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Preparation and Evaluation of Different Nutritive Vegetarian Burger for Females and Women

Nasra A. Abd -Elhak
Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

THE current study was carried out to utilize from whole white bean, whole brown lentil and whole chickpea, grits wheat and barley for preparation of healthy vegetarian burger in order to enhance the bioavailability of minerals and, it meets the daily requirements of protein and essential amino acids for females and women. The chemical, physical, cooking and sensory properties were evaluated. The results indicated that the germination process followed by cooking process led to slight significant decrement in protein for legumes. Cooking process of germinated white bean, brown lentil and chickpea resulted in significant decrement in the phytic acid and trypsin inhibitor. The results showed that, soluble and insoluble dietary fibers in cooked legumes were significantly higher than that found in raw and grits wheat and barley. Also, the results showed a significant increase in the moisture retention, oil absorption and cooking yield for vegetarian burger mixtures compared with commercial control sample. Results revealed that the incorporation of whole white bean, whole lentil and whole chickpea to grits wheat and barley caused increased *in vitro* iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphor (P) bioavailability. The tested vegetarian burgers seemed to be more preferable by consumer with respect to sensory evaluation. Finally, it is recommended to prepared good nutritional vegetarian burger for females (9-13 years) and women (over 51 years), and through it can meet the needs of working family members, especially vegetable groups. It can also be used to feed students of schools, university cities, and Christian brothers because of its high nutritional value, cheap price, and a long shelf life without the need to save it by refrigeration or freezing, and it can be used as commercial products.

Keywords: Cereals, Daily requirements, Legumes, Sensory evaluation, Vegetarian diet

Introduction

Vegetarianism was having a robust popularity, with an estimated 15 million practitioners within us (Messina et al., 2003). The vegetarian eating patterns are three types: Vegans eats vegetables and fruits, avoid dairy products and eggs. Ova vegetarians eat an equivalent type one but added eggs to their meals. Lacto- vegetarians an equivalent type one but they eat egg and dairy products (Abd El-Haleam, 2009). Also, vegetarians have a lower intake of cardiovascular disease, there for many customers preferred to eat vegetarian food, veggie burgers one among this food which suggests a meatless patty made from ground grains and vegetables. The legumes play a prominent role within the diets of many the vegetarians and should contribute to a number of the health benefits related to this eating pattern (Haddad & Tanzman, 2003). Their health benefits derive from direct attributes, like their low saturated fat content and high content of essential nutrients and phytochemicals, also on displacement effects once they are substituted for animal products within the diet. Nutritional and health attributes of common dried beans, like kidney, pinto, navy, lima beans, chickpeas and lentils, foods that the FAO defines as grain legumes or pulses as reported by McCrory et al. (2010). Legumes represent a crucial component of human diet in several areas of planet – especially within

*Corresponding author: E-mail: dr.nasraahmed@yahoo.com
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the developing countries where they complement the shortage of proteins from cereals, roots and tubers. Legumes are utilized in a spread of food preparations either intrinsically or together with cereals, because cereal proteins are generally deficient in some essential amino acids (Tharanathan & Mahadevamma, 2003).

Amino acids content is considered one of the most important factors which give valuable information about nutritional value of protein (Piskarev, 2001). Legumes play a crucial role within the traditional diet in several regions of the planet, *Phaseolus vulgaris* is a crucial source of protein, starch, fiber, vitamins, phytochemicals, and minerals like calcium (Ca), iron (Fe), zinc (Zn), phosphorus (P), all of which give potential health benefits within the human diet (Ulloa et al., 2013). Barley (*Hordeum vulgare* L.) is that the fourth most vital cereal crop worldwide, after wheat, corn and rice, belonging to Gramineae, (Marwat et al., 2012). Larsson et al. (1997) reported that solubility of minerals, dietary factors, pH of intestinal lumen and residence time at the absorption site are the various factors affecting the bioavailability of minerals. Dietary quality is an important limiting factor for proper nutrition in many resource poor settings, with a major concern, micronutrient bioavailability (Kumari et al., 2014). Nevertheless, legumes contain anti-nutritional factors, such as trypsin inhibitors and phytic acid that can diminish protein digestibility and mineral bioavailability, thus they have to be appropriately treated prior consumption, (Sandberg, 2002). Soaking is an integral part of a number of treatments, such as germination, cooking and fermentation. It consists of hydration of the seeds in water for a few hours. Several studies indicated that soaking can reduce the levels of minerals, phytic acid and proteolytic enzyme inhibitors which can be partly or totally solubilized and eliminated with the discarded soaking solution (Prodanov et al., 2004). The studies have shown barley to be a superb source of dietary fiber as reported by Vita et al. (2015). The popularity of hamburger lies in its favorable sensory characteristics, practicality and high content of protein with high biological value, vitamins and minerals, which has transformed it into a habitually consumed food in many countries (Ramadhan et al., 2011). The RDA for protein doesn't distinguish sex or age bracket beyond the classification of adult additionally to the RDA, recommendations for macronutrient intake are provided within the context of an entire diet because the acceptable (U.S, 2015). Therefore, this study, estimated the concentrations of protein in legumes which are mainly consumed (whole brown lentil, whole white bean and whole chickpea) and a few cereals (grits wheat and barley) and preparation of various nutritive vegetarian burger mixtures for females (age 9-13years) and women (age over 51 years) to satisfy the daily requirements of protein and minerals.

Materials and Methods

Materials

Whole brown lentil (*Lens culinaris* L.), whole chickpea (*Cicer arietinum*) and whole white bean (*Phaseolus vulgaris* L.) seeds were obtained from Legumes Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Grits wheat (*Triticum aestivum*) and barley (*Hordeum vulgare* L.) were obtained from the Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Other ingredients: spices (cinnamon, pink, black pepper, laura paper and love), onion, garlic, salt and refined sunflower seed oil were obtained from the local market at Giza. Amyloglucosidase, pepsin and protease were obtained from Sigma Company, USA. α-amylase was obtained from Fluka Biochemika Company., USA Commercial beef burger (Halwani Brothers, as control) was purchased from the local market at Giza.

Methods

Preparation of raw materials

Germination process of whole brown lentil, whole chickpea and whole white bean seeds administered consistent with the method of Marero et al. (1988). Grits wheat and barley were soaked in a sufficient amount of water until they became tender. Germinated brown lentil, chickpea, white bean seeds, grits wheat and barley were boiled with sufficient amounts of water, till they became tender and well cooked. All such materials were dried at 55 ˚C for 12 h, in an air forced oven, and then were milled with kitchen machine.

Preparation of vegetarian burger mixtures

The widespread extent of great nutritional and problems in developing countries required more efforts to beat such problems. It might be carried out through developed a significant of nutritious processed cereal-legume blends. Consequently, it's of importance to evaluate such blends with respect of their nutritional value. With such point of view, mixtures of the predominant Egyptian cereal (grits wheat and barley), legumes (whole brown lentil, whole chickpea and whole white bean) were blended together in a varied proportion. Ingredients (g) and ingredient percent (%), protein content (g) and protein percent (%) of every blend in found in Table (1 and 2) some essential bases were considered in formulation of such blends. In spite of there have been different sources of protein, the entire amount of all ingredients suggested to be 34 g and 46 g protein to be an adequate source to satisfy recommendation daily of protein for female (9-13 years) and women over 51 years, respectively as described by FAO/WHO (2007). The vegetarian burger mixtures were prepared by Experimental Kitchen, Food Technology Research Institute, Agricultural Research Center. The ingredients of every formulated vegetarian burger mixtures were homogenized in Braun Cutter Machine (CombiMax 700, USA), then homogenized with formation of vegetarian burger mixtures by piston burger manual about 100 gm weight, 10 cm diameter and 0.95-0.98 cm in thickness. The prepared vegetarian burger mixtures were packaged individually in polyethylene film to assist maintaining the form of vegetarian burger mixtures before freezing.

Analytical Methods

Nitrogen contents, determined by using Kjeldahl method, was multiplied by a factor of 5.7 to work out protein content in grits wheat and barley (AACC, 2004) and 6.25 to work out protein in brown lentil, chickpea and white bean (AOAC, 2019). Mineral contents (iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphorus (P) were determined using by Agilent Technologies (model 4210 MP-AES), atomic absorption spectrophotometer instrument as described by the AOAC (2019) method. Soluble and insoluble dietary fiber contents were estimated consistent with Prosky et al. (1984). Phytic acid content was decided consistent with the method of Wheeler & Ferrel (1971). Trypsin inhibitor was estimated consistent with the method of Roy & Rao (1971).

Cooking characteristics of vegetarian burger

The moisture retention value represents the quantity of moisture retained within the fried product per 100 g before and after frying of vegetarian burger (Kumar & Sharma, 2004). Cooking yield was decided by measuring the

TABLE 1. **Ingredients of the prepared vegetarian burger mixtures for females age (9-13 years).**

Ingredients	LGB				WGB				LCG				CWG				LWB			
	Weight of materials		Protein content		Weight of materials		Protein content		Weight of materials		Protein content		Weight of materials		Protein content		Weight of materials		Protein content	
	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
Cooked germinated brown lentil	50.0	22.30	12	5.35	--	--	--	--	50.0	27.59	12	6.62	--	--	--	--	50.0	25.20	12	6.04
Cooked germinated chickpea	--	--	--	--	--	--	--	--	45.45	25.10	10	5.52	54.54	29.33	12	6.45	--	--	--	--
Cooked germinated white bean	--	--	--	--	60.0	25.25	12	5.05	--	--	--	--	60.0	32.27	12	6.45	60.0	30.22	12	6.04
Grits wheat	85.71	38.23	12	5.35	71.42	30.06	10	4.20	85.71	47.31	12	6.62	71.42	38.40	10	5.37				
Barely	88.49	39.47	10	4.46	106.19	44.69	12	5.05									88.49	44.58	10	5.04
Total	224.2	100	34	15.16	237.61	100	34	14.30	181.16	100	34	18.76	185.96	100	34	18.27	198.49	100	34	17.12

L = Cooked germinated brown lentil, C = Cooked germinated chickpea, W = Cooked germinated white bean, G = grits wheat and B = barely

TABLE 2. Ingredients of the prepared vegetarian burger mixtures for women (over 51years).

Ingredients	LCBG				LWGB				LCWGB				CWGB				LWG			
	Weight of materials		Protein content		Weight of materials		Protein content		Weight of materials		Protein content		Weight of materials		Protein content		Weight of materials		Protein content	
	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
Cooked germinated brown lentil	58.33	22.66	14	5.43	37.5	13.05	9	3.13	41.66	15.34	10	3.68					75.0	30.61	18	7.34
Cooked germinated chickpea	63.63	24.73	14	5.43					40.90	15.07	9	3.31	63.63	22.93	14	5.04				
Cooked germinated white bean					70.0	24.38	14	4.87	45.0	16.57	9	3.31	70.0	25.22	14	5.04	70.0	28.57	14	5.71
Grits wheat	100.0	38.85	14	5.43	100.0	34.83	14	4.87	64.28	23.68	9	3.31	64.28	23.16	9	3.24	100.0	40.82	14	5.71
Barely	35.39	13.76	4	1.55	79.64	27.74	9	3.13	79.64	29.34	9	3.31	79.64	28.69	9	3.24				
Total	257.35	100.0	46	17.84	287.14	100.0	46	16	271.48	100.0	46	16.92	277.55	100.0	46	16.56	245.0	100.0	46	18.76

L= Cooked germinated brown lentil, C= Cooked germinated chickpea, W= Cooked germinated white bean, G = grits wheat and B = barely

difference within the sample weight before and after frying (Murphy et al., 1975).

Physical characteristics of vegetarian burger

Linear expansion: The linear expansion vegetarian burger sample was ruled with five lines. Each line was measured before and after frying in hot oil. The percentage linear expansion was calculated consistent with the method of Yu (1991). Oil absorption was measured consistent with Nurul et al. (2009). The vegetarian burger sample was weighed before and after frying in hot oil. Then, the vegetarian burger sample was dried overnight in an oven (Memmert, Schwabach, Germany) at 105 ˚C over night. The percentage of oil absorption was calculated as follows:

$$\%\ \text{Oil absorption} = \frac{\text{Dried sample weight after frying} - \text{Dried sample weight before frying}}{\text{Dried sample weight before frying}} \times 100$$

Determination of pH

The pH was measured as per the procedure of Trout et al. (1992). The suspension resulting from blending 10 g sample with 100 mL distilled water for two min, employing a pH meter (Tecnopon mod., M PA210, Piracicaba, Brazil).

Determination of bioavailability of some minerals

The bioavailability of iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphorus (P) for the vegetarian burger were decided by *in vitro* digestion method as described by Kiers et al. (2000). The sample (5 g) was subjected to simulated gastro-intestinal enzymatic degradation, using *α*-amylase lipase, pepsin, and pancreatic solutions subsequently. After digestion and centrifugation, the amounts of soluble iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphorus (P) within the supernatant were read against blank by using the Agilent Technologies (model 4210 MP-AES), atomic absorption spectrophotometer. Relative percentage of daily requirement for protein and some minerals in 100 g of vegetarian burger was calculated on fresh weight compare with Recommended Dietary Allowances (2011).

Determination of essential amino acids in vegetarian burger mixtures

The essential amino acids were determined consistent with the method described in AOAC (2019) by using High Performance Amino Acid Analyzer. Tryptophan within the tested samples decided consistent with Albert et al. (1978).

Chemical Score was calculated consistent with FAO/WHO (2007).

$$\text{Chemical Score} = \frac{\text{Mg of essential amino acid in g test protein}}{\text{Mg of essential amino acid in requirement pattern}}$$

Protein Efficiency Ratio (PER) was calculated using the equation suggested by Alsmeyer et al. (1974). PER = –0.468 + 0.454 (leucine) – 0.105 (tyrosine). Biological Value (B.V) was calculated consistent with equation of Oser (1959). B.V= 49.9+10.53 (PER)

Determination of in vitro protein digestibility (IVPD)

In vitro protein digestibility was decided consistent with the method of Akeson & Stahmann (1964).

Sensory evaluation

The sensory characteristics of the cooked vegetarian burger samples were administered by well trained 15 panelists of Food Technology Research Institute (FTRI). Panelists were asked to evaluate color, odor, texture, appearance, chewing, taste, and overall acceptability of cooked samples consistent with the method described by Miller et al. (1993).

Statistical analysis

Data analysis was performed using SAS (1996), software. All data were expressed as mean± variance. Analysis of variance was wont to test for differences between the samples. Least Significant Differences (LSD) test was wont to determine significant differences ranking among the mean values at $P < 0.05$.

Results and Discussion

Effect of cooking process on protein, soluble, insoluble, total dietary fiber, phytic acid and trypsin inhibitor in germinated legumes and grits wheat and barley

Data presented in Table 3 show protein, dietary fiber contents (*i.e*., soluble, insoluble and total dietary fiber), phytic acid and trypsin inhibitor of the raw and cooked germinated (brown lentil, chickpea and white bean) and grits wheat and barley. Table (3) shows the protein content was significantly higher in ungerminated brown lentil than that found in other materials. Protein content of raw lentil was 25.69%, the result agreed with Fouad & Ali (2015). The data showed that the cooked germinated brown lentil, chickpea and white bean possessed a scarcity of crude protein content than the ungerminated ones. These results are agreed with Ghavidel & Prakash (2007) who reported that, during germination of legume seeds, there is significant changes in the composition of protein could modify the nutritional value. The decrease in protein could also be attributed to the solubility of those components in water during boiling and therefore the loss percent was varied consistent with the degree of solubility in water for every compound. Protein content in grits wheat and barley was 14.0 and 11.3, respectively. These results were agreement with Saulius et al. (2016). There results revealed that the very best significant in total dietary fiber amount was noticed just in case of cooked germinated lentil, chickpea and white bean. The most important sources of dietary fibers are vegetable foods like cereals and legumes. Dietary fibers could also be considered as functional foods, because they positively affect of human body (Eduardo et al., 2016). Data showed that, TDF, SDF and ISDF within the barley were recorded higher than grits wheat. These results are agreement with Vita et al. (2015) who found that the entire total dietary fiber in barley grain samples ranged from 187.4 g/kg^{-1} to 208.2 g/kg. The soluble a part of fiber varied from 7 g/kg to 31.8 g/kg. The barley can substitute wheat in feeds because it contains more fiber and less protein (Marwat et al., 2012). Martin-Cabrejas et al. (2003) found that the entire dietary fiber, IDF and SDF fibers content were increased after germination process in daylight and without daylight. The result was almost like the present study where it had been found that TDF increased after germination and cooking, alongside insoluble and SDF. On the opposite hand, within Table 3, it might be noticed that the germination process followed by cooking process lowered the phytic acid definite quantity within the brown lentil, chickpea and white bean by 87.33, 84.25 and 83.33%, respectively from the raw material values. These results are in agreement with El- Adawy et al. (2004) showed that during the period of soaking before germination, the reduction in phytates content during germination of various legume seeds apparently as a result of an outsized increase in phytase activity. Because the germination process is especially a catabolic process that supplies important nutrients to the growing plant through hydrolysis of reserve nutrients. Current study put the effect of germination and cooking processes on trypsin inhibitor (TI) under the spot of lights as found in Table 3. This study showed that, raw white bean, chickpea and brown lentil contained high amount of TI (973,343.0 and 313TIU /g sample, respectively) than germinated cooked materials (45, 25 and 56 TIU /g sample, respectively) but it had been more sensitive to germination process. Moreover, it might be concluded that the germination process followed by cooking process appeared to provide a high reduction percent for TI within the white bean, chickpea and brown lentil by (95.37, 92.71 and 82.10 %, respectively from the raw material values). The utmost reduction of trypsin inhibitor activity was caused by cooking process. This trend is concurrent thereupon that found by Marero et al. (1988) who reported that the extent of antinutritional factors -trypsin inhibitor activity and phytates were considerably reduced with germination process. Also, Siddhuraju et al. (2002) reported that the inactivation of trypsin inhibitor legumes could be attributed to the destruction of disulphide (–S–S–) bonds. Various thermal treatments had reduced other antinutritive factors, including tannins, phytic acid and trypsin inhibitor activity (TIA) significantly decreased these in black gram, red and white kidney beans, as reported by Khattab & Arntfield (2009). With an absence of those inhibitors, zinc absorption is often greater than 50% (Sandstrom, 1992).

Cooking and physical characteristics of vegetarian burger mixtures

Regarding to, cooking and physical characteristics (moisture retention and cooking yield) and (oil absorption, linear expansion and pH) which are considered one among the foremost important physical quality changes occur in burgers during cooking process due to protein denaturation and releasing of fat and water from burger patties (Oroszvari et al., 2005). Data presented in Table 4 shows that moisture retention in vegetarian mixtures was significantly above that found in control. The oil absorption capacity of bean flour is vital within the development of latest fried products, as well as for its stability during storage (Marquezi et al., 2017). The same Table showed that the highly significant oil absorption was noticed within the CLGB blend (55.0%) than that found within the LCG (40.0%) blend and control (33.13%). Data in Table 4 showed that the linear expansion was nonsignificant different in vegetarian burger mixtures among the mixtures within the range of 3.06.–7.03%, the control sample recorded the lowest value (2.45%). Just in case cooking yield, this result showed that the cooking yield was significantly different in vegetarian burger mixtures. LWB, LCG and CWG recorded the very best cooking yield (92.48, 91.28 and 90.15%, respectively) compared to CWB, LGB and control which had 85.63%, 81.55 % and 72.56%, respectively.

TABLE 3. Protein, soluble, insoluble and total dietary fiber, phytic acid and trypsin inhibitor of raw and cooked germinated of brown lentil, chickpea and white bean and grits wheat and barley (on dry weight basis).

Sample	Protein %	SDF%	IDF%	TDF%	Phytic acid (mg100/gm sample)	% Reduction	Trypsin inhibitor (TIU /gm sample)	% Reduction
Ungerminated brown lentil	25.69^{a}±0.022	1.45^{c}± 0.052	19.0^{a}± 0.032	20.45^{b}± 0.052	114.5^{c}± 0.032		313.0^{b}± 0.052	
Cooked germinated brown lentil	24.0^{b}± 0.041	1.65^{c}± 0.033	19.52^{a}± .052	21.17^{a}± 0.052	14.5^{d}± 0.052	87.33	56^{c}± 0.012	82.10
Ungerminated chickpea	24.70^{b} 0.032	5.35^{a}±0.032	15.95^{b}± .052	21.30^{a}±0.042	775^{a}±0.062		343^{b}±0.042	
Cooked germinated chickpea	22.0^{c}±0.052	5.92^{a}±0.022	16.5^{b}±0.032	22.42^{a}±0.032	122^{b}±0.032	84.25	25^{d}±0.032	92.71
Ungerminated white bean	22.50^{c}±0.015	2.0^{b}± 0.052	10.25^{c}±0.032	12.25^{c}±0.032	720^{a}± 1.052		973^{a}± 3.052	
Cooked germinated white bean	20.0^{d}±0.032	2.70^{b}± 0.052	11.4^{c}± 0.052	14.10^{b}± 0.052	120^{b}± 2.052	83.33	45^{c}± 2.052	95.37
Grit's wheat	14.0^{e}±0.041	1.20^{c}± 0.032	5.60^{e}± 0.042	6.80^{e}± 0.022	0.056^{e}± 0.052		ND	
Barley	11.30^{f}±0.015	5.02^{a}± 0.042	7.05^{d}± 0.032	12.07^{d}± 0.052	ND		ND	

-Each value (an average of three replicates) is followed by the standard deviation
SDF = Soluble Dietary Fiber, IDF= Insoluble Dietary Fiber and TDF = Total Dietary Fiber

Table 4 also explained pH in mixtures under investigation. It might be noticed that no there are significantly different in pH due to cooking. Data within the same table, it might be noticed that pH was significant higher of vegetarian burger mixtures than the control sample. These results agreed with Hirdyani (2014) reported that wheat contained higher starch level than that in chickpea flour. Chickpea was also characterized with good water holding and emulsifying capacities. Marquezi et al. (2017) concluded that the sort, quantity and structure of the proteins in the beans affected these physical properties, the equivalent occurring for the starch.

Bioavailability of minerals

The data in Table 5 showed that, iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphorus (P) contents and bioavailability of these minerals in vegetarian burger products were study. It might be noticed that the percentage of iron and zinc bioavailability ranged between 31.30 - 85.17% and 49.34 - 78.71%, respectively. The commercial control was exhibited the very best in *vitro* iron bioavailability followed by LWB sample. Also, Ca and K bioavailability ranged between 52.54-92.99% and 65.53-92.96%, respectively. CGWB was exhibited the highest in calcium (Ca) bioavailability and therefore the same blends contained the lowest in potassium (K) bioavailability (80.24%). Phosphorus (P) bioavailability ranged from 71.13 to 92.77 %. The commercial control was recorded the lowest value of calcium (Ca), potassium (K) and phosphorus (P) bioavailability compared with the vegetarian burger mixtures. Supplementation with white bean, whole lentil and chickpea significantly increased *in vitro* of iron (Fe), zinc (Zn), calcium (Ca) and phosphorus (P) bioavailability. Deficiency of Fe, and perhaps Zn, is highly prevalent in developing countries, but also in vulnerable groups with high requirements in industrialized countries, such as women of fertile age, infants and adolescents. The increased number of vegetarians among young people might lead to increased prevalence of Fe deficiency, because the mineral availability may be crucial in a vegetarian diet (Sandberg, 2002). The mineral content of legumes is generally high, but the bioavailability is poor due to the presence of phytate, which is a main inhibitor of Fe and Zn absorption as reported by Sandberg (2002). In legume-based foods, the supply of iron and zinc for absorption is restricted by the presence of antinutritional factors (Luo et al., 2010). Food processing by heat generally alters the bioavailability of nutrients-both macro and micro. The digestibility and hence absorption of micronutrients like iron is believed to be improved upon heat processing; with the resultant softening of the food matrix, protein-bound iron is released, thus facilitating its absorption (Hemalatha et al., 2007).

TABLE 4. Moisture retention, cooking yield, linear expansion, oil absorption and pH of the suggested vegetarian burger mixtures.

Vegetarian burger mixtures	% Moisture retention	% Cooking yield	% linear expansion	% Oil absorption	pH
			Vegetarian mixtures for females (9-13 years)		
LGB	36.91^{b}±0.057	81.55^{e}±0.22	6.78^{b}±0.0057	48.91^{c}±0.0572	6. 6^{a}±0.03
WGB	34.07^{c}±0.017	85.63^{d}±0.01	7.03^{a}±0.0057	43.75^{e}±0.0581	6.6^{a}±0.02
LCG	37.83^{a}±0.057	91.28^{b}±0.01	5.52^{c}±0.026	40.0^{e}±0.0531	6. 3^{a}±0.08
CWG	36.4 0^{b}±0.057	90.15^{c}±0.011	6.25^{b}±0.0152	51.3^{b}±0.0545	6.6^{a}±0.06
LWB	38.26^{a}±0.057	92.48^{b}±0.05	3.78^{d}±0.0057	47.1^{c}±0.0572	6.7^{a}±0.06
			Vegetarian mixtures for women (over 51years)		
LCBG	35.97^{a}±0.057	97.1^{a}±0.057	6.12^{b}±0.057	55.0^{a}±0.057	6.5^{a}±0.06
LWGB	36.94^{b}±0.057	96.97^{a}±0.057	6.0^{b}±0.057	46.0^{d}±0.052	6.6^{a}±0.05
LCWGB	35.80^{b}±0.052	85.86^{d}±0.047	4.76^{c}±0.017	35.7^{c}±0.037	6.4^{a}±0.06
CWGB	32.44^{d}±0.027	84.94^{d}±0.027	5.73^{c}±0.037	45.8^{d}±0.052	6.6^{a}±0.08
LWG	38.36^{a}±0.057	82.79^{e}±0.017	3.06^{d}±0.047	45.0^{d}±0.052	6.3^{a}±0.06
Commercial control	30.10^{e}±0.052	72.56^{f}±0.017	2.45^{e}±0.017	33.13^{f}±0.027	4.4^{b}±0.087

L= Cooked germinated brown lentil, C = Cooked germinated chickpea, W= Cooked germinated white bean, G =grits wheat and B= barely -Each value (an average of three replicates) is followed by the standard deviation.

Relative percentage of daily requirement for protein and some minerals of the vegetarian burger

Data in Table 6 showed a nutrients content of 100 gm (one piece from vegetarian burger) also as vegetarian burger blends compared with daily requirements of FAO/WHO (2007), such data was calculated form protein and minerals content. From data in Table 6 it might be noticed that,100gm from the tested mixture provides about 9.82 to10.82, 26.37 to 37.12 % , 25.25 to 30.37%, 4.55 to 5.67%, 4.69 to 7.45% and 10.31 to 11.31% for protein, iron, zinc, calcium, potassium and phosphorus, respectively of daily requirement in vegetarian mixtures for female (9-13 years), but vegetarian mixtures for woman (over 51 years) provides about 7.13 to 8.45, 33.0 to 38.75 % , 28.0 to 34.25%, 4.7 to 7.72 %, 4.56 to 8.18% and 18.84 to 21.73% for protein, iron (Fe), zinc (Zn), calcium (Ca), potassium(K) and phosphorus (P), respectively of daily requirement. As mentioned in Table 5, commercial product had a better percent of iron (Fe) and zinc (Zn) bioavailability than vegetarian mixtures, in order that the data in Table 6 showed that, Fe and Zn recommended daily in commercial product were study. Fe and Zn were found in highest amount, the consumption of commercial product will allow to cover about 65.75 % and 26.25 % of Fe and Zn requirement per day for female (9-13 years and over 51 years), respectively. The commercial control was found lower in meet the requirement daily for Ca, K and P compared to vegetarian mixtures for female (9-13years) and woman (over 51 years). Generally, the fortification by meat of control caused increase of Fe and Zn percent of RDA compared to vegetarian mixtures. This results agreement with Robert et al. (2017) who reported that, with respect to iron, the 30% protein energy menu meets iron recommendations at 101% for a lady aged 31–50 year, whereas the 18% protein energy menu falls slightly short at 89%; adequate iron is lacking within the diets of adolescent girls and ladies aged 19–50 year and increasing the intake of select protein foods, like lean beef, may help achieve recommendations, as demonstrated during this modeling exercise. According to FAO/WHO (2007), protein requirement might be defined as "the lowest level of dietary protein intake which will balance the losses of nitrogen from the body and thus maintain the body protein mass, in persons at energy balance with modest levels of physical activity, plus, in children or in pregnant or lactating women, the requirements related to the deposition of tissues. Barley grain is a superb source of vitamins and minerals (Kerckhoffs et al., 2002). The utilization of legumes is important as an inexpensive and concentrated source of proteins, thanks to the high cost of proteins of animal origin and their inaccessibility by the poorer a part of the population (Tharanathan & Mahadevamma, 2003).

They're good and economical sources of protein, minerals and B- vitamins (Messina, 1999). Chickpea (*Cicer arietinum* L.) is a crucial pulse crop thanks to its protein content and wide adaptability as a grain. It's a source of dietary protein in generally and particularly for vegetarian segments of the Indian-subcontinent population. It is also used as a protein supplement within the European countries ((Viveros et al., 2001). Also, Zia-UL-haq et al. (2011) reported that the lentil might be considered the best source of nutritive value, thanks to its higher crude protein content. Dry common beans (*Phaseolus vulgaris*) are an important source of protein, starch, fiber, vitamins, phytochemicals, and minerals such as calcium, iron, zinc and phosphorus, all of which provide potential health benefits in the human diet (Sanchez-Arteaga et al., 2015). The adult RDA is defined because the average daily level of intake sufficient to satisfy the nutrient requirements of nearly all healthy people. The RDA for protein for adults >18 years of aged (0.8 g/kg) has been essentially unchanged for >70 years. In practice, the RDA for protein was derived to estimate the minimum amount of protein that has got to be eaten to avoid a loss of body nitrogen as reported by Robert et al. (2017). Iron may be a key component in human nutrition. This divalent metal has a crucial role in various physiological functions. It takes part in oxygen transport, the synthesis of enzymes, energy production and therefore the regulation of immune functions (Radlowski & Johnson, 2013). The Recommended Dietary Allowance (RDA) for calcium is 1000–1200 mg/day, while calcium is absorbed with the diet at approximately 700 mg/day (Moshfegh et al., 2009). Calcium is that the most abundant cation within the body and it's of importance for muscle functions, nerve transmission, intracellular transmission, vascular contraction and vasodilation as reported by Beto (2015). Iron may be a key component in human nutrition. This divalent metal has a crucial role in various physiological functions. It takes part in oxygen transport, the synthesis of enzymes, energy production and therefore the regulation of

TABLE 5. Bioavailability of minerals *in vitro* for the tested vegetarian burger mixtures (mg/100g fresh weight).

Minerals / Vegetarian burger mixtures	Fe			Zn			Ca			K			P		
	Total mg	Bioavailability		Total mg	Bioavailability		Total mg	Bioavailability		Total mg	Bioavailability		Total mg	Bioavailability	
		mg	%		mg	%		mg	%		mg	%		mg	%
Vegetarian burger mixtures for females (9-13 years)															
LGB	6.04	2.52	41.72	2.37	1.49	62.86	78.75	59.18	75.14	275.57	211.26	76.66	191.29	140.28	73.33
WGB	6.05	2.32	38.34	2.42	1.42	58.67	90.76	78.57	81.05	407.11	340.06	83.57	174.36	128.95	73.95
LCG	6.74	2.11	31.30	2.12	1.57	74.05	83.34	72.42	74.89	331.60	252.68	76.20	176.22	141.48	80.22
CWG	5.90	2.80	47.45	2.02	1.59	78.71	88.86	70.52	79.36	385.19	300.63	78.04	142.23	131.96	92.77
LWB	5.99	2.97	49.58	2.43	1.44	59.25	90.79	73.81	81.29	390.03	337.11	86.43	162.30	129.63	79.87
Vegetarian burger mixtures for women (over 51years)															
LCBG	7.22	2.68	37.11	2.29	1.13	49.34	67.53	57.20	84.70	273.77	214.39	78.31	151.62	131.94	87.02
LWGB	7.57	3.10	40.99	2.53	1.25	49.40	86.93	71.58	82.34	378.32	351.69	92.96	167.31	135.36	80.90
LCWGB	7.66	2.64	34.48	2.60	1.90	73.07	98.20	80.74	82.21	426.16	384.88	81.86	188.39	152.15	80.72
CGWB	8.22	2.95	35.88	2.74	1.39	50.72	84.56	78.64	92.99	301.74	242.43	80.34	163.29	136.75	83.73
LWG	6.11	2.97	48.60	2.12	1.72	76.78	98.39	79.89	79.89	410.18	346.99	84.59	176.22	144.54	82.02
Commercial control	6.17	5.26	85.25	3.24	2.10	64.81	44.25	23.25	52.54	115.30	75.56	65.53	120.12	85.45	71.13

L= Cooked germinated brown lentil, C= Cooked germinated chickpea W= Cooked germinated white bean, G = grits wheat and B = barely

TABLE 6. Relative percentage of daily requirement for protein and some minerals in 100 gm of vegetarian burger on fresh weight compare with recommended dietary allowances for females (9-13 years) and women (over 51 years).

Vegetarian burger mixtures	Protein	Fe	Zn	Ca	K	P
	Vegetarian mixtures for females (9-13 years)					
LGB	9.85	31.50	29.62	4.55	4.69	11.22
WGB	10.06	29.0	30.25	5.65	7.55	10.31
LCG	10.82	26.37	26.50	5.57	5.61	11.31
CWG	10.73	35.0	25.25	5.42	6.68	10.55
LWB	9.82	37.12	30.37	5.67	7.49	10.37
Control (18.5% protein)	54.41	65.75	26.25	1.78	1.67	1.23
% Contribution to RDA* for female from protein (g/day) and minerals (mg/day)	34	8	8	1300	4500	1250
	Vegetarian mixtures for women (over 51years)					
LCBG	8.23	33.50	28.62	5.62	4.56	18.84
LWGB	7.17	38.75	31.62	7.24	7.48	19.33
LCWGB	7.13	33.0	32.50	8.18	8.18	21.73
CWGB	7.41	36.87	34.25	7.04	5.15	19.53
LWG	8.45	37.12	28.0	8.19	7.38	20.64
Control (18.5% protein)	40.21	65.75	26.25	0.27	1.60	12.20
% Contribution to RDA* for women from protein (g/day) and minerals (mg/day)	46	8	8	1200	4700	700

L= Cooked germinated brown lentil, C= Cooked germinated chickpea, W= Cooked germinated white bean, B= barely and G=grits wheat. RDA*= Recommended Dietary Allowance (2011).

immune functions. The recommended daily intake of iron for female (9-13 years and over 51 years) is 8 mg. Those are relatively high doses, especially for pregnant women. Thus, approximately 30% of humans suffer from iron deficiency as reported by Soleimani (2011). Meat and meat products aren't perceived nearly as good sources of calcium. The average typical content of calcium in several species ranges from 7 mg (beef) as reported by Beto (2015). Zn-deficiency is representing as a problem of developing countries, among adults or young adults. Meat and meat products are the most source of zinc within the human diet (20–40%) as reported by Yang et al. (2016).

Essential amino acid, chemical score, in vitro protein digestibility PER and B.V of the vegetarian burger mixtures

The protein quality supported essential amino acid content is that the better of any grain. Legumes (whole brown lentil, whole chickpea and whole white bean) and cereals (grits wheat and barley) is a crucial food within the world because it are often stored for long periods of your time and provides a honest foundation for a home food storage plan. The nutritional quality of dietary protein is related to the concentration of essential amino acids in the protein, compared with their nutritional requirements within the human body (FAO/WHO, 2007). With such point of views, the amino acids of the investigated burgers protein were compared with the reference pattern reported by FAO/WHO pattern (Table 7). Results in Table (7) show essential amino acid content, chemical score, IVPD %, PER and B.V of vegetarian burgers. It might be observed that isoleucine, leucine, methionine + cystine, phenlalanine + tryrosine, threonine, valine and tryptophan represented the highest value of amino acid altogether vegetarian burgers as compared with the FAO/WHO pattern, while lysine represented the lowest value as compared with the FAO/WHO pattern. However, that level was higher as compared with the FAO/WHO pattern (57.9 and 50.6 mg/g protein) in LWB and LWG, respectively. This good coverage of essential amino acids explains how pulses can partially substitute for animal proteins in a vegetarian diet. Hirdyani (2014) reported that the protein quality is taken into account to be better than other pulses. The pulses were rich in essential amino acids. Indeed, the contribution of 200 g of household-cooked white beans to the recommended amino acid intakes for a 70 kg man as reported by Hirdyani (2014) is 72% for Histdine, 72% for Isoleucine, 57% for leucine, 63% for lysine, 81% for Threonine, 78% for Trptophan, and 81% for Valine. Chickpea has significant amounts of all the essential amino acids except sulphur-containing amino acids, which may be complemented by adding cereals to the daily diet. Data presented in Table 7 showed also, that the protein digestibility of the vegetarian burgers. It had been found that the vegetarian burgers for women over 51 years possessed the very best IVPD value compared with the vegetarian burgers for females 9-13 years. The variation in IVPD might be demonstrated to one or more reasons: IVPD depends on the kind of protein and consequently it's content of essential amino acids. Heat treatment and germination processes, could also be attributed to denaturation of protein or destruction of the trypsin inhibitor and phytic acid (Khattab & Arntfield, 2009). Barley is digestible (due to low gluten contents) and has superior nutritional qualities and high concentrations of lysine (Marwat et al., 2012). Data in Table 7 also, revealed that the calculated protein efficiency ratio (PER) of all vegetarian burgers might be divided into two groups. The primary group included LCG, LWB, LGB and WGB formula, such formula had PER quite 2.0. The second group included CWGB, LGB, LCGB and CWG formula which had PER was less than 2.0. This variation in PER might be attributed to the variation of essential amino acids in vegetarian burgers. Also, data in Table 7 recorded that the biological values (BV) ranged between 69.9 to 80.96 in the vegetarian burgers. Scientifically, it's documented that a protein-based food material is of excellent nutritional quality when its biological values (BV) is high (70 to 100%) and to be useful as food when the values is around 80% and to be inadequate for food material (Oser, 1959). Chickpea has several potential health benefits, and together with other legumes and cereals, it could have beneficial effects on a number of the important human diseases like, Type 2 diabetes, digestive diseases and a few cancers as reported by Taylor et al. (2016). According to FAO/WHO (2007), amino acid composition and protein digestibility are the most factors influencing protein quality. Proteins are linear polymers of 20 different amino acids (essential and nonessential). To stop protein degradation, dietary protein has got to provide a minimum of nine essential amino acids (EAAs). Plant proteins have more amino acids patterns and have a bent to be limiting in one or more EAAs, and protein digestibility and bioavailability.

Sensory characteristics of the prepared vegetarian burger mixtures

Results of the sensory evaluation of color, odor, texture, appearance, chewing, taste and overall acceptability for vegetarian mixtures for female (9-13 years) are shown in Table 8. It confirmed that LGB, WGB, LWB and CWG possessed the best color, odor, texture, appearance, chewing, taste and overall acceptability with no significant difference in between, but was significantly differed than the LCG. Whilst, LCG recorded the lowest value of color, chewing and overall acceptability. With reference to the sensory evaluation of the vegetarian burger mixtures for women (over 51years, Table 8), LCGB, LWGB and CWGB were the foremost consumers preferable with no significant difference. Meanwhile, there are significant differences between the other tested samples including LWG vegetarian burger blends. On the other hand, LCWGB and LWG showed the lowest score of color attribute and were statistically differed than the other tested vegetarian burger blends and control. The control was recorded the lowest score of chewing attribute compared with the tested vegetarian mixtures.

Generally, the tested vegetarian mixtures appeared to be more preferable burger. Legumes display nutritional benefits and are recommended in sustainable diets. Indeed, they're rich in proteins, fibers and may contain variable amounts of micronutrients. However, legumes also contain bioactive compounds like phytates, or polyphenols/tannins which will exhibit ambivalent nutritional properties counting on their amount within the diet (Marielle et al., 2018). Cereals, including barley and grits wheat have been recognized as functional foods that provide beneficial effect on the health of the consumer and reduce the danger of varied diseases (Vita et al., 2015).

Conclusion

Protein constitutes a vital portion of body composition, and is required for growth and development. In addition, dietary protein is

TABLE 7. Amino acid contents (mg/g protein), chemical Score, in vitro protein digestibility%, PER and B.V. of the prepared vegetarian burger mixtures.

Amino acid	Daily requirement of *FAO/WHO	Vegetarian burger mixtures for females (9-13 years)										Vegetarian burger mixtures for women (over 51years)										Daily requirement of *FAO/WHO
		LGB	CS*	WGB	CS*	LCG	CS*	CWG	CS*	LWB	CS*	LCGB	CS*	LWGB	CS*	LCWGB	CS*	CWGB	CS*	LWG	CS*	
Isoleucine	31	35.0	1.12	55.8	1.80	35.5	1.14	37.0	1.19	38.0	1.22	35.0	1.16	37.0	1.23	37.0	1.23	38.0	1.26	36.3	1.21	30
leucin	61	63.0	1.03	72.3	1.18	64.4	1.05	63.2	1.03	78.2	1.28	63.2	1.07	74.1	1.25	68.2	1.15	64.3	1.08	76.5	1.29	59
Lysine	48	39.3	0.81	36.1	0.75	40.0	0.83	39.1	0.81	59.7	1.24	39.3	0.81	42.3	0.88	44.3	0.93	39.7	0.82	50.6	1.05	48
Methionine+ Cystine	24	26.0	1.08	35.1	1.46	44.7	1.86	51.1	2.12	24.0	1.0	26.0	1.18	29.5	1.34	38.0	1.72	48.8	2.21	23.8	1.08	22
Phenylalanine + Tyrosine	41	42.0	1.02	72.8	1.77	74.0	1.80	79.3	1.93	86.1	2.1	70.8	2.36	68.8	2.29	78.8	2.62	80.8	2.69	70.8	2.36	30
Threonine	25	28.0	1.12	34.6	1.38	30.0	1.20	37.9	1.51	33.5	1.34	31.3	1.36	32.1	1.39	33.8	1.46	36	1.56	30.8	1.33	23
Valine	40	44.0	1.1	47.0	1.17	44.4	1.11	40.2	1.0	52.0	1.30	44.6	1.14	48.2	1.23	45.8	1.17	41.7	1.06	50.0	1.28	39
Tryptophan	6.6	8.2	1.2	8.80	1.33	7.0	1.06	7.3	1.10	8.5	1.28	7.30	1.21	8.0	1.33	8.0	1.33	8.0	1.33	7.10	1.18	6.0
Total essential amino acids		336.6		362.0		340.5		356.3		378.9		336.6		340.0		353.9		357.7		409.8		
In vitro protein digestibility %		78		77		79		80		79		83		82		80		81		84		
PER		1.93		2.49		2.95		1.90		2.76		1.91		2.55		2.19		1.93		2.66		
B.V		70.01		76.40		80.96		69.9		78.96		70.01		76.75		72.96		70.43		77.90		

L= Cooked germinated brown lentil, C= Cooked germinated chickpea, W= Cooked germinated white bean, B = barely and G = grit wheat, CS*= Chemical Score, PER = Protein Efficiency Ratio and B.V= Biological Value * FAO/WHO (2007).

TABLE 8. Sensory characteristics of the prepared vegetarian burger mixtures.

Vegetarian burger mixtures	Color (10)	Odor (10)	Texture (10)	Appearance (10)	Chewing (10)	Taste (10)	Overall acceptability (10)
Vegetarian burger mixtures for females (9-13years)							
LGB	8.12^{ab}±0.737	8.36^{ab} ±0.83	8.75^{a} ±0.74	8.5^{a} ±0.82	8.0^{ab} ±0.82	8.2^{a} ±1.24	8.72^{ab}±0.069
WGB	8.12^{ab}±0.87	8.35^{ab} ±0.90	8.75^{a} ±0.92	8.7^{a} ±0.84	8.87^{a} ±0.83	8.37^{a} ±1.14	9.0^{a} ±0.267
LCG	7.75^{b}±0.788	8.25^{ab} ±0.82	7.62^{b} ±0.66	7.8^{b} ±0. 74	8.0^{ab} ±0.74	7.87^{b} ±0.82	7.85^{c} ±0.29
CWG	8.87^{a}±0.78	8.5^{a} ±0.68	8.73^{a}±0.56	8.7^{a} ±0.42	8.87^{a} ±0.72	8.37^{a}±0.82	9.0 ^{a} ±0.082
LWB	8.5^{a}±1.07	8.62^{a} ±0.79	8.13^{ab} ±0.70	8.2^{ab} ±0.63	8.6 ^{ab} ±0.73	7.62^{b} ±0.98	8.37^{b} ±0.11
Vegetarian burger mixtures for women (over 51years)							
LCBG	8.12^{a}±0.082	8.37^{a} ±0.74	8.12^{a}±0.64	8.3^{a}±0.76	8.6^{a}±0.69	8.37^{a}±0.69	8.12^{a}±0.79
LWGB	8.50^{a}±0.022	8.25^{a}±0.59	8.75^{a}±0.59	8.3^{a}±0.76	8.7^{a}±0.69	8.0^{a}±0.79	8.72^{a}±0.69
LCWGB	7.75^{b}±0.232	8.25^{a}±0.79	8.25^{a}±0.69	7.8^{b}±0.49	8.5^{a}±0.57	8.37^{a}±0.69	8.28^{a}±0.89
CGWB	8.12^{a}±0.072	8.47^{a}±0.71	8.25^{a}±0.79	8.3^{a}±0.79	8.34^{a}±0.59	8.12^{a}±0.79	8.25^{a}±0.79
LWG	7.37^{b}±0.788	7.70^{b}±0.19	7.2^{b}±0.39	7.6^{b}±0.19	7.8^{b}±0.26	7.5^{b}±0.39	7.62^{b}±0.49
Control	7.5^{b}±0.588	8.56^{a}±0.688	7.6^{b}±0.488	8.5^{a}±0.358	6.6^{c}±0.788	8.4^{a}±0.128	8.45^{a}±0.238

L= Cooked germinated brown lentil, C= Cooked germinated chickpea, W= Cooked germinated white bean B=barely and G = grits wheat. Each value (average of 10 replicates) within the same column, each value is followed by the standard deviation.

required throughout life to replace irreversibly amino acids that cannot be synthesized in the body (*i.e*., the essential amino acids (EAAs). It could be concluded that the results of this study clearly demonstrated the usefulness of white bean, whole lentil, chickpea, grits wheat and barley for prepared a good nutritional vegetarian burger mixture for females (9-13 years) and women (over 51 years) from local materials and low price in home or as commercial products. Where, they're a reasonable source of protein, iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphorus (P), of daily requirement. Addition, the tested vegetarian burger mixtures could be considered as good *in vitro* digestibility of protein and bioavailability of minerals, with good stability and extending shelf-life. Along overall sensory quality of the vegetarian burger samples, it had satisfactory sensory properties. The vegetarian burger mixtures prepared within the present study are often successfully utilized in under weight, over weight and normal females and women.

References

AACC (2004) Approval Method of American Association of Cereal Chemists Publ. by *American Association of Cereal Chemists, In. St. Paul. Minnesota*, USA. 2.

Abd.El-Haleam, N. S. (2009) Chemical and physical characteristics of beef and vegetarian (Veggie) burger served in some hotels. *Alexandria Science Exchange Journal*, 30(3), 406-411.

Akeson, W.R. and Stahmann, A. (1964) A pepsin pancreatin digest index of protein quality. *Journal of Nutrition,* **83**, 257-261.

Albert, E., William, M. J. and Francis, G. G. (1978) Protein and amino acids of sweet potato (*Ipomoea batatas* L). Fractions. *Journal Agriculture and Food Chem*istry*,* **26** (3), 699-701.

Alsmeyer, R. H., Cuningham, M. L. and Happich, M. L. (1974) Equations predict PER from amino acid analysis. *Food Technology,* **28**, 34–38.

AOAC (2019) Official Methods of Analysis, AOAC International 21st edition Association of Official Analytical Chemists. Washington, D.C. Available from: https://www.aoac.org/official-methods-of analysis-21st edition-2019 .All Rights Reserved © AOAC International

Beto, J. A. (2015) The role of calcium in human aging. *Clinical Nutrition Research,* **4**, 1–8. http://dx. doi.

org./10.7762/cnr.2015.4.1.1

Eduardo, H., Diego, L. F., Vanessa, B., Natalia, M., Sandra, R. and Salvador, F. (2016) Characterization of vegetable fiber and its use in chicken burger formulation. *Journal of Food Science and Technology*, **53** (7), 3043–3052. https:// doi. org/10.1007/s13197-016-2276-Y

El-Adawy, T.A., Rahma, E.H., El-Bedawey, A.A. and El-Beltagy, A.E. (2004) Nutritional potential and functional properties of germinated mungbean, pea and lentil seeds. *Plant Foods for Human Nutrition,* **58** (3), 1-13.

FAO/WHO (2007) Food and Agriculture Organization/World Health Organization/United Nations University. Joint FAO/WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition: Geneva, Switzerland. Protein and amino acid requirements in human nutrition: report of a joint FAO/WHO/UNU expert consultation. *World Health Organization Technical Report Series*, **935**, 1–265. https://apps. who.int/iris/handle/10665/43411

Fouad, A. A. and Ali. Rehab, F. M. (2015) Effect of germination time analysis bioactivity of lentil (*Lens Culinaris* MEDIK) sprouts. *Acta Scientiarum Polonorum Technologia Alimentaria*, **14** (3), 233–246. https:// doi.org 10.17306/J.AFS.2015.3.25.

Ghavidel, R. A. and Prakash, J. (2007) The impact of germination and dehulling on nutrients, antinutrients, in vitro iron and calcium bioavailability and in vitro starch and protein digestibility of some legume seeds. *LWT-Food Science and Technology,* **40** (7), 1292-1299.

Haddad, E. H. and Tanzman, J. S. (2003) What do vegetarians in the United States eat? *The American Journal of Clinical Nutrition*, **78**(suppl), 626S–632S. https://doi.org/10.1093/ ajcn/78.3.626S

Hemalatha, S., Platel, K. and Srinivasan, K. (2007) Bioavailability influence of heat processing on the bioaccessibility of zinc and iron from cereals and pulses consumed in India. *Journal of Trace Elements in Medicine and Biology,* **21**, 1-7. https:// doi.org / 10.1016/j.jtemb.2006.10.002

Hirdyani, H. (2014) Nutritional composition of chickpea (*Cice rarietinum*-L) and value added products. *Indian Journal of Community Health*, **26** (2), 102-106. Available from: https://www.iapsmupuk.org/ journal/index.php/IJCH/article/view/477

Kerckhoffs, D. A., Brouns, F., Hornstra, G. and Mensink, R. P. (2002) Effects on the human serum lipoprotein profile of β -glucan, soy protein and isoflavones, plant sterols and stanols, garlic and tocotrienols*. The Journal of Nutrition,* **132** (9), 2494 –2505.

Khattab, R. Y. and Arntfield, S. D. (2009) Nutritional quality of legumes seeds as affected by some physical treatments. 2. Antinutritional factors. *LWT-Food Science and Technology,* **42**, 113-118. https://doi.org/10.1016/j.lwt.2009.02.004

Kiers, J. L., Nout, M. J. and Rombouts, F.M. (2000) *In vitro* digestibility of processed and fermented soya bean, cowpea and maize. *Journal of the Science of Food and Agricultur, **80***, 1325-1331. https://doi. org/10.1002/1097-0010(200007)80:9<1325::AID-JSFA648>3.0.CO;2-K

Kumar, M. and Sharma. B. D. (2004) The storage stability and textural, physico-chemical and sensory quality of low-fat ground pork patties with carrageenan as fat replacer. *International Journal of Food Science and Technology*, **39**, 31-42. https:// doi.org/10.1111/j.1365-2621.2004.00743.x

Kumari, S., Krishnan, V., Jolly, M. and Archana, S.A. (2014) In *vivo* bioavailability of essential minerals and phytase activity during soaking and germination in soybean (*Glycine max* L.). *Australian Journal of Crop Science,* **8** (8), 1168 – 1174.

Larsson, M., Minekus, M. and Havenaar, R. (1997) Estimation of the bioavailability of Fe2+ and phosphorus in cereals using a dynamic in vitro gastrointestinal model. Journal of the Science of Food and Agriculture, 74, 99-106. https://doi.org/10.1002/ (SICI)1097-0010(199705)74:1<99::AID-JSFA775>3.0.CO;2-G

Luo, Y., Xie, W. and Cui, Q. (2010) Effects of phytase, cellulase, and dehulling treatments on iron and zinc in vitro solubility in faba bean (*Vicia faba L.*) flour and legume fractions. *Journal Agriculture and Food Chem*istry, **58**, 2483-2490. https://doi. org/ 10.1111/j.1750-3841.2009.01490.x

Marero, L. M., Payumo, E. M., Librando, E. C., Lainez, W. N., Gopez, M. D. and Homma, S. (1988). Technology of weaning food formulations prepared from germinated cereals and legumes. *Journal of Food Science,* **53** (5), 1391-1395. https://doi. org/10.1111/j.1365-2621.1988.tb09284.x

Marielle, M., Stephane, G., Noureddine, H., Didier, R., Marion, N., Laure, D. C., Chaffaut, M. A. and Emmanuelle, R. (2018) Nutritional composition and bioactive content of legumes: characterization of pulses frequently consumed in France and effect of the cooking method. *Nutrients,* **10**, 1668. 1-12. https://doi.org/:10.3390/nu10111668.

Marquezi, M., Gervin, V. M., Watanabe, L. B., Moresco, R. and Amante, E. R. (2017) Chemical and functional properties of different common Brazilian bean (*Phaseolus vulgaris* L.) cultivars. *Brazilian Journal of Food Technology,* **20**, 1-9. https://doi.org/10.1590/1981-6723.0616

Martin-Cabrejas, M. A., Ariza, N., Esteban, R., Molla, E., Waldron, K. and Lopez-Andreu, F. J. (2003) Effect of germination on the carbohydrate composition of the dietary fiber of peas (*Pisum sativum* L.). *Journal of Agriculture and Food Chemistry,* **51**(5), 1254 -1259. https://doi.org/:10.1021/jf0207631

Marwat, S. K., Hashimi, M., Khan, K. U., Khan, M. A., Shoaib, M. and Fazalur, R. (2012) Barley (*Hordeum vulgare* L.) a prophetic food mentioned in Ahadith and its ethnobotanical importance. *American-Eurasian Journal Agriculture and Environ Science*, **12**(7), 835 – 841. https://doi.org/ 10.5829/idosi.aejaes.2012.12.07.1794

McCrory, M. A., Hamaker, B. R., Lovejoy, J. C. and Eichelsdoerfer, P. E. (2010) Pulse consumption, satiety, and weight management. *Advances in Nutrition*, **1**, 17–30. https://doi.org/10.3945/an.110.1006

Messina, V. E., Melina, L. and Angles, A. R. (2003) A new food guide for American vegetarians. *Journal American Dietetic Association,* **103** (6), 771-775 https://doi.org/10.1053/jada.2003.50141.

Miller, M. F., Andersen, M. K., Ramsey, C. B. and Reagan, J. O. (1993) Physical and sensory characteristics of low fat ground beef patties. *Journal of Food Science,* **58**, 461- 463. https://doi.org/10.1111/j.1365-2621.1993.tb04299.x

Moshfegh, A., Goldman, J., Ahuja, J., Rhodes, D. and Lacomb, R. (2009) What we eat in America, nhanes 2005-2006: Usual Nutrient Intakes from Food and Water Compared to 1997 Dietary Reference Intakes for Vitamin D, Calcium, Phosphorus, and Magnesium; U.S. Department of Agriculture, Agricultural Research Service: Washington, DC, USA.

Murphy, E. W., Criner, P. E. and Grey, B. C. (1975) Comparison of methods for calculating retention of nutrients in cooked foods. *Journal of Agriculture and Food Chemistry*, **23**, 1153 -1157. https://doi.org/10.1021/jf60202a021

Nurul, H., Boni, L. and Noryati, I. (2009) The effect of different ratios of dory fish to tapioca flour on the linear expansion, oil absorption, colour and hardness of fish crackers. *International Food Research Journal,* **16**, 159 -165.

Oroszvari, B. k., Bayod, E., Shohola, I. and Tornberg, E. (2005) The mechanisms controlling heat and mass transfer on frying beef burgers. 2. The influence of the pan temperature and patty diameter. *Journal of Food Engineering,* **71**, 18 – 27. https://doi.org/10.1016/j.jfoodeng.2004.10.013

Oser, B. L. (1959) In: Albanese, A.A. (Ed.), An integrated essential amino acid index for predicting the biological value of protein in protein and amino acid nutrition. Academic Press, New York.

Piskarev, A. T. (2001) Changes in free amino acid peptides during frozen meat. *Food Science and Technology,* **48**, 40-49.

Prodanov, M., Sierra, I. and Vidal-Valverde, C. (2004) Influence of soaking and cooking on the thiamin, riboflavin and niacin contents of legumes. *Food Chemistry,* **84**, 271–277. https://doi.org/10.1016/S0308-8146(03)00211-5

Prosky, L., Asp, N. G., Furda, I., Devries, J. W., Schweizer, T. F. and Harland, B. F. (1984) Determination of total dietary fiber in foods, food products and total diets inter laboratory study. *Journal of Association of Official Analytical Chemists*, **67**(6), 1044 -1052. https://doi.org/10.1093/jaoac/67.6.1044

Radlowski, E. C. and Johnson, R. W. (2013) Perinatal iron deficiency and neurocognitive development. Frontiers in Human Neuroscience, 7, 34 – 43. https://doi.org/10.3389/fnhum.2013.00585

Ramadhan, K., Huda, N. and Ahmad, R. (2011) Physicochemical characteristics and sensory properties of selected Malaysian commercial chicken burgers. *International of Food Research Journal,* **18**, 1349 –1357.

Recommended Dietary Allowance (2011) Recommended Dietary Allowance: 10 th edition, The national academies press. Washington. DC. Retrieved, 3-30.

Robert, R. W., Amy, M. C., Georgia, K. and Il-Young, K. (2017) Optimizing protein intake in adults: interpretation and application of the recommended dietary allowance compared with the acceptable macronutrient distribution range. *Advances in Nutrition,* **8**, 266 –275. https://doi.org/10.3945/an.116.013821

Roy, D. N. and Rao, P. S. (1971) Evidence, isolation and some properties of trypsin inhibitor in *Lathyrus sativus*. *Journal of Agriculture and Food Chemistry*, **19**, 257-258. https://doi.org/10.1021/jf60174a001

SAS Program, (1996) SAS/STAT User's Guide Release 6.12 edition. SAS Inst. Inc, Cary NC, USA.

Sanchez-Arteaga, H. M., Urías-Silvas, J. E., Espinosa-Andrews, H. and García-Marquez, E. (2015) Effect of chemical composition and thermal properties on the cooking quality of common beans (*Phaseolus vulgaris*). *CyTA – Journal of Food*, **13** (3), 385–391. https://doi.org/10.1080/19476337.2014.988182.

Sandberg, A. S. (2002) Bioavailability of minerals in legumes. *British Journal of Nutrition*, **88**, S281–S285. https://doi.org/ 10.1079/BJN/2002718

Sandstrom, B. (1992) Dose dependence of zinc and manganese absorption in man. *Proceeding of the Nutrition Society*, **51**(2), 211-218. https://doi.org/10.1079/PNS19920031

Saulius, A., Gintautas, J. S., Vilma, K., Romas, G., Vilma, S., Asta R. S., Agila, D. and Jurgita, D. (2016) The chemical composition of different barley varieties grown in Lithuania. *Veterinarija IR Zootechnika,* **73**(95), 9-13.

Siddhuraju, P., Osoniyi, O., Makkar, H. P. S. and Becker, K. (2002) Effect of soaking and ionising radiation on various antinutritional factors of seeds from different species of an unconventional legume, sesbania and a common legume, green gram (*Vigna radiata*). *Food Chemistry,* **79**,273-281. https://doi.org/10.1016/S0308-8146(02)00140-1

Soleimani, N. (2011) Relationship between anaemia, caused from the iron deficiency, and academic achievement among third grade high school female students. Procedia – Social and Behavioral Sciences, 29,1877–1884. https://doi.org/10.1016/j.sbspro.2011.11.437

Taylor, C., Wallace., M. R. and Kathleen, M. Z. (2016) **Review** the nutritional value and health benefits of chickpeas and hummus. *Nutrients,* **8**,766, 1-10. https://doi.org/10.3390/nu8120766

Tharanathan, R. N. and Mahadevamma, S. (2003) Grain legumes been to human nutrition. *Trends in Food Science. & Technology,* **14**, 507-518. https://doi.org/ 10.1016/j.tifs.2003.07.002

Trout, E. S., Hunt, N. C., Johnson, D. E., Claus, J. R., Kastner, C. L., Kropf, D. H. and Stroda, S. (1992) Chemical, physical and sensory characterization of ground beef containing 5 to 30% fat. *Journal of Food Science,* **57**,25-29. https://doi.org/10.1111/j.1365-2621.1992.tb05416.x

Ulloa, J. A., Bonilla-Sánchez, C. R., Ortíz-Jiménez, M. A., Rosas-Ulloa, P., Ramírez-Ramírez, J. C. and Ulloa-Rangel, B. E. (2013) Rehydration properties of precooked whole beans (*Phaseolus vulgaris*) dehydrated at room temperature. *CyTA – Journal of Food,* **11**(1), 94–99. https://doi.org/10.1080/19476337.2012.699104

U.S. (2015) Department of Health and Human Services and U.S. Department of Agriculture. 2015–2020 dietary guidelines for Americans [Internet].8th Edition, [cited 2016 Feb 9]. Available from: http://health.gov/dietaryguidelines/guidelines.

Vita, Đ., Sanita, Z. and Ida J. (2015) Grain composition and functional ingredients of barley varieties created in Latvia. *Proceedings of the Latvian Academy of Sciences. Section B. Natural, Exact, and Applied Sciences*, **69**(4), 158–162. https://doi.org/10.1515/prolas-2015-0023

Viveros, A., Brenes, A., Elices, R., Arija, I. and Canales, R. (2001) Nutritional value of raw and autoclaved kabuli and desi chickpea (*Cicer arietinum* L.). *British Poultry Science,* **42**, 242–251. https://doi.org/ 10.1080/00071660120048500

Wheeler, E. I. and Ferrel, R. E. (1971) A method for phytic acid determination in wheat and wheat fractions. *Cereal Chemistry,* **48**, 312 – 316.

Yang, W. L., Chen, Y. P., Cheng, Y. F., Li, X. H., Zhang, R. Q., Wen, C. and Zhou, Y. M. (2016) An evaluation of zinc bearing palygorskite inclusion on the growth performance, mineral content, meat quality, and antioxidant status of broilers. *Poultry Science*, **95**, 878 – 885. https://doi.org/10.3382/ps/pev445

Yu, S. Y. (1991) Acceptability of fish crackers (keropok) made from different types of flour. *Asean Food Journa*l, **6** (3), 114 -116.

Zia-UL-haq, M., Ahmed, S., Aslam, M. Iqbal, S., Qayum, M., Ahmed, A., Luthria, D. L. and Amarowicz, R. (2011) Compositional studies of (*Lens culinaris* MEDIK) lentil cultivars commonly grown in Pakistan. *Pakistan Journal Botany,* **43** (3), 1563- 1567.

إعداد وتقييم انواع مختلفة من البرجر النباتي المغذي للإناث والنساء

نصرة أحمد عبد الحق
معهد بحوث تكنولوجيا الأغذية ، مركز البحوث الزراعية ، جيزة ، مصر

لقد أجريت الدراسة الحالية للإستفادة من الفاصوليا البيضاء الكاملة والعدس البنى الكامل والحمص الكامل وفريك القمح والشعير لإعداد برجر نباتى صحى من أجل تحسين الإتاحة الحيوية للعناصر المعدنية ويفى بالإحتياجات اليومية من البروتين والأحماض الأمينية للإناث والنساء . تم إجراء التقييم الكيميائى وخواص الطهى والخواص الطبيعية والحسية . أشارت النتائج إلى أن عملية الإنبات التى أعقبتها عملية الطهى أدت إلى إنخفاض معنوى طفيف فى بروتين البقوليات . كما أدت عملية الطهى للفاصوليا البيضاء والحمص والعدس المنبت إلى إنخفاض معنوى فى حمض الفيتك ومثبط التربسين . وأظهرت النتائج أن الألياف الغذائية الذائبة والغير ذائبة أعلى معنويا فى البقوليات المطهية عن البقوليات الخام وفريك القمح والشعير . أيضا أظهرت النتائج زيادة معنوية فى الإحتفاظ بالرطوبة وإمتصاص الزيت وعائد الطهى فى البرجر النباتى بالمقارنة بالعينة التجارية .أوضحت النتائج أن إدماج الفاصوليا البيضاء الكاملة والعدس البنى الكامل والحمص الكامل مع فريك القمح والشعير أدى إلى زيادة فى الإتاحة الحيوية للحديد والزنك والكالسيوم والبوتاسيوم والفوسفور . و أظهرت خلطات البرجر النباتى المختبرة أنها أكثرقبولا خلال التقييم الحسى . وأخيرا أوصى بإعداد برجر نباتي غذائي جيد للإناث (٩-١٣ سنة) والنساء (فوق ٥١ سنة). حيث يمكن من خلالها تلبية إحتياجات أفراد الأسرة العاملة خاصة الفئات النباتية كما يمكن إستخدامها فى تغذية طلاب المدارس والمدن الجامعية والإخوة المسيحين لما تتميز به من قيمة غذائية عالية ورخيصة الثمن وفترة صلاحية طويلة دون الحاجة لحفظها بالتبريد أو التجميد ويمكن استخدامها كمنتجات تجارية.