Nutritional Evaluation and Functional Properties of Chickpea (Cicer arietinum L.) Flour and the Improvement of Spaghetti Produced from its

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Abstract: Chemical composition of chickpea raw flour proved that protein, fat and ash contents were higher than that recorded in wheat flour. However, crude fiber and total carbohydrates were detected in wheat flour at higher levels than that found in chickpea raw flour. Protein, total nitrogen, non protein nitrogen content, and in-vitro protein digestibility (IVPD) as well as mineral content, functional properties, amino acid composition and amino acid scores were affected as different chickpea flour processing (traditional, microwave and fried).Wheat flour (72 % extraction) was replaced with different processed chickpea flours (10, 15, 20, 25 and 30 %.) to produce spaghetti. Chemical composition, cooking quality, color attributes and sensory evaluation of produced spaghetti were determined. Different treatment for chickpea flours tend to reduced the content of protein in all processed chickpea flours, lowered the contents of fat and ash by 7.96 % and 4.40 %, respectively. Generally, protein solubility values of all processed flours decreased in water and NaCl solution as compared with raw flour. As the replacement level in spaghetti samples with different processed chickpea flours increased, all the contents were increased except fibers and total carbohydrates contents where, values of fibers lowered with increasing the replacement level of samples with raw and fried chickpea flours. The content of minerals was high in spaghetti samples contained microwave cooking chickpea flour at different levels as compared with spaghetti samples contained traditional cooking and fried chickpea flours. The reduction in cooked weight and cooked volume was greater in spaghetti samples replaced with microwave cooked chickpea flour than samples replaced with the other different forms of chickpea flours. Cooking loss of replaced spaghetti was increased gradually with increase the level of replacement compared to the control spaghetti. Replacing wheat flour with different processed chickpea flours tend to reduced lightness and yellowness values, increased redness values of spaghetti samples from control. Spaghetti samples replaced with microwave chickpea flour at all levels had a better color values than those found in samples replaced with different processed chickpea flour. The highest values for all sensory characteristics were observed in control sample. Spaghetti samples replaced with microwave cooking flour at all levels were found to be the highest values for all evaluated sensory characteristics.
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1. Introduction:

Pulses, including beans and chickpea are one of the most important crops in the world because of their nutritional quality. They are rich sources of complex carbohydrates, protein, vitamins and minerals (Costa et al., 2006 and Wang et al.,2010). Pulses have shown numerous health benefits, e.g. lower glycemic index for people with diabetes Goni and Valentine- Gamazo, 2003), increased satiation and cancer prevention as well as protection against cardiovascular diseases due to their dietary fiber content (Chillo et al., 2008).

It is well known that plant proteins are an alternative to proteins from animal sources for human nutrition. Legumes are recognized as the best source of vegetable protein legumes (Molina et al., 2002). However, in recent years, there has been an increasing interest in other legumes such as chickpea (Cicer arietinum L.).

Chickpea is a popular crop in the arid and semi-arid areas of North-Western China (Zhang and Wang 2007). Due to their good balance of amino acid, high protein bioavailability and relatively low levels of anti-nutritional factors, chickpea seed have been considered a suitable source of dietary proteins.

In Egypt chickpea seed 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 (Alajaji and El-Adawy, 2006).

The seeds of chickpea 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 carbohydrate (El-Adawy 2002).

Chickpea seed has a high protein digestibility, contains high levels of complex carbohydrates (low glycaemic index), is rich in vitamins and minerals and is relatively free from anti-nutritional factors (Muzquiz and Wood, 2007; Wood and Grusak, 2007).

In view of the increasing utilization of grain legumes in composite flours for various food formulations, their functional properties (water absorption, oil absorption, emulsion capacity, emulsion stability, foaming capacity and foaming stability etc.) are assuming greater significance. Functional properties constitute the major criteria for the adoption and acceptability of proteins in food systems (Kaur and Singh 2005). Functionality has been defined as any property of a food ingredient, except its nutritional values, that has a great impact on its utilization (Mahajan and Dua, 2002).

Chickpea seed is processed and cooked in a variety of forms depending upon traditional practices and taste preferences. Different domestic processing methods (decortications, soaking, sprouting, fermentation, boiling, roasting, parching frying, and steaming) was used to obtain a suitable texture for the consumer, improvement in the nutritional factors and increase the protein digestibility (Attia, 1994 and Clemente, et al., 1998).

Cooking softens legumes and the determination of the most appropriate condition to obtain a tender products in several legumes has been reported (Uzogara et al., 1992). Studies have shown that microwave heating did affect nutrient content in foods more than conventional cooking due to shorter preparation times and smaller amounts of water (Finot and Merabet, 1993).

Cooking of chickpea by microwave has not been extensively studied but it has been shown to reduce anti-nutritive agents in soybean and have positive effects on protein digestibility (Khatoon and Prakash, 2004) in eight whole legumes.

Heat treatment significantly improve protein quality in pulses by destruction or inactivation of heat labile anti-nutritional factors. Cooking results in significant reductions in phytic acid and tannins in pulses (Wang, et al.,2008). The chemical composition of pulses is also affected by cooking (Wang et al., 2009). It reduces the nutritive value of pulses as the levels of some essential amino acids are markedly decreased..

The chemical composition and nutritive value of chickpea protein are both affected by processing method. An increase of in-vitro protein digestibility of legume seeds after heat treatment has been reported, probably resulting from protein denaturation and inactivation of protease (Salunke and Kadam, 1989). However, in spite of the general positive effect of cooking, the final protein digestibility seems to depend on the type of process applied (Barampama and Simard, 1994).

Digestibility of protein and bioavailability of its constituent amino acid are very important factors in determining protein quality (FAO/ WHO, 1990 and Clemente, et al., 1998). They found in vitro protein digestibility of Kabuli chickpea seed was only 71.8 % and could be improved significantly to 83.5 % after cooking.

Cooked chickpea seeds had a decrease of methionine, cysteine, tyrosine and leucine (Clement et al., 1998). The highest reductions being in cysteine (15 %) and lysine (13.20 %).

The inclusion of pulses in cereal based food is known to increase the nutritive value by improving protein content and lysine availability (Reyes-Moreno et al., 2004; Wood and Grusak, 2007). Several studies have examined various aspects of chickpea incorporation into pasta Sabanis et al., 2006), however the end-product qualities of pasta produced from bean (dehulled desi chickpea flour) has not been thoroughly investigated. Pasta is traditional and highly popular cereal-based food product because of its convenience nutritional quality and palatability (Cubadda et al., 2007).

Pasta, on the other hand, is a popular food with a high rate of acceptability in many population groups (fitness enthusiasts, children, adolescents, and the elderly). Moreover, new ingredients can be readily incorporated in industrial past-making processes (Goni and Valentine- Gamazo, 2003).Pasta also contains 11-15 % proteins (dry basis) but is deficient in lysine and therionine (the first and second limiting amino acid), common to most cereal products .This provides an opportunity for the use of non-traditional raw materials to increase the nutritional quality of pasta Chillo et al., 2008).Consequently, legumes and cereals are nutritionally complementary (Duranti, 2006).

Goni and Valentine- Gamazo (2003) showed that spaghetti containing 25 % chickpea flour had a significantly lower glycaemic index (G l) than traditional durum spaghetti chickpea inclusion also increased the mineral and fat content without affecting the total starch content. Zhao et al., (2005) incorporated

5-30 % of different pulse flour into spaghetti and found that trimness and color intensity increased, while overall quality decreased. On the other hand, Sabanis et al., (2006) investigated 5-50 % inclusion of chickpea flour in durum lasagna and found that the physical properties of the dough were improved, however, processing, handling and cooking characteristics deteriorated with the higher substitution levels.

The present investigation was carried out to study the nutritive evaluation and functional properties of chickpea flour as well as improve the nutritive value of spaghetti produced from wheat flour by replacement with different processed of chickpea flour at levels 10, 15, 20, 25 and 30 % and evaluate the quality and sensory characteristics of produce spaghetti.

2. Materials and methods:

Materials:

Chickpea (Cicer aritinum, L.) variety Giza 88 was obtained from the Field Crops Research Institute, Agricultural Research Centre (A.R.C.), Ministry of Agriculture, Giza, Egypt. Hard wheat flour (72 %) extraction was purchased from the North Cairo Mills Company, Egypt. Trypsin enzyme which used for in-vitro protein digestibility (IVPD) from bovine pancreas type IIII, 16.500 BAEF Umg $^{-1}$ and pepsin (P-7000) were purchased from Sigma Chemical Company, St. Louis, MO, USA.

Samples preparation:

Chickpea (Cicer aritinum, L.) seeds were manually sorted to remove split, wrinkled and moldy legumes and foreign materials.

Soaking:

Chickpea seeds were soaked in distilled water (1:10, w/v) for 12hrs, at room temperature (~ 25 ºC). The soaked seeds were drained and dehulled and were divided into three parts for cooking.

Cooking:

Traditional cooking:

The first part was cooked in distilled water (1:20, w/v) in a beaker placed on a hot-plate for 90 min according to the method described by Alajaji and El-Adawy (2006). The cooked sample was then drained through strainer.

Microwave cooking:

The second part was cooked in distilled water (1:20, w/v) in beaker using microwave oven (Gold star model. No. ER-535MD, 245OMHZ, Egypt) with power level 10 for 5 min. according to the method described by Alajaji and EL-Adawy (2006).

Frying:

The third part was fried in corn oil using frying pan at 170 ºC for 1 min according to the method described by Helmy (2003b). After frying, seeds were placed on filter paper to absorb oil residue. Fried seeds were defatted by the soxhlet procedure.

The cooked and fried seeds were mashed separately and dried at 50 ºC for 10 hrs, in an electric oven with a motor fan. Raw seeds after dehulling and processed seeds were ground to pass through a 30 mesh sieve and kept in polyethylene pouches until analysis.

Analytical Methods:

Moisture, protein, fat, crude fiber and ash were determined in different samples (wheat and chickpea flours) according to the methods described in the A.O.A.C. (2000).A total carbohydrate was calculated by difference. All the measurement of analyzed samples were made in triplicate.

Amino acids determination:

After hydrolysis of different samples flour with 6 N HCL at 110 ºC for 24 hrs, the HPLC apparatus (Waters Assoc, USA) was used for identifying the amino acids of the tested samples according to Millipore Cooperative (1987) modified PICO-TAG method.

Evaluation of amino acids and nutritional parameters:

The different amino acids recovered were presented as g/100g protein. The nutritional values of chickpea were summarized according to the method of Chavan, et al., (2001).

$$\text{Amino acid score (\%)} = \frac{\text{mg of *EAA in 1g of test protein}}{\text{mg of EAA in 1g **reference protein}} \times 100$$

* Essential-amino acid.
** FAO/WHO (1985).

Minerals determination:

Mineral contents, i.e. copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe) and zinc (Zn) were determined according to the method of A.O.A.C. (2000) using Atomic Absorption Spectrophotometer, Perkin-Elmer 2380. The flame photometer was applied for calcium (Ca), potassium (K) and sodium (Na) determination according to the method described by Pearson (1976).

In vitro protein digestibility procedure (IVPD):

In vitro digestibility of protein was determined by successive pepsin trypsin enzyme system according to method of Chavan et al., (2001) with minor modification. The procedure of digestibility was as follows: for pepsin digestion, in a 50 ml. centrifuge tube, 0.5 g of protein sample was suspended in 9.5 ml. of 0.1 M HCL and then mixed with 5 mg pepsin in 0.5 ml. of 0.1 M HCL. The mixture was gently shaken at 37 ºC for 120 min. and then, the solution was neutralized with 1.0 M phosphate buffer (pH 8.0), followed by adding appropriate trypsin (100 : 1 ratio of substrate/enzyme ratio, w/w), and the tubes were covered and incubated again at 37 ºC for 120 min.

For digestibility evaluation, the trichloroacetic acid (TCA) soluble nitrogen released during digestion was determined as follows: after 10, 30, 60, 90, and 120 min of incubation for pepsin or trypsin, enzyme activity was terminated by adding an equal volume TCA (10 % w/v). Samples were immediately transferred to an ice bath, and then all samples were centrifuged (6000g, 20 ºC) for 20 min. The content of TCA soluble nitrogen of the supernatant was determined by micro-kjeldahl nitrogen analysis. In vitro digestibility was reported as percentage enzymatic digestion, as given below:

$$\text{Enzymatic digestion (\%)} = \frac{\text{mg of NPN in supernatant} \times 100}{\text{mg of total N content of undigested sample}}$$

Functional properties:

Water absorption:

Water absorption capacity was determined using the method of Salunkhe (1985) modified by Adebowale and Lawal (2004) at room temperature. The values were expressed as g of water absorbed by 100 g of flour.

Oil absorption:

This was determined by the method of Sosulski and McCurdy (1987) at room temperature using refined corn oil. The oil absorption capacity was expressed as g of oil absorbed by 100 g of flour.

Protein solubility:

protein solubility of raw and processed flours was determined according to Clemente et al., (1998) in water or in 0.5N NaCL at pH 7.0 and 1:2 (w/v) ratio . The pH was adjusted by 0.5 N HCL or 0.5 N NaOH. The suspension was shaken for 1h at room temperature and centrifuged at 6000 rpm for 15 min. Supernatant was analyzed for nitrogen by micro-kjeldahl method. Protein solubility is expressed as a percentage of the total protein content (N x 6.25) in each sample. Total nitrogen and non-protein nitrogen contents in samples were determined using a micro-kjeldahl method (A.O.A.C, 2000). Crude protein content was calculated using a factor of 6.25. An extraction of samples with 10% trichloroacetic acid (TCA) was carried out for determination of non-protein nitrogen (Singh and Jambunathan, 1981).

Oil emulsification:

Emulsification capacity (EC) and emulsification stability (ES) of the samples were determined in triplicate according to the method described by Naczk et al., (1985) at room temperature. One gram sample was blended in a Braun mixer with 50 ml distilled water for 30 sec. at maximum speed. Refined corn oil was added continuously from a burette and blending continued until emulsion breakpoint was reached. The amount of oil added up to this was interpreted as the emulsifying capacity of the sample.

Foaming properties:

Foaming capacity (FC) and foaming stability (FS) of the samples was determined in triplicate using the method described by Makri et al., (2005) at room temperature using 1% protein solution. Foaming capacity was expressed as the percentage increase in the volume after 30 sec. and foam stability was expressed as the foam volume measured after 10, 30, 60, 90 and 120 min.

Processing methods:

Processing of spaghetti samples:

The spaghetti samples were prepared in the Food Technology Department, NRC, Cairo, Egypt, by using pasta matic 1000 simac Machine corporation, Millano, Italy. For preparation of replacement spaghetti, 10, 15, 20, 25 and 30 g of raw, cooked, microwave and fried chickpea flours were individually added to the base spaghetti recipe, substituting for an equivalent amount of wheat flour. The mixing time was 4-6 min. at 30 rpm under vacuum value of 35 cm Hg. Spaghetti was hydrated under atmospheric air for 15 min., then dried in a cabinet dryer at 40 ºC for 14 hours. The samples were cooked enough at room temperature, then packed in polyethylene pouches and stored at room temperature until analysis.

Cooking quality of spaghetti weight increase, volume increase, and cooking loss were evaluated according to the methods described by AACC (2000).

Spaghetti color:

Color of spaghetti was measured by using a spectro-colorimeter (tristimulus color machine with CIE lab color scale) (Hunter, Lab Scan X E, Reston VA) calibrated with a white standard tile of Hunter Lab color standard (LX No 16379); X = 77.26, Y = 81.94 and Z = 88.14 (L*= 92.43, a*= - 0.86, b*= - 0.16) color difference (ΔE) was calculated from a, b, and L parameters, using Hunter-Scot field's equation (Hunter. 1975).

$$\Delta E = (\Delta a^2 + \Delta b^2 + \Delta L^2)\ \%$$

Where: $a = a - a_o$, $b = b - b_o$ and $L = L - L_o$.

Subscript *O* indicates color of control. Hue angle (tg^{-1} b/a) and saturation index ($\sqrt{a^2 + b^2}$) were also calculated

Sensory evaluation and statistical analysis:

Appearance, color, taste, tenderness and stickiness of the spaghetti were evaluated organoleptically as described by Hallabo et al.,(1985). The results were statistically analyzed by analysis of variance and least significant difference (LSD) as reported by McClava and Benson (1991).

3. Results and Discussion:

Chemical composition of wheat and chickpea flours:

Data in (Table1) indicate that proximate composition varied among wheat flour as well as chickpea raw flour. Protein, fat and ash contents in chickpea raw flour were higher than that recorded in wheat flour. However, crude fiber and total carbohydrates were detected in wheat flour at higher level than that found in chickpea raw flour. These results confirmed by statistical analysis, which highly significant differences ($P<0.05$) were observed between the two type of flours. Data obtained proved that, the chemical composition of chickpea flour was affected as different cooking applied (traditional cooking on a hot plate for 90 min., microwave cooking with power level 10 for 5 min, and frying in corn oil at 170 °C for 1 min.). Different treatments of chickpea flours tend to reduced the content of protein in all processed chickpea flours. The reduction (%) were 1.06, 4.14 and 7.15 with traditional, microwave and fried treatments, respectively. Regarding to fat and ash content with, traditional and microwave processing decreased these components by (8.01 and 8.90 %) with fat and (5.76 and 6.97 %) with ash, respectively. On the contrary, fried treatment tends to increased in fat and ash contents by 41.64 and 33.33 %, respectively. On the other hand, crude fiber increased by 40 % with traditional cooking and 51.89 % with microwave cooking. However, with fried treatments, reduction (12.43 %) was observed. With total carbohydrates slightly reduction or increase were recorded. These results confirmed by statistical analysis. Data proved insignificant differences with protein and carbohydrates contents in different chickpea flour treatments. However, highly significant differences recorded with other components.

Table (1). Chemical composition of wheat flour, raw and different processed chickpea flours (on dry weight basis).

Components %	Wheat flour	Different chickpea flour				LSD (0.0 5 %)
		Raw	Traditional cooking	Microwave Cooking	Fried	
Protein	24.63 [a] ± 1.33	24.63 [a] ± 1.33	24.37 [a] ± 1.21	23.61 [a] ± 1.32	22.87 [a] ± 1.29	1.82
Fat	5.62 [b] ± 0.68	5.62 [b] ± 0.68	5.17 [c] ± 0.75	5.12 [c] ± 0.78	7.96 [a] ± 0.66	1.83
Ash	3.30 [b] ± 0.25	3.30 [b] ± 0.25	3.11 [c] ± 0.28	3.07 [d] ± 0.22	4.40 [a] ± 0.31	1.83
Crude fiber	1.85 [c] ± 0.11	1.85 [c] ± 0.11	2.59 [b] ± 0.12	2.81 [a] ± 0.14	1.62 [d] ± 0.10	1.58
***Total carbohydrates**	64.60 [b] ± 1.0	64.60 [b] ± 1.0	64.76 [b] ± 1.0	65.39 [b] ± 1.0	63.15 [b] ± 2.0	2.30

*Calculated by difference

-All values are means of triplicate determinations ± standard deviation (SD)

- Means within row with different letters are significantly different ($P < 0.05$)

Cooking treatments caused a decrease in protein, ash and fat contents, these decreases might be attributed to their diffusion into cooking water (Alajaji and El-Adawy, 2006). Crude fiber was increased by cooking treatments; this increase could have been due to protein-fiber complexes. Formed after possible chemical modification induced by the soaking and cooking of dry seeds. These results are in agreement with those obtained by Guo et al., (2008) and Guo et al., (2010).

Nitrogen compounds, protein solubility and IVPD values of chickpea flours:

Protein, total nitrogen and non protein nitrogen content as well as in-vitro protein digestibility (INPD) were affected as different chickpea flour processing (traditional, microwave and fried cooking) applied (Table 2). The highest reduction of protein (7.15 %) was observed with fried method followed by microwave (4.14 %) and traditional (1.06 %) cooking. Similar trend was recorded with total nitrogen contents. The reduction (%) was 7.34, 4.30 and 1.52 % with fried, microwave and traditional cooking, respectively. Regarding to non-protein nitrogen contents, its reduced at higher levels during the different processing. The reduction (%) were, 51.02, 30.61 and 20.41 with fried, microwave and traditional treatments, respectively. Protein solubility was also affected as different processing. The reduction (%) was 55.1, 37.99 and 6.84 protein solubility in water as well as 46.12, 24.22 and 15.48 protein solubility in 0.5 N NaCI with fried, microwave and traditional methods, respectively. Regarding to INPD data proved that the different processing methods under investigation led to increased in their contents. The higher increase was found with microwave followed by traditional and fried which recorded 24.04, 13.57 and 3.88 %, respectively. These results indicated that the different cooking decreased the studied components and highly significant differences ($P<0.05$) was observed between the applied methods.

Table (2): Nitrogen protein solubility and In-vitro protein digestibility (IVPD) value in raw and different processed chickpea flours.

Components (%)	Chickpea flour samples				LSD (0.05 %)
	Raw	Traditional cooking	Microwave cooking	Fried	
Protein	$24.63^{a}\pm1.22$	$24.37^{b}\pm1.25$	$23.61^{c}\pm1.20$	$22.87^{d}\pm1.24$	1.04
Total nitrogen	$3.95^{a}\pm0.32$	$3.89^{b}\pm0.28$	$3.78^{c}\pm0.25$	$3.66^{d}\pm0.28$	1.97
Non-protein nitrogen	$0.49^{a}\pm0.05$	$0.39^{b}\pm0.04$	$0.34^{c}\pm0.03$	$0.24^{d}\pm0.04$	0.88
Protein solubility					
In water-	$79.20^{a}\pm1.41$	$73.78^{b}\pm1.38$	$49.11^{c}\pm1.25$	$35.56^{d}\pm1.39$	1.88
-In(0.5N) NaCl	$50.46^{a}\pm1.65$	$42.65^{b}\pm1.54$	$38.24^{c}\pm1.48$	$27.19^{d}\pm1.21$	2.98
In-vitro protein digestibility (IVPD)	$66.19^{c}\pm1.66$	$75.17^{b}\pm1.45$	$82.10^{a}\pm1.38$	$63.62^{c}\pm1.41$	2.98

-All values are means of triplicate determinations ± standard deviation (SD)
- Means within row with different letters are significantly different ($P < 0.05$)

Negi et al., (2001), showed that, on microwave cooking of soaked seeds (12 hrs.) the protein digestibility of all the four varieties of moth bean improved to the extent of 17-19 % over the control. Cooking of chickpea by microwave has not been extensively studied but it has been shown to reduce ant-nutritive agents and have positive effects on protein digestibility (Khatoon and Prakash, 2004).The improvement in digestibility may be attributed to denaturation of protein, destruction of the trypsin inhibitor or reduction of tannins and phytic acid that are more vulnerable to enzyme action (Angulo-Bejarano et al., 2008 & Alajaji and El-Adawy, 2006).

Minerals contents:

Minerals contents of wheat and raw chickpea flours as well as processed chickpea flour were investigated (Table 3). Data showed that major minerals (K, Ca, Na and Mg) and minor elements (Cu, Fe and Zn) were detected in raw chickpea flour at higher levels than that observed in wheat flour. The content of K, Ca, Na, Mg, Cu, Fe and Zn in raw chickpea flour were equal about 7.5, 3.6, 75.6, 1.7, 2.6, 2.5 and 1.7, respectively times of the content in wheat flour. These levels were decreased as processing methods applied. The highest reduction

(%) was observed with fried method samples, which recorded 61.55, 34.46, 8.14, 19.52, 41.84, 21.02 and 30.81 with K, Ca, Na, Mg, Cu, Fe and Zn, respectively.

Table (3). Effect of different cooking methods on selected mineral content of chickpea flour (mg/100 g dry weight basis).

Macro-elements (mg/100g)	Wheat flour	Different chickpea flour			
		Raw	Traditional cooking	Microwave Cooking	Fried
Major minerals					
Potassium (K)	102.50	771.77	298.27	377.85	296.74
Calcium (Ca)	42.91	156.13	109.20	114.58	102.33
Sodium (Na)	1.42	107.34	100.40	103.21	98.60
Magnesium (Mg)	89.87	152.58	145.31	151.31	122.79
Minor heavy metals)					
Copper (Cu)	0.38	0.98	0.64	0.82	*0.57*
Iron (Fe)	2.70	6.85	5.96	6.38	5.41
Zinc (Zn)	2.19	3.83	2.97	3.45	2.65

Moderate reduction was detected with traditional cooking. The relative reduction (%) was 61.35, 30.06, 6.47, 4.76, 34.69, 12.99 and 22.45 with K, Ca, Na, Mg, Cu, Fe and Zn, respectively. On the other hand, the lowest reduction was detected with microwave cooking treatments; the reduction (%) was 51.04, 26.61, 3.85, 0.83, 16.33, 6.86 and 9.92, respectively. These results proved that different processing led to decreasing in the contents of minerals. This decrease is mainly due to the minerals leached from the chickpea seeds into the water during cooking treatments. From the data, microwave cooking resulted in the greatest retention of all minerals followed by traditional cooking, then fried. Similar finding were observed by Gupta et al., (2006), Wang et al., (2008) and Wang et al., (2010). They reported that, cooking beans and chickpeas in water significantly reduced the mineral contents.

Functional properties:

Functional properties of chickpea flours was affected as the applied processing methods (Table 4). Raw chickpea flour had higher values of water absorption capacity, oil absorption capacity, emulsion capacity, emulsion stability, foaming capacity and foaming stability than that of different processed chickpea flours. Besides, it was noticed that, chickpea flour sample processed with microwave cooking had the highest values of all investigated functional properties compared with those of other chickpea flours processed with traditional cooking and fried. Statistical analysis proved that highly significant differences ($P<0.05$) was detected between the different cooking methods. According to Kaur and Sing (2005)**,** flours with high water absorption have more hydrophilic constituents, such as polysaccharides. Therefore, the higher water absorption capacity of raw chickpea flour than the all processed flours could be attributed to the presence of greater amounts of hydrophilic constituents in them. The inherent proteins in raw chickpea flour may also have played some role in the higher water absorption capacity. On the other hand, oil absorption capacity of raw flour was high because it had more available non-polar side chains in its protein molecules than did processed chickpea flours (Seena and Sridhar, 2005). The difference in total protein composition (soluble plus insoluble), as well as components other than proteins (possibly carbohydrates), may contribute substantially to the emulsification properties of protein-containing products like legume flours. Also, the same trend of results was observed in values of foaming capacity and foaming stability for raw chickpea flour where, it had higher values of foaming stability at all time periods. The values of foaming capacity and foaming stability of raw chickpea flour reached to the highest point compared to all processed flours, this result may be due to the increase in concentration of protein. Similar findings were found by Seena and Sridhar (2005) and agreement with those reported by Kaur and Singh (2005) and Alajaji and El-Adawy (2006).

Table (4): Functional properties of different forms of chickpea flours

Functional properties	Chickpea flours				LSD (0.05)
	Raw	Traditional cooking	Microwave Cooking	Fried	
Water absorption capacity % (g.water/100g sample)	132.64 ^{a} ± 2.11	123.17 ^{c}± 1.91	127.93 ^{b} ±1 .85	119.35^{d} ±1.77	2.49
Oil absorption capacity % (Ml oil/100g sample)	110.43 ^{a} ± 1.81	100.49 ^{c} ±1.71	105.25 ^{b}±1.65	95.62 ^{d}±1.48	1.88
Emulsion capacity(EC) (ml oil/g sample)	145.91 ^{a} ± 2.21	136.34 ^{c}± 2.12	140.71 ^{b}± 2.25	130.50^{d}± 2.13	1.88
Emulsion stability	79.35 ^{a} ± 1.24	68.76 ^{c} ± 1.14	73.62 ^{b} ± 1.18	63.81^{d}± 1.17	1.87
Foaming capacity (FC) ml/g sample	246.70 ^{a} ± 2.38	233.28 ^{c}±2.51	239.30 ^{b}± 2.44	228.94^{d}± 2.48	1.77
Foaming stability (FS) after time (min) ml/g sample					
10 min	74 ^{a} ± 0.25	62 ^{c} ± 0.24	69 ^{b} ± 0.25	57 ^{d} ± 0.24	1.71
30 min	52 ^{a} ± 0.20	41^{c} ± 0.22	47 ^{b} ± 0.23	34 ^{d} ± 0.21	1.70
60 min	41 ^{a} ± 0.15	30 ^{c} ± 0.11	36 ^{b} ± 0.15	25 ^{d} ± 0.14	1.71
90 min	28 ^{a} ± 0.12	20 ^{c}± 0.08	24 ^{b} ± 0.11	17 ^{d} ± 0.12	1.70
120 min	19 ^{a} ± 0.08	13 ^{c} ± 0.05	16 ^{b} ± 0.08	10 ^{d} ± 0.08	1.72

All values are means of triplicate determinations ± standard deviation (SD)

- Means within row with different letters are significantly different ($P < 0.05$)

Amino acid composition:

Amino acids composition of wheat flour and different forms of chickpea flours are presented in Table (5). Essential amino acids except methionine and non-essential amino acids except glutamic acid and proline were higher in raw chickpea flour than that detected in wheat flour. Also, the total essential amino acids (39.89 g/100g protein) and total non-essential amino acids (58.64) in raw chickpea flour were higher than that determined in wheat flour which were 32.20 and 56.55 g/100 g protein, respectively. Boye et al., (2010) reported that glutamic acid was present in maximum concentration in the total amino acids content followed by aspartic acid and arginine, where as sulfur-containing amino acids were deficient. The effect of cooking (traditional, microwave and fried) in general on chickpea flour was decreased all the essential and non- essential amino acids. The highest reduction of total essential amino acids (6.82 %) was observed with fried chickpea flour, followed by 3.33 % with microwave and 1.63 % with traditional cooking. The same pattern was recorded with total non-essential amino acids.

Table (5): Amino acids profiles of wheat flour, raw chickpea and different processed chickpea flours (g/100g protein)

Amino acids	Amino acid (g/100g protein)				
Essential-amino acids	**Wheat flour**	**Raw**	**Traditional cooking**	**Microwave cooking**	**Fried**
Leucine	6.96	7.59	7.48	7.44	7.14
Isolucine	4.25	4.76	4.69	4.61	4.42
Lysine	2.14	6.00	5.94	5.73	5.65
Methionine	2.00	1.54	1.49	1.44	1.39
Phenyl alanine	4.48	5.57	5.51	5.44	5.25
Therionine	2.60	3.89	3.82	3.79	3.57
Valine	4.94	5.60	5.54	5.45	5.28
Cystine	1.33	1.36	1.30	1.26	1.22
Tyrosine	3.50	3.58	3.47	3.40	3.25
Total essential amino acids	32.20	39.89	39.24	38.56	37.17
Non essential-amino acids					
Alanine	3.94	4.88	4.82	4.80	4.52
Arginin	3.61	7.82	7.79	7.70	7.40
Aspartic acid	4.64	11.18	10.92	10.87	10.45
Glutamic acid	26.59	18.05	17.87	17.79	16.92
Glycine	3.36	4.30	4.24	4.20	3.98
Histidine	2.45	2.96	2.89	2.82	2.72
Proline	8.11	4.68	2.62	2.60	2.49
Serine	3.85	4.77	4.69	4.66	4.42
Total non- essential amino acids	56.55	58.64	55.84	55.44	52.90
Total determined amino acids	88.75	98.53	95.08	94.00	90.07

EAA (essential amino acids) in proteins from chickpea flour.

The reduction (%) was 9.79, 5.46 and 4.77 % with fried, microwave and traditional cooking chickpea flours, respectively. These results indicate that amino acids slightly affected as the applied cooking methods. The reduction in amino acids may be attributed to the denaturation of the protein during the heat treatment. Similar results obtained by Fadlallah et al., (2011) who reported that essential amino acids decreased during the cooking.

Amino acid scores:

Amino acid score is very important to evaluate the content of essential amino acids in foods and also to cover the nutritional requirements of protein. The comparison between the amino acids content of wheat flour and processed chickpea flours (traditional, microwave and fried) with reference pattern (FAO/WHO, 1985) are given in (Table 6). The results showed that lysine, therionine and methionine + cystine were found to be the first, second and third limiting amino acids in wheat flour respectively. Methionine + cystine, therionine and lucine were the first, second and third limiting amino acids in raw, traditional cooking and fried chickpea flours, respectively. While methionine + cystine, therionine and lysine were the first, second and third limiting amino acids in microwave cooking chickpea flours. Similar results were observed by Angulo-Bejarano et al., (2008), they reported that, total sulfur (methionine + cystine) was the first limiting.

Chemical composition of spaghetti replaced with raw and different processed chickpea flours.

Data in Table (7) indicate the chemical composition of spaghetti made from wheat flour as control and replaced by different levels (10, 15, 20, 25 and 30 %) of chickpea flours and cooked by different methods (traditional, microwave and fried). It was noticed that, Spaghetti made from wheat flour (control) was lowered in all contents (protein, fat, ash and fiber) except total carbohydrates compared with spaghetti samples made from different forms for chickpea flour. As the replacement level in spaghetti samples with different processed chickpea flours increased, all the contents were increased except fibers and total carbohydrates contents where, values of fibers lowered with increasing the replacement level of samples with raw and fried chickpea flours. The reduction of total carbohydrates was noticeable in results for all spaghetti samples replaced with all different processed chickpea flours. Regarding to the protein content, the replacing of wheat flour with all different forms of chickpea flour at different levels tend to increase the protein content in spaghetti samples and the maximum contents of protein in samples present in spaghetti contained raw chickpea flour were 14.71, 15.26, 15.81, 16.36 and 16.91 % at replacement levels 10, 15, 20, 25 and 30 %, respectively. Diaz et al., (2008) showed that, the protein content was improved in the pasta added with chickpea flour, a change that varied according to the legume / wheat ratio, where pasta added with chickpea flour presented protein contents that ranged between 13.00 and 18.36 % (Sabanis et al., 2006). The protein level in chickpea added pasta might be considered significant for the nutraceutical properties attributed to legume proteins (Duranti, 2006). High fat content was found in spaghetti samples contained fried chickpea flour compared to the other spaghetti samples. While, the replacing with raw chickpea tend to increase the fat content of spaghetti samples which increased with increasing the replacement levels from the other spaghetti samples contained traditional and microwave cooking flours. On the other hand, the fat content in chickpea flour was 5.20 %, (Iqbal et al., 2006) and 5.69 % (Zhao et al., 2005), which is appreciably higher than found in wheat flour. For ash and fiber values it was observed from the results in the same table that, spaghetti samples replaced with raw chickpea flour had high ash values compared to samples replaced with traditional and microwave cooking flours but high ash values was noticeable in samples replaced with fried chickpea flour from the other samples. A similar situation has been observed by Sabanis et al., (2006). Also, fiber content was lowered with increasing the replacing levels in spaghetti samples with raw and fiber chickpea flours while, the opposite was found in samples replaced with traditional and microwave chickpea flours. These results are agreement with those obtained by Diaz et al. (2008).

Mineral analysis

Mineral analysis of spaghetti from wheat flour and different forms of chickpea flours are presented in Table (8). The results indicated that, as the level of replacement increased, values of mineral content in spaghetti samples increased. The highest mineral content was found in spaghetti samples replaced with raw chickpea flour. All values of mineral in spaghetti samples replaced with different forms of chickpea flour were higher than those found in control spaghetti sample. The content of minerals was high in spaghetti samples contained microwave cooking chickpea flour at different levels as compared with spaghetti samples contained traditional cooking and fried chickpea flours but, samples of spaghetti which had fried chickpea flour were represented the lowest mineral values. The reduction percent in mineral values for spaghetti samples contained different processed chickpea flours from spaghetti samples contained raw chickpea flour were ranged from 27.75 to 38.91 % for potassium, from 8.62 to 15.89 % for calcium, from 1.15 to 5.69 % for sodium, from 0.49 to 2.61% for magnesium, from 8.93 to 16.67 % for copper, from 4.08 to 5.21 % for iron and from 6.30 to 6.90 % for zinc. These results are in agreement with those reported by Wang et al., (2008) and Wang et al., (2010).

Table (6): Amino acid scores of wheat flour, raw chickpea and different processed chickpea flours.

Amino acids	Wheat flour	Different chickpea flours				Ref. Pattern (FAO/WHO 1985)	Wheat flour	Amino acid scores (%)			
Essential-amino acids (g/100g protein)		Raw	Traditional cooking	Microwave cooking	Fried			Raw	Traditional cooking	Microwave cooking	Fried
Leucine	6.96	7.59	7.48	7.44	7.14	7.00	99.43	108.43	106.86	106.29	102.00
Isolucine	4.25	4.76	4.69	4.61	4.42	4.00	106.25	119.00	117.25	115.25	110.50
Lysine	2.14	6.00	5.94	5.73	5.65	5.50	38.91	109.09	108.00	104.18	102.73
Methionine+Cystine	3.33	2.90	2.79	2.70	2.61	3.50	95.14	82.86	79.71	77.14	74.57
Phenyl alanine + Tyrosine	7.98	9.15	8.98	8.84	8.50	6.80	117.35	134.56	132.06	130.00	125.00
Therionine	2.60	3.89	3.82	3.79	3.57	4.00	65.00	97.25	95.50	94.75	89.25
Valine	4.94	5.60	5.54	5.45	5.28	5.00	98.80	112.00	110.80	109.00	105.60

Table (7): Chemical composition of spaghetti replaced with raw and different processed chickpea flours (on dry weight basis).

Spaghetti with different forms of chickpea flours	Components %				
	Protein	Fat	Ash	Fiber	* Total carbohydrate
Raw					
Control	12.38^{c}± 0.31	0.98^{f}±0.11	0.87^{f}±0.10	0.71^{f}±0.12	85.06^{a}±2.0
10 %	0.3514.71^{b}±	2.21^{e}±0.12	1.91^{e}±0.21	2.53^{a}±0.20	78.64^{b}±3.0
15 %	15.26^{ab}±0.41	2.40^{d}±0.15	1.99^{d}±0.22	2.48^{b}±0.24	77.87^{b}±2.0
20 %	15.81^{ab}±0.38	2.58^{c}±0.14	2.07^{c}±0.18	2.42^{c}±0.19	77.12^{b}±3.0
25 %	16.36^{ab}±0.33	2.78^{b}±0.12	2.14^{b}±0.17	2.39^{d}±0.20	76.33^{b}±3.0
30 %	16.91^{a}± 0.28	2.96^{a}±0.15	2.22^{a}±0.19	2.36^{e}±0.18	75.55^{b}±2.0
LSD at (0.05 %)	1.78	1.32	1.78	1.77	4.53
Traditional cooking					
Control	12.38^{d}±1.53	0.98^{f}±0.01	0.87^{f}±0.01	0.71^{e}±b0.11	85.06^{a}±3.0
10 %	14.68^{c}± 0.27	2.16^{e}±0.13	1.89^{e}±0.15	2.58^{d}± 0.20	78.69^{b}±4.0
15 %	15.23^{b}±0.30	2.34^{d}±0.14	1.96^{d}±0.18	2.61^{cd}±0.19	77.86^{b}±3.0
20 %	15.76^{b}±0.32	2.49^{c}±0.15	2.03^{c}±0.17	2.64^{c}± 0.18	77.07^{b}±2.0
25 %	16.30^{a}±0.28	2.67^{b}±0.14	2.10^{b}±0.20	2.68^{b}±0.21	76.25^{b}±3.0
30 %	16.84^{a}±0.30	2.83^{a}±0.13	2.16^{a}±0.18	2.72^{a}± 0.20	75.45^{b}±4.0
LSD at (0.05 %)	1.97	1.99	1.64	1.55	4.82
Microwave cooking					
Control	12.38^{d}±0.25	0.98^{f}± 0.01	0.87^{d}±0.01	0.71^{e}±0.02	85.06^{a}±3.0
10 %	14.61^{c}± 0.27	2.12^{e}±0.12	1.80^{c}±0.62	2.60±0.82	78.84^{b}±2.0
15 %	15.11^{b}±0.09	2.32^{d}±0.63	1.91^{bc}± 0.30	2.63^{cd}±0.71	78.03^{b}±3.0
20 %	15.61^{b}±1.29	2.48^{c}±0.11	2.00^{ab}±1.24	2.66^{bc}±0.53	77.25^{b}±4.0
25 %	16.11^{a}±1.42	2.65^{b}±0.21	2.07^{b}±0.38	2.70^{b}±1.06	76.47^{b}±3.0
30 %	16.61^{a}±1.59	2.80^{a}±1.26	2.13^{a}±0.48	2.75^{a}±0.05	75.69^{b}±2.0
LSD at (0.05 %)	1.87	0.91	0.15	0.37	4.04
Fried					
Control	12.38^{e} ± 2.0	0.98^{f}±0.01	0.87^{f}± 0.01	0.71^{f}± 0.02	85.06^{a}±3.0
10 %	14.54^{d}±1.35	2.44^{e}±0.15	2.02^{e}±0.19	2.50^{a}±0.26	78.50^{b}±2.0
15 %	15.00^{c}±0.21	2.75^{d}±0.64	2.15^{d}± 0.28	2.45^{b}±1.29	77.65^{b}±3.0
20 %	15.46^{b}±1.20	3.05^{c}±0.59	2.29^{c}±1.11	2.40^{c}±1.18	76.80^{b}±2.0
25 %	15.93^{ab}±0.79	3.36^{b}±0.65	2.42^{b}±0.89	2.36^{d}±1.23	75.93^{b}±3.0
30 %	16.39^{a} ± 2.0	3.67^{a}±0.02	2.55^{a}±0.02	2.29^{e}± 0.01	75.10^{b}±2.0
LSD at (0.05 %)	1.89	1.48	1.08	1.48	4.54

*Calculated by difference.
-All values are means of triplicate determinations ± standard deviation (SD)
- Means within column with different letters are significantly different ($P < 0.05$)
- Control: wheat flour.

Cooking quality:

Cooking quality (change in cooked weight, volume and loss %) of spaghetti replaced with raw, traditional cooked and microwave cooked chickpea flours are presented in Table (9). The results showed that, replacement with all different forms of chickpea flours caused gradually reduction in cooked weight and volume of spaghetti with the increase of replacement level compared to the control sample (100 %wheat flour). The reduction in cooked weight and cooked volume was greater in spaghetti samples replaced with microwave cooked chickpea flour than samples replaced with the other different forms of chickpea flours. Also, in the same table, the results proved that, cooking loss of replaced spaghetti was increased gradually with increase the level of replacement compared to the control spaghetti. The increase of cooked loss in spaghetti samples replaced with fried chickpea flour was higher than control sample and samples contained all forms of chickpea flour. Helmy (2003a) reported that, all levels of replacement (10 % - 30 %) with different both type of faba bean and lentil flours (raw, germinated and blanched) decreased the change in cooked weight and volume and increased the change in cooked loss in produced spaghetti compared with control. Similar trend of results were obtained by Zhao et al., (2006), they reported that, spaghetti was made from semolina, containing 5 % to 30 % milled flours of green pea, yellow pea, chickpea, and lentil, respectively, cooking loss increased with an increase in legume flour content.

Color evaluation:

Data presented in Table (10) show Hunter color values of spaghetti replaced with different forms of chickpea at levels 10, 15, 20, 25 and 30 %. Replacing wheat flour with different processed chickpea flours tend to reduced lightness and yellowness values, increased redness values of spaghetti samples from control. A great reduction was observed in lightness (L) results of spaghetti samples replaced with fried chickpea flour at different levels. Also results of redness (a) values reached to maximum values (4.43).The color of spaghetti samples contained raw, traditional cooking, microwave cooking and fried were became less bright and more red, less yellow when compared with control. Saturation values were decreased until reached to their high levels in spaghetti replaced with fried flour. As the level of different replaced chickpea flours increased values of lightness and Hue were decreased. Values of redness (a) were increased as the replacing level of different chickpea flours increased. A little effect in ΔE in spaghetti samples compared with control was noticed in results of samples replaced with raw chickpea flour at all replacing levels. Spaghetti samples replaced with microwave chickpea flour at all levels had a better color values than those found in samples replaced with different processed chickpea flour.

The color of all spaghetti samples became less bright (lower L*), more red (higher a*) and less yellow (lower b*) as the percentage of traditional cooking and microwave cooking chickpea flours replaced spaghetti were evaluated by the sensory panel as visually similar to the control, however the spaghetti fortified with 20 % or more tended to display an undesirable brownish tint (supported by L*, a*, and b* measurements, Table (10). These results are in agreement with those reported by Zhao et al., (2005) and Jennifer Ann Wood (2009).

Sensory characteristics of spaghetti

Data in Table (11) represent the mean scores for appearance, color, taste, tenderness and stickiness for prepared spaghetti replaced with raw and other processed chickpea flours at different levels. The highest values for all sensory characteristics were observed in control sample. Spaghetti samples replaced with microwave cooking flour at all levels were found to be the highest values for all evaluated sensory characteristics. There was no significant difference between control, replacement levels 10 and 15 % regarding appearance, color, taste, tenderness and stickiness in spaghetti samples contained raw, traditional cooking and microwave cooking flours. No significant differences were detected regarding the appearance of samples as a result of the presence of raw chickpea flour between levels 20 and 25 %. Also, the same trend was found between levels 25 and 30 % in samples contained traditional cooking chickpea flour and samples contained 15 and 20 % fried chickpea flour. Between samples contained 20 and 25 % raw chickpea flour, 25 and 30 % traditional chickpea flour, 30 % microwave chickpea flour and 15, 20 and 25 % fried chickpea flour there was no significant differences in color. Taste of samples contained 25 and 30 % raw, traditional flours and samples contained fried flour at levels 20, 25 and 30 % was not different. The same observation for taste was found between samples replaced with raw and traditional chickpea flours at level 20 %, samples replaced with microwave cooking chickpea at levels 20, 25 and 30 % and spaghetti sample contained 15 % fried flour. Results in the same table indicated that replacement with traditional cooking flour at levels 20 and 25 % and with microwave cooking flour at levels 25 and 30 % had no effect on tenderness. Also, the same trend was found in samples replaced with raw and fried chickpea flours at levels 20 and 25 % and spaghetti sample replaced with 30 % traditional cooking flour. Stickiness was not different between levels 20 and 25 % in samples contained raw and fried chickpea flours and between levels 20 and 25 % for samples replaced with traditional and microwave chickpea flours. Also, similar result was found between samples contained 30 % raw, traditional cooking and microwave cooking flours. The obtained results confirmed these obtained by Zhao et al., (2006) and Wood (2009).

Table (8): Mineral analysis for spaghetti with different forms of chickpea flours (on dry weigh basis).

Spaghetti with different forms of chickpea flours	Macro-elements (mg/100g)						
	Major minerals				Minor (heavy metals)		
	Potassium (K)	Calcium (Ca)	Sodium (Na)	Magnesium (Mg)	Copper (Cu)	Iron (Fe)	Zinc (Zn)
Control	99.42	41.26	0.93	86.71	0.31	2.39	1.98
Raw							
10 %	168.37	53.14	11.95	95.78	0.42	3.07	2.32
15 %	200.79	58.72	17.27	99.16	0.46	3.31	2.41
20 %	234.28	64.90	22.49	101.34	0.49	3.49	2.52
25 %	266.25	70.18	27.64	104.93	0.52	3.68	2.61
30 %	301.40	76.52	32.15	108.61	0.56	3.92	2.70
Traditional cooking							
10 %	121.64	48.56	11.27	93.28	0.37	2.98	2.11
15 %	130.72	52.61	16.18	96.14	0.40	3.10	2.20
20 %	139.52	56.07	21.20	100.58	0.42	3.30	2.29
25 %	150.28	59.15	26.13	103.29	0.44	3.49	2.37
30 %	158.47	62.40	31.07	105.94	0.46	3.62	2.41
Microwave cooking							
10 %	129.71	49.36	11.48	95.83	0.38	2.97	2.24
15 %	142.30	52.58	16.62	98.76	0.41	3.19	2.36
20 %	156.42	56.70	21.54	101.54	0.45	3.38	2.42
25 %	170.26	60.49	26.39	104.90	0.48	3.59	2.49
30 %	184.13	64.36	31.78	108.12	0.51	3.76	2.53
Fried							
10 %	119.86	47.94	11.05	91.67	0.35	2.91	2.16
15 %	130.43	50.82	15.90	94.73	0.38	3.04	2.19
20 %	138.70	53.65	20.79	96.39	0.40	3.20	2.22
25 %	149.95	56.81	25.68	98.00	0.43	3.34	2.26
30 %	158.67	60.49	30.51	99.63	0.46	3.48	2.30

- Control: wheat flour. - Raw: Chickpea flour.

Table (9): Cooking quality of spaghetti replaced with raw and different processed chickpea flours.

Spaghetti samples		Change in cooked weight		Change in cooked volume		Change in cooked Loss	
		%	Relative value	%	Relative value	%	Relative value
Control (100% wheat flour)		$315.92^{a}\pm0.47$	100.00	$298.64^{a}\pm0.62$	100.00	$7.53^{d}\pm0.91$	100.00
Spaghetti replaced with raw chickpea flour at levels of:							
	10%	$290.25^{b}\pm0.27$	91.87	$256.30^{b}\pm0.41$	85.82	$8.27^{c}\pm0.28$	109.83
	15%	$284.17^{b}\pm0.59$	89.95	$239.54^{c}\pm0.73$	80.21	$8.64^{c}\pm0.34$	114.74
	20%	$279.46^{c}\pm0.48$	88.46	$218.94^{d}\pm0.65$	73.31	$9.36^{b}\pm0.30$	124.30
	25%	$256.39^{d}\pm0.64$	81.16	$197.70^{e}\pm0.42$	66.20	$9.75^{b}\pm0.42$	129.48
	30%	$238.50^{e}\pm0.72$	75.49	$189.63^{f}\pm0.36$	63.50	$10.42^{a}\pm0.51$	138.38
Spaghetti replaced with traditional cooked chickpea flour at levels of:							
	10%	$280.36^{b}\pm0.25$	88.74	$248.61^{b}\pm0.06$	83.25	$8.02^{c}\pm0.24$	106.51
	15%	$272.72^{b}\pm0.46$	86.33	$227.53^{c}\pm0.08$	76.19	$8.10^{c}\pm0.19$	107.62
	20%	$264.51^{c}\pm0.32$	83.73	$210.81^{d}\pm0.10$	70.59	$8.17^{b}\pm0.26$	108.50
	25%	$251.80^{d}\pm0.40$	79.70	$188.72^{e}\pm0.16$	63.19	$8.62^{b}\pm0.09$	114.48
	30%	$229.93^{e}\pm0.52$	72.78	$179.25^{f}\pm0.35$	60.02	$9.48^{a}\pm0.15$	125.90
Spaghetti replaced with microwave cooked chickpea flour at levels of:							
	10%	$271.19^{b}\pm0.18$	85.84	$242.32^{b}\pm0.73$	81.14	$7.84^{c}\pm0.12$	104.12
	15%	$264.26^{b}\pm0.24$	83.65	$219.50^{c}\pm0.62$	73.50	$7.99^{c}\pm0.14$	106.11
	20%	$252.34^{b}\pm0.37$	79.87	$206.81^{d}\pm0.51$	69.25	$8.09^{b}\pm0.19$	107.44
	25%	$243.65^{c}\pm0.42$	77.12	$183.75^{e}\pm0.42$	61.53	$8.38^{b}\pm0.23$	111.29
	30%	$221.72^{d}\pm0.64$	70.18	$174.29^{f}\pm0.79$	58.36	$9.25\pm^{a}$ 0.28	122.84
Spaghetti replaced with fried chickpea flour at levels of:							
	10%	$295.40^{b}\pm0.49$	93.50	$264.6\ ^{b}\pm0.37$	88.61	$8.43^{c}\pm0.64$	111.95
	15%	$289.72^{b}\pm0.76$	91.71	$243.10^{c}\pm0.29$	81.40	$8.70^{c}\pm0.81$	115.54
	20%	$280.65^{c}\pm0.68$	88.84	$224.51^{d}\pm0.17$	75.18	$9.64^{b}\pm0.70$	128.02
	25%	$260.48^{d}\pm0.54$	82.45	$203.35^{e}\pm0.11$	68.09	$9.92^{b}\pm0.92$	131.74
	30%	$241.37^{e}\pm0.81$	76.40	$196.46^{f}\pm0.09$	65.78	$10.68^{a}\pm0.85$	141.83

-All values are means of triplicate determinations ± standard deviation (SD)

- Means within column with different letters are significantly different ($P < 0.05$)

Table (10): Hunter color values of spaghetti replaced with raw and different processed chickpea flours.

Spaghetti samples		L	A	b	a / b	Saturation	Hue	ΔE*
Control (100% wheat flour)		80.40	1.10	11.62	0.09	11.67	84.59	□
Spaghetti replaced with raw chickpea flour at levels of:								
	10%	79.81	1.39	10.70	0.13	10.79	82.60	1.13
	15%	77.94	1.65	9.82	0.17	9.96	80.46	3.10
	20%	76.67	1.90	8.65	0.22	8.86	77.61	3.83
	25%	75.72	2.16	7.49	0.29	7.80	73.91	6.33
	30%	74.53	2.45	6.37	0.38	6.82	68.96	7.99
Spaghetti replaced with Traditional cooking chickpea flour at levels of:								
	10%	74.18	1.99	11.34	0.18	11.51	80.05	6.29
	15%	73.25	2.31	10.51	0.22	10.76	77.60	7.34
	20%	72.36	2.82	9.62	0.29	10.02	73.66	8.46
	25%	71.41	3.35	8.74	0.38	9.36	69.03	9.70

	30%	69.87	3.68	7.48	0.49	8.34	63.80	11.61
Spaghetti replaced with microwave cooking chickpea flour at levels of:								
	10%	77.25	1.71	11.29	0.15	11.42	81.39	3.23
	15%	75.37	2.16	10.47	0.21	10.69	78.34	5.27
	20%	74.64	2.50	9.72	0.26	10.04	75.58	6.24
	25%	73.51	2.84	8.80	0.32	9.25	72.11	7.65
	30%	71.49	3.16	7.61	0.42	8.24	67.45	9.83
Spaghetti replaced with fried chickpea flour at levels of:								
	10%	70.19	2.45	11.40	0.21	11.66	77.87	10.30
	15%	68.32	3.14	10.64	0.30	11.09	73.56	12.29
	20%	66.41	3.52	9.76	0.36	10.38	70.17	14.32
	25%	64.53	3.94	8.94	0.44	9.77	66.22	16.34
	30%	63.61	4.43	7.18	0.62	8.44	58.33	17.68

*Color difference

Table (11): Organoleptic evaluation of sensory characteristics for spaghetti sample replaced with raw and different processed chickpea flours.

Spaghetti replaced with different levels of raw and different processed chickpea flours	Characteristics					
	Appearance (10)	Color (10)	Taste (10)	Tenderness (10)	Stickiness (10)	Total (50)
Control	$9.24^{a}\pm 0.26$	$9.53^{a}\pm 0.71$	$8.81^{a}\pm1.08$	$8.46^{a}\pm0.53$	$8.62^{a}\pm1.17$	44.66
Raw						
10 %	$8.75^{a}\pm0.07$	$8.82^{a}\pm0.11$	$0.158.30^{a}\pm$	$8.22^{a}\pm0.09$	$8.43^{a}\pm0.16$	42.52
15 %	$8.64^{a}\pm0.85$	$8.70^{a}\pm0.54$	$8.14^{a}\pm0.20$	$8.10^{a}\pm0.12$	$8.27^{a}\pm0.21$	41.85
20 %	$7.32^{c}\pm 0.6$	$7.25^{b}\pm0.06$	$0.086.78^{b}\pm$	$6.96^{c}\pm0.76$	$6.50^{c}\pm0.93$	34.81
25 %	$6.59^{c}\pm0.41$	$6.61^{bc}\pm0.32$	$6.42^{bc}\pm0.16$	$6.57^{c}\pm1.37$	$6.39^{c}\pm1.23$	32.58
30 %	$5.70^{d}\pm0.90$	$5.90^{c}\pm1.13$	$5.63^{c}\pm1.27$	$5.72^{d}\pm0.96$	$5.80^{cd}\pm0.71$	28.75
Traditional cooking						
10 %	$8.86^{a}\pm1.41$	$9.10^{a}\pm1.20$	$\pm0.988.41^{a}$	$8.30^{a}\pm0.32$	$8.50^{a}\pm1.30$	43.17
15 %	$8.78^{a}\pm0.14$	$8.95^{a}\pm0.39$	$0.188.30^{a}\pm$	$0.68\ 8.18^{a}\pm$	$8.30^{a}\pm0.54$	42.51
20 %	$8.59^{a}\pm0.09$	$8.60^{a}\pm1.37$	$7.56^{b}\pm1.29$	$7.72^{ab}\pm0.49$	$0.54\ 7.28^{b}\pm$	39.75
25 %	$7.18^{c}\pm0.13$	$7.64^{b}\pm1.02$	$6.70^{bc}\pm0.10$	$7.45^{b}\pm0.31$	$7.13^{b}\pm0.25$	36.10
30 %	$6.83^{c}\pm0.64$	$7.05^{b}\pm$o.40	$6.22^{c}\pm0.24$	$\pm1.286.90^{c}$	$6.64^{c}\pm0.17$	33.64
Microwave cooking						
10 %	$8.94^{a}\pm0.93$	$9.27^{a}\pm1.25$	$8.67^{a}\pm1.18$	$8.34^{a}\pm0.14$	$8.56^{a}\pm0.9$	43.78
15 %	$8.85^{a}\pm0.22$	$9.14^{a}\pm0.29$	$8.49^{a}\pm0.33$	$8.29^{a}\pm1.05$	$8.38^{a}\pm0.62$	43.15
20 %	$8.74^{a}\pm0.18$	$8.91^{a}\pm0.47$	$7.85^{ab}\pm1.23$	$7.91^{a}\pm1.47$	$7.64^{b}\pm1.12$	41.05
25 %	$8.30^{b}\pm0.14$	$8.72^{a}\pm0.17$	$7.60^{ab}\pm0.75$	$7.76^{ab}\pm0.26$	$7.55^{b}\pm0.82$	39.93
30 %	$7.46^{b}\pm1.09$	$7.86^{b}\pm0.1$	$7.24^{b}\pm1.16$	$7.38^{b}\pm1.13$	$6.97^{bc}\pm0.5$	36.91
Fried						
10 %	8.10 ± 0.05	$8.51^{a}\pm0.34$	$\pm0.67\ 7.89^{a}$	$8.06^{a}\pm1.34$	$8.25^{a}\pm1.19$	40.81
15 %	$7.26^{c}\pm0.38$	$7.80^{b}\pm0.89$	$7.64^{a}\pm0.52$	$7.83^{a}\pm0.18$	$8.14^{a}\pm0.74$	38.67
20 %	$6.90^{c}\pm0.96$	$7.11^{b}\pm0.62$	$6.51^{bc}\pm0.29$	$6.67^{c}\pm1.29$	$6.29^{c}\pm1.20$	33.48
25 %	$6.31^{d}\pm0.19$	$6.58^{bc}\pm 0.50$	$6.25^{c}\pm$o.63	$6.39^{c}\pm0.76$	$6.10^{c}\pm0.30$	31.63
30 %	$5.49^{d}\pm0.80$	$5.62^{c}\pm0.38$	$5.34^{c}\pm$o.41	$\pm0.17\ 5.50^{d}$	$5.61^{d}\pm$o.47	27.56
LSD (0.05)	0.94	1.63	1.25	0.75	0.98	

-All values are means of triplicate determinations ± standard deviation (SD)

- Means within column with different letters are significantly different ($P < 0.05$)
- Control: wheat flour.

4. Conclusion

It could be concluded that, chemical composition, functional properties and amino acids of chickpea flour were affected by different processing methods (traditional, microwave and fried). Different treatment for chickpea flours reduced the content of protein in all processed chickpea flours. Protein solubility values of all processed flours decreased in water and NaCl solution as compared with raw flour. Chickpea flour processed with microwave cooking had the highest value of IVPD and values of all macro-elements compared with the other treatments. All values of functional properties for microwave cooking flour were high compared with those of other chickpea flours. Methionine, cystine, and tyrosine were lowered in different processed chickpea flours. Methionine, cystine, therionine and lysine were the first, second and third limiting amino acids in microwave cooking chickpea flours. All values of chemical composition for Spaghetti replaced with different processed chickpea were increased except fibers and total carbohydrates contents. Spaghetti samples contained microwave cooking flour had lowest cooked weight and cooked volume than samples replaced with the other different forms of chickpea flours. Spaghetti samples contained microwave chickpea flour at all levels had a better color values and the highest values for all evaluated sensory characteristics compared with the other processed chickpea replaced Spaghetti samples.

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