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Chemical and Anti-Nutritional of Two Kidney Bean after Soaking, Boiling Processing and Sensory Evaluation of Their Produced Burger

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KIDNEY beans (*Phaseolus vulgaris L*) are rich source of nutrients. Effect of soaking for 12hr and boiling after soaking processes on some constituents of white kidney and red kidney beans was performed. Determination of some anti-nutritional factors (Phytic acid and trypsin activity), vitamins, and minerals was achieved using standard procedures. Chemical composition of raw white kidney bean powder was 9.54, 2.05, 2.31, 3.09, 73.06 and 9.95 g/100gwhile it was 17.47, 1.4, 2.9, 5.63, 64.75 and 8.03g/100g, in red kidney beanfor protein, fat, crude fiber, ash, carbohydrates and moisture contents, respectively. The results showed significant differences in the levels of estimated anti-nutritional factors between raw beans and after soaking and boiling processes of kidney beans. The reduction percentages of phytic acid were 15.23, 60.95 and 35.89. While the reduction percentage of trypsin activity were 60.20, 65.30 and 26.87 in white and red kidney beans respectively after soaking and boiling processes compared with raw kidney beans. Generally, soaking and boiling reduced significantly ($p<0.05$) all the anti-nutritional factors and vitamins content of kidney bean. However, the levels of the three minerals (K, Ca and Mg) increased compared with rawbeans. The sensory score of overall acceptability was 6.50 and 8.74 out of ten for white and red kidney bean burger which revealed the acceptability of prepared burger. The current study showed that, burger of red bean are rich sources of protein thus could be useful vegetarian people in their nutrition programs as alternative for beef to improve the health status and prevent chronic diseases.

Keywords: Anti-nutritional; Kidney beans; Cooking processes; Sensory evaluation

Introduction

Legumes are essential sources of protein in the human diets in Egypt and are commonly used throughout the world as they improve the nutritional status of many low-income populations (Akseer et al., 2017; Ahmed et al., 2020). Kidney beans *(Phaseolus vulgaris L)* are considered as valuable source of nutrients because it contains considerable amount of proteins, crude fibers, carbohydrates, folic acid, vitamins and minerals, such as iron, potassium, phosphorous and manganese. However, anti-nutritional factors reduce the quality of kidney beans as they interfere with biological utilization of the legumes nutrients (Kamboj and Nanda, 2018). White kidney bean belongs to the bean family Leguminosae. White beans contain approximately 18 g of protein/100 g , making them an alternative to meat for vegetarians (Maphosa and Jideani, 2017). Red kidney been also being a good source of vegetable protein, soluble and insoluble fibers, minerals and vitamins which are benefits to the cells of the body (Ikram et al., 2021; Mullins and Arjmandi, 2021). Red kidney bean which is an herbaceous annual plant mainly cultivated in hot

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climate in the world. While the varieties of red and black kidney-shaped beans are also cultivated but less widely used (Worku and Sahu, 2017).

Anti-nutrients are compounds found in high concentration in legumes which impair the absorption of protein, minerals, vitamins and digestion (Samtiya et al., 2020).Anti-nutrients affect the bioavailability of food and thus adverse physiological effects can occur when ingested by humans and animals. These anti-nutrients are destroyed by heat or other treatments (Thakur et al., 2019). In the meantime, legumes contain compounds that act as a form of defense mechanism and help to protect the plant from infections or consumption by animals and insects. Moreover, most anti-nutrients can be removed or deactivated by soaking, sprouting, or boiling before consumption, and some traditional methods of preparation, such as fermentation, have been shown to increase nutritional value. Several studies showed that heat treatments like boiling and frying are common forms of household preparation of beans can lower anti-nutritive values (Abbas &Ahmad, 2018).

At domestic levels, legumes are mostly consumed after ordinary processing such as soaking, boiling, cooking, etc. These processes have been reported to reduce the level of anti-nutritional factors (Yasmin et al., 2008; Kamalasundari et al., 2019). The act of cooking food in water is called boiling. This process eliminates the anti-nutritional factors from foods (Nzewi and Egbuonu, 2011). The present study was conducted to assess the effects of boiling and soaking processes on the levels of anti-nutritional factors in two types of kidney beans besides the sensory evaluation of white and red beans burger.

Materials and Methods

Materials

Bean samples

Two varieties of kidney beans (white and red) samples and other used materials such as onion, oat, spices,vegetable oil, and salts etc. were obtainedfrom a local market in Alexandria, Egypt.

Processing of white and red kidney beans

Soaking process

Samples of beans white and red kidney were cleaned; grit and broken beans were removed. Then 500 gm of beans were placed in plastic bowl and washed two times. After that samples were soaked for 12 h in tap water (1:5 w/v) at a room temperature. The soaked samples were then washed in running water and further divided into two equal parts, one part was used for boiling process, while the second part was dried at 40°C for 16 h in oven, then grind. The ground part was used to evaluate the effect of soaking on the anti-nutritional factors.

Boiling process

The soaked samples of kidney beans after draining and washing in running water was used for boiling process. Boiling process was performed in a beaker of water (1:3 w/v) beans: water. Samples were cooked until became soft and uniformly for about 25 minutes.

Chemical composition

The chemical composition including, crude protein, total fats, crude fibers, carbohydrates and moisture, were analyzed in raw samples of white and red beans according to Thomas et al. (2007).

Minerals and vitamins analysis

Minerals include, K, Ca and Mg, were analyzed in raw samples and processing seeds of white and red beans using Atomic Absorption Spectrophotometer (Shimadzu model AA- 6650) (Latimer, 2016).

Vitamins compositions include, B_6, A and E were determined in raw samples and processing seeds of white and red beans (Latimer, 2016).

Anti-nutritional factors analysis

Phytic acid was determined in raw, soaked and boiled bean samples according to the method of Wheeler and Ferrel (1971).

The activity of Trypsin was determined in raw, soaked and boiled bean samples according to Kakade et al. (1969) using benzoyl-DL-arginine-p-nitroanalide hydrochloric as a substrate.

Methods

Formulation of bean burgers

Burger of red and white kidney bean was formulated according to Saba (1991) methods. The ingredients of vegan burger are presented in Table 1.

Preparing of bean burgers

In a large bowl, beans were mashed with a fork. Then onion, salt and spices mixture were added and mixed well. After that oat was added to the mixture and mixed. The resultant mixtures of burgers were shaped into medium-sized circles (each about 10 cm diameter). In a large skillet vegetable oil was placed and heated. After heating burger circles were transferred to the skillet and cooked until turned brown.

TABLE 1. Ingredients and quantity of bean burgers

Ingredients	Quantity
Red or white kidney bean	500 g
Onion	110g
Oat	10 g
Vegetable oil	30 mL
Salts	5g
Spices mixture *	5g

*Turmeric, Curry, Black Pepper, Ginger, Cumin, Parsley, Chili and Celery

Sensory evaluation

Sensory evaluation was organized with forty panelists from staff and students of High Institute of public health, Alexandria University. The samples of the two types of beans burger were evaluated for color, odor, taste, texture and overall acceptability according to the method of Cross et al. (1978).

Statistical analysis

Complete randomize design was used and data analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Student t-test was used to compare two groups for normally distributed quantitative variables while, ANOVA was used for comparing studied groups and followed by Post Hoc test (LSD) for pairwise comparison. Significance of the obtained results was judged at the 5% level.

Results and Discussion

Chemical composition of white and red kidney bean

Nutrients in white and red kidney beans were analyzed to determine their nutrient profile which includes, protein, fat, fiber, carbohydrates and minerals contents. The gross chemical composition of white and red kidney bean raw powder is shown in Table 2. The results showed that the percentages of protein contents, fat, fiber, ash, carbohydrates and moisture were 9.542, 2.05, 2.31, 3.09, 72.94 and 9.95 g/100g, respectively in white kidney bean,while it was 17.47, 1.4, 2.9, 5.63, 64.07 and 8.03g/100g, respectively in red kidney bean. The data displayed the type of red kidney been containing more contents of protein and fiber than white kidney bean. Although the type of white kidney bean contains more percentages of fat and carbohydrates compared with red kidney bean. Variation in Protein were not significantly different (P=0.05) ranging from 7.92% to 10.70%of Lima Bean (Adebayo, 2014).

Percentage of dry mater(n = 3)

The obtained results are in contrast with the findings of Rui et al. (2011) who reported that protein content was ranged between 22.36–28.50% on dry basis in different varieties of beans. Also, United States Department of Agriculture (USDA) (2015), reported that some beans contain between 22.50 to 27.90 % of protein by weight, which considered much higher than other sources of vegetable protein (United States Department of Agriculture (USDA), 2015).

Concerning fat content in raw of the two varieties of kidneys bean, the percentage of fat was found to be fairly low 2.05 and 1.4 g/100g for white and red beans, respectively. These values matched with Roy et al. (2020) who found that the crude fat content in beans was about 3.07%, the variation might due to the cultivar and environmental impacts of varied regions. The ash content was found to be 3.09 and 5.63 g/100g, which falls within the range of 4.25% to 5.09% as recorded for various bean varieties (Rui et al., 2011). The crude fiber content was 2.31 and 2.9 g/100g for white and red kidney beans, while Pathak and Kulshrestha (2017) reported that the crude fiber content in small and large red kidney bean was 7.87and 8.16%, again this variation might depend on cultivar, fertilizers and environmental conditions of the region. Moreover, Tosh and Yada (2010) found that dry beans are rich in both soluble and insoluble fibers. With regard to the carbohydrate content the data showed the percentages were 72.94 and 64.07 g/100g in raw of white and red kidney beans. The carbohydrate value observed in this study is in conformity with the value of 60.65 g /100g that reported by Sasanam et al. (2011) in red kidney bean and values of 58.64 g /100g for dark red kidney bean (Scholnick &Winslow, 2020). The percentages of moisture content were 9.95 and 8.03 g/100g in raw of white and red kidney beans. The variations in moisture content of the two cultivars may be attributed to various factors like time of harvesting, agro conditions and the cultivar differences. Further, the variations of ash percentages between the two types of kidney bean might due to the varietal variations and cultural practices.

TABLE 2. Gross proximate composition of red and white kidney bean powder

Parameters	White kidney (g100/g)	Red kidney (g100/g)	t	p
Protein	9.54 ± 0.74	17.47 ± 0.88	6.878	0.002*
Fat	2.05 ± 0.19	1.40 ± 0.32	1.759	0.153
Fiber	2.31 ± 0.11	2.90 ± 0.64	0.898	0.420
Ash	3.09 ± 0.27	5.63 ± 0.67	6.090	0.004*
Carbohydrate	73.06 ± 1.70	64.57 ± 1.21	7.047	0.002*
Moisture	9.95 ± 0.81	8.03 ± 1.14	1.365	0.244

Data was expressed using Mean ± SE.
*: Statistically significant at p ≤ 0.05

Effect of soaking and boiling processes on levels of anti-nutritional factors

The effect of soaking and boiling processes on the levels of anti-nutritional factors (phytic acid and trypsin activity) of white and red kidney bean is presented in Table 3 and Fig. 1&2. The results showed that phytic acid percentage showedlower values compared to raw white and red kidney beans, respectively in the white and red kidney bean samples that soaked for 12hr (0.89 and 2.5%). The same trend was estimated for boiled samples after soaking for 12 hr, whereas the phytic acid percentage was 0.41 and non-detected (N.D) compared with the highest percentage (1.05 and 3.9%), respectively in raw white and red kidney bean. The results also showed that trypsin activity was reduced in the white and red kidney bean samples that soaked for 12hr (0.39 and 1.85 U/mg). The same trend was estimated for boiled samples after soaking for 12 hr (0.34 U/mg, respectively and ND), compared with the trypsin activity (0.98 and 2.53 U/mg, respectively) in raw white and red kidney bean. The results showed significant differences in the levels of estimated anti-nutritional factors between raw beans and after soaking and boiling processes of kidney beans. The reduction percentages of phytic acid were 15.23 ,60.95 and35.89, while the reduction percentage of trypsin activity were 60.20, 65.30 and 26.87 in white and red kidney beans respectively after soaking and boiling processes compared with raw kidney beans. The data showed significant differences in the estimated levels of anti-nutritional factors between the raw beans of two types of kidney beans and between the two processes (soaking and boiling). Generally soaking and boiling reduced all the anti-nutritional factors. The results in the line with Haileslassie et al. (2019) who reported that phytates level reduced after soaking and clarify that might due to leaching of the anti-nutrients in the soaked water. This conforms to study carried out by Laurena et al. (1986) who observed that soaking cowpea in alkaline and acidic media led to decrease in phytic acid. The reduction of anti-nutritional (tannin) content after soaking might be due to the leaching out of polyphenols into the soaking water (Adebayo, 2014). Tannin are polyphenols which soluble in water and generally located in the seed coat (Singh, 1988). The levels of anti-nutrients are higher in red kidney bean, chickpea and lentil compared with white kidney bean, and white gram (Berrios-Silva, 1995). Our results are consistent with those observed Huma et al. (2008) in which the reduction of phytic acid is attributed to its leaching in soaking and boiling water. Furthermore, cooking soaked legumes in a pressure cooker for 15 min showed a reduction of 25.2-50.1% in anti-nutritional legume contents.

Effect of soaking and boiling processes on vitamins content

Table 4 shows the presence of vitamins content in raw, soaking and boiling seed of red and white kidney beans. The results showed that soaking for 12 hr decreased the content of vitamin B_6, A and E to 2.25, 1.19 and 0.81 mg/100g), respectively for white kidney bean as compared to the values obtained in the raw. While soaking for 12 hr decreased the content of vitamin B_6, A and E to 2.11, 1.12 and 0.8 mg/100g), respectively for red kidney bean as compared to the values obtained in the raw. The results showed that boiling after soaking process decreased the content of vitamin B_6, A and E to 2.15, 1.02 and 0.77 mg/100g), respectively for white kidney bean as compared to the values obtained in the raw. While boiling after soaking process decreased the content of vitamin B_6, A and E to 1.95, 0.98 and 0.74 mg/100g), respectively for red kidney bean as compared to the values obtained in the raw.

TABLE 3. Level of anti-nutritional factors in Raw, Boiled and soaked of white and red kidney bean of different processes

Bean samples	Process	Time	Phytic acid (%)		Trypsin inhibitor (TIU*/mg)	
			Mean ± SE	RD %	Mean ± SE	RD %
White kidney	Raw seeds	0	1.05c ± 0.03	0.00	0.98c ± 0.26	0.00
	Soaked	12 hr	0.89c ± 0.01	15.23	0.39d ± 0.03	60.20
	Boiling after soaking	25min	0.41b ± 0.03	60.95	0.34d ± 0.02	65.30
Red kidney	Raw seeds	0	3.90a ± 0.35	0.00	2.53a ± 0.23	0.00
	Soaked	12 hr	2.50b ± 0.31	35.89	1.85b ± 0.11	26.87
	Boiling after soaking	25min	N.D	100	N.D	100
	LSD 5%		0.46		0.51	

Data was expressed using Mean ± SE.
Statistically significant at $p \leq 0.05$ (n = 5)
∗ TIU = Trypsin inhibited unit. RD=Reduction %

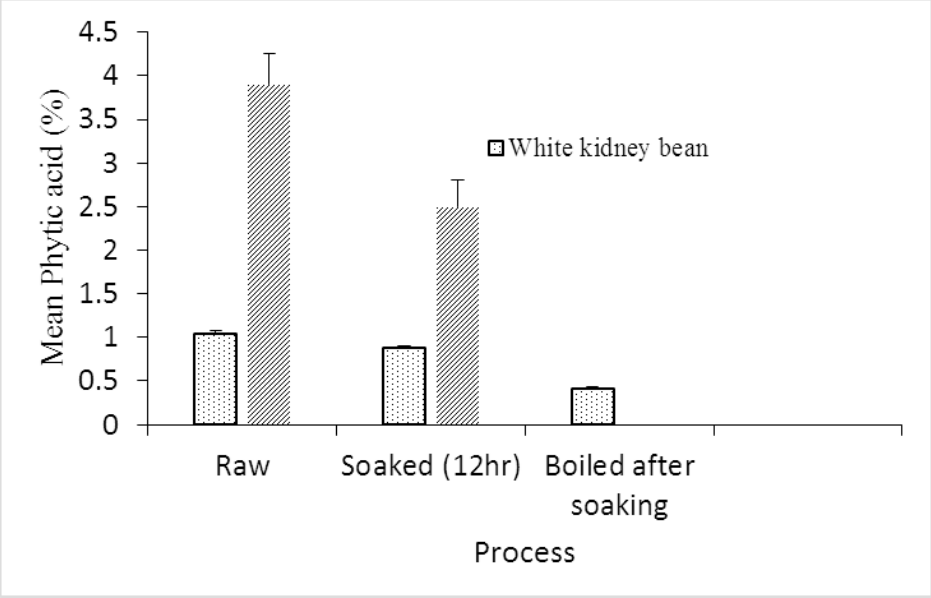

Fig.1. Level of phytic acid in raw, soaked and boiled processes of white and red kidney bean

The data showed that the level of vitamin B_6 was significantly higher in white than red bean kidney. The present results indicated that there was no significant difference between the two types of beans in the levels of vitamin A or vitamin E. Moreover, significant differences were observed in the level of vitamin B_6 between raw bean and processed bean (soaking and boiling). In the case of red kidney, no significant differences were observed in the level of the three vitamins between raw bean and soaking red bean. While significant difference in the reduction of the three vitamins were observed between raw bean and boiling red bean.

The results in Table 3 reveal that cooking processes reduced significantly ($p<0.05$) vitamins content of kidney bean. The current results in line with the earlier report, that processing of legumes by heating led to reduction of vitamins content (Olanipekun et al., 2015). Davey et al. (2000) reported that vitamins are lost during heat treatment due to their high sensitivity to oxidation, and leaching into a water-soluble media. The current data showed that boiling reduced vitamin A value of the sample of white and red kidney beans to 1.02 and 0.98 mg/100g, respectively; while vitamin was reduced to 0.77and 0.74 mg/100g by boiling, respectively.

Fig. 2. Level of trypsin activity in raw, soaked and boiled processes of white and red kidney bean

TABLE 4. Mean vitamin content of raw and processed seed of red and white kidney bean (Phaseolus vulgaris).

Vitamins (mg/100g)	White kidney bean			Red kidney bean			F	P	LSD 5%
	Raw	Soaked for 12hr	Boiled after soaking	Raw	Soaked for 12hr	Boiled after soaking			
B_6	$2.43^{a} \pm 0.07$	$2.25^{b} \pm 0.02$	$2.15^{bc} \pm 0.02$	$2.13^{bc} \pm 0.01$	$2.11^{c} \pm 0.06$	$1.95^{d} \pm 0.03$	15.258*	<0.001*	0.1262
A	$1.33^{a} \pm 0.05$	$1.19^{abc} \pm 0.07$	$1.02^{bc} \pm 0.01$	$1.26^{ab} \pm 0.18$	$1.12^{abc} \pm 0.06$	$0.98^{c} \pm 0.02$	2.469	0.093	0.2665
E	$0.83^{ab} \pm 0.03$	$0.81^{ab} \pm 0.01$	$0.77^{ab} \pm 0.02$	$0.87^{a} \pm 0.06$	$0.80^{ab} \pm 0.05$	$0.74^{b} \pm 0.04$	1.355	0.307	0.1217

Data was expressed using Mean ± SE.

F: F for ANOVA test, pairwise comparison bet. Each 2 groups was done using Post Hoc Test (LSD)

Means in the same column with common letters are not significant (*i.e.* Means with Different letters are significant)

p: p value for comparing between the studied groups

*: Statistically significant at $p \leq 0.05$.

Sen &Chakraborty (2011)mentioned that vitamins A and E are antioxidants which play a major role in fighting diseases, such as cancer and diabetes. Our result showed that the levels of vitamin B_6 was 2.15 mg/100g in white kidney bean, while the level was low (1.95 mg/100g) in red kidney beans, after boiling. These results matched with the results of Mananga et al. (2022) who reported that the level of vitamin B_6 was (3.16 mg/100g) in white kidney beans. The observations of the levels of vitamins made in this study are similar to those reported by Ziarno et al. (2019).

Effect of soaking and boiling processes on mineral composition

Table 5 shows the mineral composition of raw, soaking and boiling after soaking seed of red and white kidney beans. Soaking for 12 hours and boiling increased the content of Ca (0.31- 0.35mg/100g), K (0.51- 0.55mg/100g) and Mg (0.27 - 0.31mg/100g) for white kidney bean as compared to the values obtained in the raw. Soaking for 12 hrand boiling increased the content of Ca (0.27- 0.29mg/100g), K (0.49-0.50mg/100g) and Mg (0.24- 0.27mg/100g) for red kidney bean as compared to the values obtained in

the raw, however there were no significant effect between groups of white and red kidney beans. The current results are matched with that reported byAmarowicz et al. (2009) in which minerals are not destroyed by exposure to heat. In contrast some studies reported reduction in mineral concentration due to leaching of minerals into the boiling water, and removal or destroying the seed coat of kidney bean. Removal of seed coat might be concerned with mineral reduction in grainsas reported by Damodaran &Parkin (2008).

In contrast, Obasi &Wogu (2008) reported that the increases of mineral contents upon soaking might be due to the decrease in the anti-nutritional factors with increase in soakingtime. The anti-nutritional factors leached into the soaking water, thereby decreasing theirconcentration in the lima bean seed, thus releasing more minerals from their organically bound complexes due totheir decreased concentration as these anti nutritional factors bind with minerals.

Sensory evaluation of cooked bean burgers

Vegan burger could be used as alternative to beef burger. Chemical composition of white and red kidney bean showed that both types of beans contain pronounced contents of protein and low level of fat which makes them candidates to be alternatives to beef in preparing burgers particularly for vegetarian peoples. The data in Table 6, and Fig.3 showed that evaluation of the sensory properties of white and red kidney bean burger. The data revealed significant differences in color, taste, odor, texture and overall acceptability between white and red kidney burger. The data showed that red kidney burger was more preferable for panelists compared with white bean burger. The sensory score of overall acceptability were 6.50 and 8.74 out of ten for white and red kidney bean burger.

In general, the overall acceptability revealed that the burger which prepared from red kidney bean was more acceptable for the panelists than burger of white kidney bean. Moreover, white or red kidney bean burger considered rich sources of protein might be useful for vegetarian people as alternative for beef proteins. Thus, bean burger might implement in the programs to improve the health status and prevent chronic diseases. Faid (2019) reported that antioxidant characteristics of germinated red beans were the major reason for the elevated sensory scores of the formulations preventing the formation of rancidity and off-odors during storage. Kassem &Emara (2010) mentioned that adding vegetable products such as bean to meat improve its functional properties, minimize product cost, keeping nutritional and sensory qualities. However, the best taste was significant for the control of beef burger which was prepared from 15% fat followed by 10 and 7.5%. The bean protein of soy is one of the most widely used vegetable proteins that mixed with minced meat industry which to decrease the final cost of meat products. Vegetables beans provide essential minerals and vitamins (Kassem &Emara, 2010). Moreover, vegetables beans considered rich sources of dietary fiber and natural antioxidants in a meat system (Aminzare et al., 2019). Mixing vegetables beans with meat might improve eating quality characteristics, desirability, and palatability which are determinants of consumer acceptance and preference. In this respect, many efforts have been made to improve the quality and stability of burgers to meet the consumer.

TABLE 5. Mean mineral content of raw and processed seed of red and white kidney bean

Mineral (mg/100g)	White kidney bean			Red kidney bean			F	P	LSD 5%
	Raw	Soaked for 12hr	Boiled after soaking	Raw	Soaked for 12hr	Boiled after soaking			
Ca	0.27^{a} ±0.02	0.31^{a} ±0.04	0.35^{a} ±0.03	0.24^{a} ±0.03	0.27^{a} ±0.02	0.29^{a} ± 0.16	0.268	0.922	0.215
K	0.49^{a} ±0.14	0.51^{a} ±0.14	0.55^{a} ±0.18	0.45^{a} ±0.15	0.49^{a} ±0.09	0.50^{a} ± 0.17	0.055	0.998	0.4528
Mg	0.25^{a} ±0.09	0.27^{a} ±0.09	0.31^{a} ±0.13	0.21^{a} ±0.06	0.24^{a} ±0.10	0.27^{a} ± 0.10	0.134	0.981	0.2935

Data was expressed using Mean ± SE. n=3

F: F for ANOVA test, Pairwise comparison bet. Each 2 groups was done using Post Hoc Test (LSD)

Means in the same column with common letters are not significant (*i.e.* Means with Different letters are significant)

p: p value for comparing between the studied groups

*: Statistically significant at p ≤ 0.05

TABLE 6. Sensory evaluation of cooked bean burgers

Burgers	Color	Taste	Odor	Texture	Overall acceptability
White Kidneybean	6.84 ± 0.37	6.70 ± 0.46	6.62 ± 0.49	7.06 ± 0.42	6.50 ± 0.51
RedKidneybean	9.02 ± 0.14	8.66 ± 0.48	9.06 ± 0.31	8.58 ± 0.50	8.74 ± 0.44
t	38.886*	20.817*	29.643*	16.418*	23.574*
p	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

t: Student t-test *: Statistically significant at p ≤ 0.05

Fig. 3. Burger prepared from white and red kidney bean

Conclusions

We concluded that soaking and boiling reduced all the anti-nutritional factors and vitamins content of kidney bean. Evaluation of sensory properties of white and red kidney bean burger revealed that the overall acceptability of the burger prepared from red kidney bean was more acceptable for the panelists than burger of white kidney bean.

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