$	$36.81^a \pm 0.50$

Means in the same column with different letters are significantly ($P<0.05$) different.
Means ± standard deviation of three determinations.

Table 3
Effect of different cooking methods on the antinutritional factors of chickpea seeds (dry weight basis)

Treatment	Trypsin inhibitor		Haemagglutinin activity		Tannins		Phytic acid		Saponin	
	TIU/mg protein	Reduction (%)	HU/mg sample	Reduction (%)	mg/g sample	Reduction (%)	mg/g sample	Reduction (%)	mg/g sample	Reduction (%)
Raw	$11.90^{d}\pm0.10$	00.00	$6.22^{b}\pm0.22$	00.00	$4.85^{b}\pm0.05$	00.00	$1.21^{b}\pm0.09$	00.0.0	$0.91^{b}\pm0.10$	00.00
Boiling	$2.11^{b}\pm0.09$	82.27	$0.00^{a}\pm0.00$	100	$2.52^{a}\pm0.07$	48.04	$0.86^{a}\pm0.06$	28.93	$0.44^{a}\pm0.08$	51.65
Autoclaving	$1.92^{a}\pm0.10$	83.87	$0.00^{a}\pm0.00$	100	$2.42^{a}\pm0.10$	50.10	$0.71^{a}\pm0.08$	41.32	$0.51^{a}\pm0.06$	43.97
Microwave cooking	$2.32^{c}\pm0.08$	80.50	$0.00^{a}\pm0.00$	100	$2.50^{a}\pm0.09$	48.45	$0.75^{a}\pm0.05$	38.02	$0.48^{a}\pm0.07$	47.25

Means in the same column with different letters are significantly ($P<0.05$) different.
Means ± standard deviation of three determinations.
*TIU = Trypsin inhibited unit.
**HU = Haemagglutinin unit.

(83.87%), followed by boiling (82.27%) and microwave cooking (80.50%). Wang et al. (1997) reported that steam blanching of cowpea resulted in higher reduction in trypsin inhibitor activity than using water blanching. However, Hernandez-Infante et al. (1998) reported that microwave cooking destroyed trypsin inhibitors to a degree similar to that observed in six legumes cooked using the conventional method.

Haemagglutinin activity was completely destroyed by cooking treatments. Khalil and Mansour (1995) reported that boiling and autoclaving of faba bean seeds completely eliminated haemagglutinin activity. Also, Hernandez-Infante et al. (1998) reported that microwave cooking of common beans failed to destroy haemagglutinin.

Tannins (48.04–50.10%), phytic acid (28.93–41.32%) and saponins (43.96–51.65%) in chickpeas were significantly ($P<0.05$) reduced by cooking. Similar results were obtained by Vijayakumari et al. (1998) for cooked seeds of *Vigna aconitifolia* and *Vigna sinensis*.

3.4. Vitamins

The B-vitamin contents in raw and treated chickpea seeds are presented in Table 4. Riboflavin, thiamin, niacin and pyridoxine in chickpea seeds were significantly ($P<0.05$) reduced by cooking treatments. These losses were probably due to a combination of leaching and chemical destruction. The losses by microwave cooking were smaller ($P<0.05$) than those obtained with boiling and autoclaving. The improvement in vitamin retention by microwave cooking may have been the result of shorter cooking time compared to boiling and autoclaving. The sensitivity of vitamins to loss from cooking was, in descending order: pyridoxine, riboflavin, thiamin and niacin. Similar results were obtained by Salama and Ragab (1997) for cooked kidney beans and carrot. Boiling resulted in a greater loss for each vitamin compared to the other cooking treatments. Uherova et al. (1993) reported that conventional and microwave cooking caused a high loss of thiamin, riboflavin and ascorbic acid in all vegetables studied, but microwave cooking and autoclaving improved the retention of these vitamins compared to boiling. Khatoon and Prakash (2004) reported that microwave cooking and pressure cooking decreased the thiamin content of eight legumes.

3.5. Minerals

Mineral contents of raw and cooked chickpea seeds are presented in Table 5. The minerals leached from the chickpea seeds into the water at different rates during cooking treatments. However, microwave cooking resulted in the greatest retention of all minerals, followed by autoclaving, then boiling. Haytowitz and Matthews (1983) reported that cooking in boiling water caused great losses of K (24%), Cu (15%) and Fe (8%). Longe (1983) reported losses of 31% Cu and 22% Mg from mature cowpeas when

Table 4
Effect of different cooking methods on the B- vitamin contents of chickpea seeds (μg/100 g dry weight basis)

Treatment	Riboflavin		Thiamin		Niacin		Pyridoxine	
	μg/100 g	Retention (%)	μg/100 g	Retention (%)	μg/100 g	Retention (%)	μg/100 g	Retention (%)
Raw	$173.33^{c} \pm 6.66$	100	$453.33^{c} \pm 6.51$	100	$1602.67^{d} \pm 12.22$	100	$466.33^{d} \pm 7.52$	100
Boiling	$84.00^{a} \pm 1.73$	48.46	$153.33^{a} \pm 7.37$	33.82	$69.33^{a} \pm 3.51$	4.33	$266.67^{a} \pm 5.71$	57.19
Autoclaving	$90.33^{ab} \pm 7.51$	52.12	$161.00^{a} \pm 6.25$	35.51	$82.33^{b} \pm 3.51$	5.14	$306.33^{b} \pm 6.17$	65.69
Microwave cooking	$101.33^{b} \pm 3.79$	58.46	$192.00^{b} \pm 8.19$	42.35	$223.33^{c} \pm 2.89$	13.94	$375.00^{c} \pm 6.08$	80.42

Means in the same column with different letters are significantly ($P<0.05$) different.
Means $\pm$ standard deviation of three determinations.

Table 5
Effect of different cooking methods on selected mineral contents of chickpea seeds (mg/100 g dry weight basis)

Treatment	Macro-elements					Micro-elements			
	Na	K	Ca	Mg	P	Mn	Zn	Cu	Fe
Raw	121	870	176	176	226	2.11	4.32	1.10	7.72
Boiling	114	341	124	165	195	1.80	3.42	0.73	6.81
Autoclaving	118	407	131	171	208	1.90	3.89	0.81	7.10
Microwave cooking	118	432	131	173	216	2.03	3.95	0.94	7.30

Average of two determinations.

cooked by autoclaving. Salama and Ragab (1997) reported that kidney beans and carrot cooked by conventional and microwave methods had different retention rates of minerals.

3.6. Amino acid composition

Data presented in Table 6 show the amino acid composition of raw and treated chickpea seeds. Chickpea protein was rich in essential amino acids such as isoleucine, lysine, total aromatic amino acids and tryptophan compared with the FAO/WHO (1973) reference. Therefore, chickpea protein could very well complement those protein sources that are low in lysine and tryptophan. However, leucine, total sulfur amino acids, threonine and valine were slightly deficient in chickpea protein compared with the reference pattern. Boiling and microwave cooking caused a slight increase in total essential amino acids, but they were not influenced by autoclaving. Cooking treatments decreased the concentration of lysine (except microwave cooking), tryptophan, and total aromatic and sulfur amino acids. However, cooked chickpea seeds were still higher in lysine, isoleucine (except autoclaving) and total aromatic amino acid contents than the FAO/WHO (1973) reference pattern. These results confirmed those reported by Khalil and Mansour (1995), who found that cooking reduced sulfur-containing amino acids and tryptophan in faba bean. All treatments increased the concentration of leucine, but valine was not affected. The leucine:isoleucine ratios of all treated chickpea seeds were typical, with an ideal ratio of 1.8:1 suggested by FAO/WHO (1973). Deosthale et al. (1970) showed that excess leucine in foods interfered with the utilization of isoleucine and lysine.

3.7. In-vitro protein digestibility and biological value

In-vitro protein digestibility and biological values of raw and treated chickpea seeds are given in Table 7. The in-vitro protein digestibility was improved by cooking treatments. In-vitro protein digestibility of cooked seeds was significantly ($P<0.05$) higher than for raw chickpea seeds. However, autoclaving and microwave cooking treatments did not significantly ($P>0.05$) differ in their effect on in-vitro protein digestibility. The improvement in digestibility may be attributed to denaturation of protein, destruction of the trypsin inhibitor or reduction of tannins and phytic acid. Khatoon and Prakash (2004) reported that the legumes treated by microwave cooking had lower in-vitro protein digestibility than those treated by pressure cooking.

Protein efficiency ratio (PER) was improved slightly by cooking treatments. There was a slight improvement in essential amino acid index (EAAI) by microwave cooking, while boiling and autoclaving lowered the EAAI. This lowering is attributed to the reduction of some essential amino acids during boiling and autoclaving. Valine was the first limiting amino acid, while sulfur-containing amino acids were the second limiting amino acids in raw and microwave cooked chickpea seeds. However, the first and second limiting amino acids were sulfur-containing amino acids and valine, respectively, in both boiled and autoclaved chickpea seeds. Chemical score was not affected by

Table 6
Effect of different cooking methods on the amino acid composition of chickpea seeds (g/16gN)

Amino acid	Raw	Boiling	Autoclaving	Microwave cooking	FAO/WHO (1973)
Isoleucine	4.1	4.1	4.0	4.1	4.00
Leucine	7.0	7.4	7.3	7.4	7.00
Lysine	7.7	7.5	7.4	7.7	5.50
Cystine	1.3	1.1	1.0	1.2	—
Methionine	1.6	1.4	1.4	1.4	—
Total sulfur amino acids	2.9	2.5	2.4	2.6	3.5
Tyrosine	3.7	3.6	3.6	3.7	—
Phenylalanine	5.9	5.8	5.8	5.8	—
Total aromatic amino acids	9.6	9.4	9.4	9.5	6.00
Threonine	3.6	4.3	4.5	4.5	4.00
Tryptophan	1.1	1.0	1.0	1.0	1.00
Valine	3.6	3.6	3.6	3.6	5.00
Total essential amino acids	39.6	39.8	39.6	40.4	36.00
Histidine	3.4	3.2	3.1	3.2	—
Arginine	10.3	10.1	10.0	10.1	—
Aspartic acid	11.4	11.2	11.4	11.2	—
Glutamic acid	17.3	18.5	18.0	17.9	—
Serine	4.9	4.5	4.8	4.5	—
Proline	4.6	4.3	5.1	5.0	—
Glycine	4.1	4.5	3.9	4.0	—
Alanine	4.4	3.9	4.1	3.7	—
Total non-essential amino acids	60.4	60.2	60.4	59.6	—
Leucine/isoleucine ratio	1.7:1	1.8:1	1.8:1	1.8:1	1.8:1

Table 7
Effect of different cooking methods on the in-vitro protein digestibility (IVPD) and protein quality of chickpea seeds

Treatment	IVPD (%)	PER[a]	EAAI[b] (%)	CS[c] (%)	Limiting amino acids	
					First	Second
Raw	$83.61^a \pm 0.40$	2.32	67.10	72.00	Valine	Methionine + Cystine (82.86)
Boiling	$88.52^b \pm 0.50$	2.51	66.48	71.43	Methionine + Cystine	Valine (72.00)
Autoclaving	$89.96^c \pm 0.70$	2.47	66.56	68.57	Methionine + Cystine	Valine (72.00)
Microwave cooking	$89.40^c \pm 0.28$	2.50	67.64	72.00	Valine	Methionine + Cystine (74.29)

Means in the same column with different letters are significantly ($P < 0.05$) different.
Means ± standard deviation of three determinations.
[a]Protein efficiency ratio.
[b]Essential amino acid index.
[c]Chemical score.

microwave cooking, but was decreased by the boiling and autoclaving. Therefore, the chemical score and limiting amino acid of chickpea varied considerably depending on treatment.

4. Conclusions

As shown in this study, boiling, autoclaving and microwave cooking affect the composition, antinutritional factors, flatulence factors and nutritional quality of chickpeas. However, microwave cooking caused slight losses in B-vitamins and minerals, while boiling and autoclaving caused significant losses. All cooking treatments improved the in-vitro protein digestibility and protein efficiency ratio of chickpeas. It is quite clear that cooking chickpea by microwave not only saves time but also retains the most nutritive value.

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