BEEF SAUSAGE AND BEEF BURGER PRODUCTION BY ADDING TREATED MUNG BEAN

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ABSTRACT

This study was carried out to remove the antinutritional matters from mung bean seeds used to produce beef sausage and beef burger products. Crude protein content in mung bean seeds was 26.8%, while, the antinutritional factors: trypsin inhibitor, tannins, α-amylase inhibitor, hemagglutinating, phytic acid, total vicine, raffinose, stachyose and verbascose were: 4.6 mg/g, 1.36%, 299 U/g, 1902 U/g, 1.93%, 4.7 mg/g, 0.28%, 0.63% and 1.46%, respectively.

Soaking mung bean seeds in sodium bicarbonate solution (pH 7.85) was effective in removing all antinutritional matters except phytic acid, however, germination was most effective for its reduction. But soaking in citric acid solution was more effective when compared in lowering the content of phytic acid, raffinose, stachyose and varbascose.

In order to reduce the cost of beef products, meat was replaced by rehydrated mung bean flour at the levels of 0, 5, 10, 15, 20, 25, 30 and 35% besides improving their physico-chemical propeties.

INTRODUCTION

Mung bean is considered an important source of high quality plant protein for human consumption, however, it contains various antinutritional matters. It is of great importance to find a formula for beef sausage and beef burger which lowers the cost of these products, especially under local conditions of meat shortage and high price.

Several conventional processing methods such as soaking and heat treatment were required to remove the undesirable components from dry mung bean seeds for improving their nutritional quality.

Germination has been suggested as an inexpensive and effective method for improving the quality of legumes by enhancing their digestibility (Reddy *et al.*, 1985), increasing the level of amino acids (Chang and Harrold, 1988) and reducing the content of antinutritive matters (Vidal-Valverde *et al.*, 1994; Urbano *et al.*, 1995; Zaki, 1996; Abuel-Fetouh *et al.*, 1998 and El-Bagoury *et al.*, 1999).

The objective of the present work was to decrease antinutritive matters in mung bean seeds by using soaking, germination and autoclaving. After that using treated mung bean seeds in preparing beef sausage and beef burger.

MATERIALS AND METHODS

Materials:

Seeds of mung bean (*Vigna radiate* L.) variety 2010 were obtained from Agricultural Research Center, Giza, Egypt.

Raw beef meat and mutton fat purchased from supermarkets of Kalyobia. Spices ingredients (black pepper, cardamom, cloves, cubeb, cumin, garlic, nutmeg, fennel, coriander, laurel and cardamom) were purchased from local market.

Treatments:

Soaking: Dry mature mung bean seeds were soaked in three treatments distilled water, 0.1% citric acid (pH 4.94) and 0.07% sodium bicarbonate (pH 7.85). The seeds were soaked for 3, 6, 9 and 12 h then drained.

Germination: Dry mature mung bean seeds were soaked for 2 h in distilled water then germinated in sterile beakers lined with filter paper, and placed in dark incubator at 25°C. Distilled water was sprinkled on seeds twice a day during germination. Seeds germinated for 24, 48 and 72 h.

Autoclaving treatment: Soaked, germinated and unsoaked seeds were autoclaved at 121°C for 10, 20, 30, and 40 min and dried in oven at 50°C then ground to flour.

Preparation of beef sausage and burger samples:

Visible fat tissues were trimmed from lean meat, then minced by electric chopper. Mutton fat tissues also, were minced. Mung bean flour was rehydrated by mixing with distilled water at ratio 1 : 2 (w:w) and added by levels, 0 (control), 5, 10, 15, 20, 25, 30 and 35% replace with beef meat to prepare sausage and burger. The formula of beef sausage and burger is shown in Table (1) as mentioned by Moghazy and El-Shaarawy (2001) and Moghazy *et al.* (2004):

Table (1): The formula of beef sausage and burger prepared in laboratory

Component	Sausage	Burger	Spices mixture
Beef meat	**70.60%**	**62.00%**	**For sausage:** Fennel 59.76%, coriander 27.09%, cubeb 3.19%, black pepper 3.19%, clove 3.19%, laurel 1.99% and cardamom 1.59%.
Mutton fat	**14.00%**	**-**	
Water (as ice flakes)	**7.00%**	**10.00%**	
Starch	**4.65%**	**-**	
Sodium pyrophosphate	**0.30%**	**-**	
Salt (NaCl)	**2.00%**	**1.50%**	
Garlic	**0.24%**	**-**	**For burger:** Black pepper 5.61%, cardamom 2.24%, cloves 2.24%, cubeb 22.42%, cumin 11.21%, garlic 56.05%, and nutmeg 0.22%.
Skimmilk powder	**0.40%**	**-**	
Glucose	**0.1%**	**-**	
Ascorbic acid	**0.04%**	**-**	
Sodium nitrite	**0.01%**	**-**	
Ground onion	**-**	**7.00%**	
Egg	**-**	**7.00%**	
Semolina	**-**	**12.00%**	
Spices mixture	**0.66%**	**0.50%**	

Beef sausage and beef burger products were fried according to Modi *et al.* (2003).

Methods:

Assay of trypsin inhibitors (TI): The trypsin inhibitors activity (TIA) was measured as described by Stauffer (1993).

Determination of Hemagglutinating (HA): Lectin activity was determined by measuring its hemagglutinating action according to the method described by Lis and Sharon (1972).

Determination of phytic acid: Phytic acid content was estimated colorimmetrically using Wade reagent (Latta and Eskin, 1980).

Determination of total vicine: Total vicine was extracted and determined according to the method of Collier (1976).

Determination of raffinose oligosaccharides: Oligosaccharides were extracted from powdered samples with 80% (v/v) ethanol (Akpapunam and Markakis, 1979). Unidirectional descending paper (Whatman No. 1, 20x45 cm) chromatography using a solvent of n-butanol, ethanol and water (5:3:2 by volume) was conducted for 48 h to separate oligosaccharides. The sugars were identified on the basis of their R_F and R_G values according to Akpapunam and Markakis (1979). The concentration of the identified sugars was determined using the phenol sulphuric acid method of Dubois *et al.* (1956).

Alpha-Amylase inhibitor assay: The extraction of α-amylase inhibitor was performed as described by Bernfeld (1955).

***In vitro* protein digestibility:** The digestibility of protein *in vitro* was carried out as described by Santosh and Chauhan (1986).

Chemical analysis: Moisture, crude protein, ether extract, ash and crude fiber contents were determined according to A.O.A.C. (1995). Carbohydrates content was calculated by difference.

Freshness tests: Total volatile nitrogen (TVN) was determined according to the methods mentioned by Winton and Winton (1958). Thiobarbituric acid (TBA) value was determined according to Harold *et al.* (1981). The pH value of meat product was measured using digital pH-meter model SA 210 according to the method of Woye Woda *et al.* (1986).

Water holding capacity (WHC) and plasticity were measured according to the method described by Soloviev (1966).

Cooking loss and shrinkage were determined according to Darweash and Moghazy (1998).

Sensory evaluation was evaluated according to Watts *et al.* (1989).

Statistical analysis was applied on the results of organoleptic evaluation of different samples of beef sausage and beef burger which were treated as data for complete randomization design. Least significant difference (L.S.D.) was calculated at 0.05 level of significance according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Chemical composition of raw mung bean seeds:

Data in Table (2) show that crude protein content was 26.8% which was higher than 23.4% in ten mung bean genotypes studied by Ismail (1995), but, lower than 28.2% found by Abou Arab and Helmy (2001) for unspecified cultivar. This difference in protein content could be attributed to genetical and environmental factors. The antinutritive matters, trypsin inhibitor (TI), tannins, α-amylase inhibitor (α-AI), hemagglutinating (HA), phytic acid, total vicine, raffinose, stachyose and verbascose in the dry mature mung bean seeds were determined to be 4.60 mg/g, 1.36 g/100g, 299 U/g, 1902 U/g, 1.93%, 4.70 mg/g, 0.28%, 0.63% and 1.46%, respectively. Our data were different from those reported by Zaki (1996), but, agreed with the results of Abuel-Fetouh *et al.* (1998).

Table (2): Chemical composition of mung bean seeds.

Components		
Moisture	**(%)**	**10.53**
Crude protein*	**(%)**	**26.80**
Ether extract*	**(%)**	**1.24**
Ash*	**(%)**	**4.35**
Crude fiber*	**(%)**	**3.10**
Available carbohydrate*#	**(%)**	**64.51**
Trypsin inhibitor *	**(mg/g)**	**4.60**
Tannins*	**(g/100 g)**	**1.36**
α-amylase inhibitor*	**(U/g)**	**299.00**
Hemagglutinating*	**(U/g)**	**1902.00**
Phytic acid*	**(g/100 g)**	**1.93**
Total vicine*	**(mg/g)**	**4.70**
Raffinose*	**(%)**	**0.28**
Stachyose*	**(%)**	**0.63**
Verbascose*	**(%)**	**1.46**

*** Calculated on dry weight basis**

Effect of soaking on antinutritional matters:

Soaking mung bean seeds in the three treatments resulted in gradual decline in all antiutrional matters as shown in Table (3) and illustrated in Fig. (1). These treatments were effective in removing about 24 to 29% of TI, 31 to 33% of α-AI, 25 to 28% of HA, 11 to 13 of tannins, 18 to 30% phytic acid, 29 to 38% of vicine, 13 to 28% of raffinose, 25 to 36% of

stachyose and 31 to 38% of verbascose contents. Fig. (1) included two lines only in the case of verbascose that distilled water and $NaHCO_3$ have the same line. The results clearly show that soaking in 0.07% sodium bicarbonate solution was more effective in removing all antinutritional matters except phytic acid. But soaking in citric acid solution was more effective when compared in lowering the content of phytic acid, raffinose, stachyose and varbascose.

These results are in agreement with those of Fernandez *et al.* (1993) who observed that after soaking faba beans in H_2O, citric acid and sodium bicarbonate solutions, a decrease in TI took place except in citric acid soaking, due probably to the stability of the inhibitor in acidic pH.

Effect of germination on antinutritional matters:

Germination increases the activity of anabolic and catabolic reactions which has been applied to mung bean seeds to study its effect on the levels of various antinutrional matters. As shown in Table (4) and Fig (2) TIA gradually decreased to 27% of its original level in ungerminated seeds. These results are in agreement with those of Bau *et al.* (1997), Abdel-Galil (1998) and Zaki *et al.* (1999).

Germination for 72 h removed 81% of HA in mung bean seeds. Bau *et al.* (1997) observed disappearance of most HA activity in soybean after 4 days of germination.

The germination process led to sharp decrease in α-AI levels to reach 22%. Decrease in α-AI in germinated seeds could be attributed to proteolytic degradation of inhibitor during germination (Gupla and Wagle, 1980).

Germination is the most effective process for reduction of phytic acid content in mung bean seeds. These losses may be attributed to the activity of the phytase enzyme. Vidal-Valverde *et al.* (1994) noted that phytic acid was hydrolyzed during germination.

A sharp reduction was observed in verbascose sugars during the first 24 h of germination to 53% but, slight decrease was for stachyose (24%) and verbascose (8%) during the same period. At the end of germination (72 h) the reduction of sugars was 76%, 71% and 56% for verbascose, stachyose and raffinose, respectively.

Table (4): Effect of germination time on antinutritional matters

Germination time (h)	Trypsin inhibitor (%)	Alpha-amylase inhibitor (%)	Hemagglutinating (%)	Phytic acid (%)	Total vicin (%)	Tannins (%)	Raffinose (%)	Stachyose (%)	Verbascose (%)
Raw	100	100	100	100	100	100	100	100	100
24	76	56	48	72	89	100	92	76	47
48	42	34	26	44	75	70	70	73	38
72	27	22	19	15	45	40	44	29	24

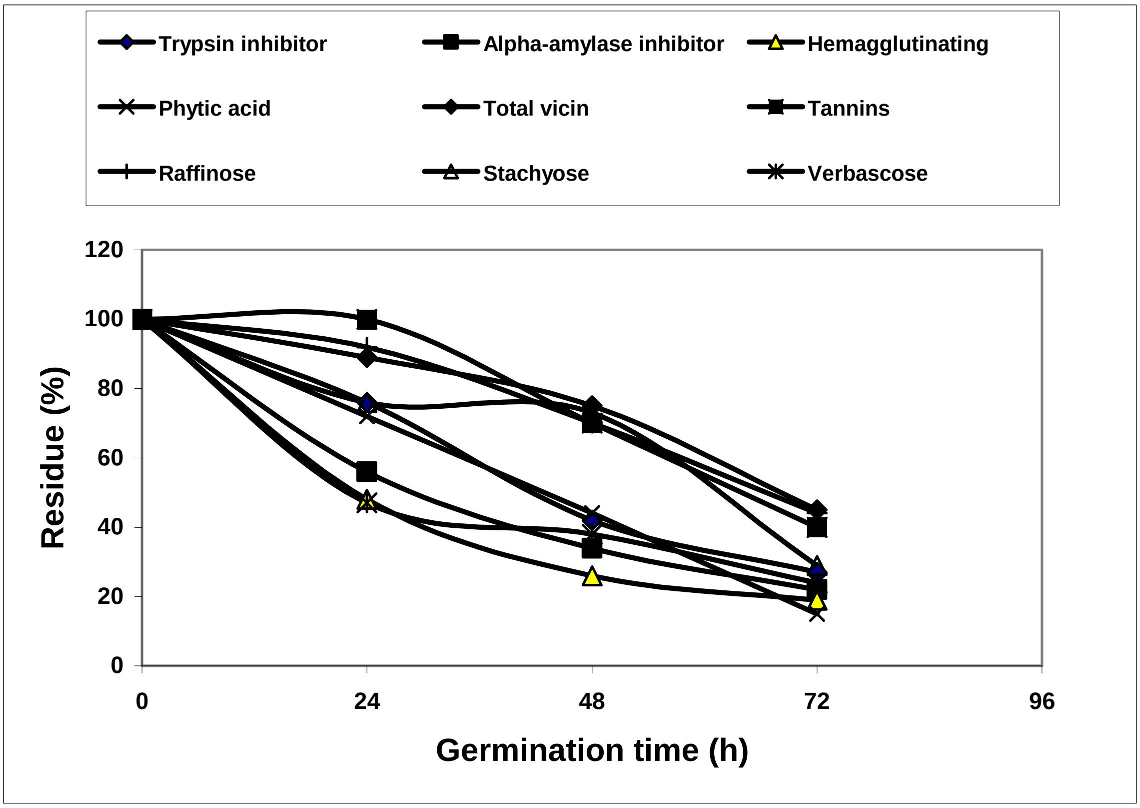

Fig. (2): Effect of germination time on antinutritional matters.

The effect of autoclaving on the antinutritional matters in mung bean seeds:

Data in Table (5) and Fig. (3) indicated that autoclaving was more effective than soaking for inactivating antinutritional matters in mung bean seeds. However high reduction was observed in soaked-autoclaved seeds.

Moreover, autoclaved germinated seeds revealed enormous reduction. The results of the present work suggest that a combination of two or more simple processing methods may be used to improve the nutritional value of mung bean seeds. Our data agreed with those of Khalil and Mansour (1995), on faba beans.

Table (5): Residual percentage from antinutritional matters after autoclaving

Treatments	Trypsin inhibitor (%)	Tannins (%)	Alpha-amylase inhibitor (%)	Hemagglutinating (%)	Phytic acid (%)	Total vicine (%)	Raffinose (%)	Stachyose (%)	Verbscose (%)
Control without autoclaving	100	100	100	100	100	100	100	100	100
Dry seed	44	46	45	35	65	51	42	39	40
Soaking in water	18	17	12	0	29	38	13	11	9
Soaking in sodium bicarbonate	16	21	14	0	25	35	11	9	8
Soaking in citric acid	34	23	17	0	19	37	8	6	5
Germinated for 72 h	4	10	10	0	13	33	13	11	9

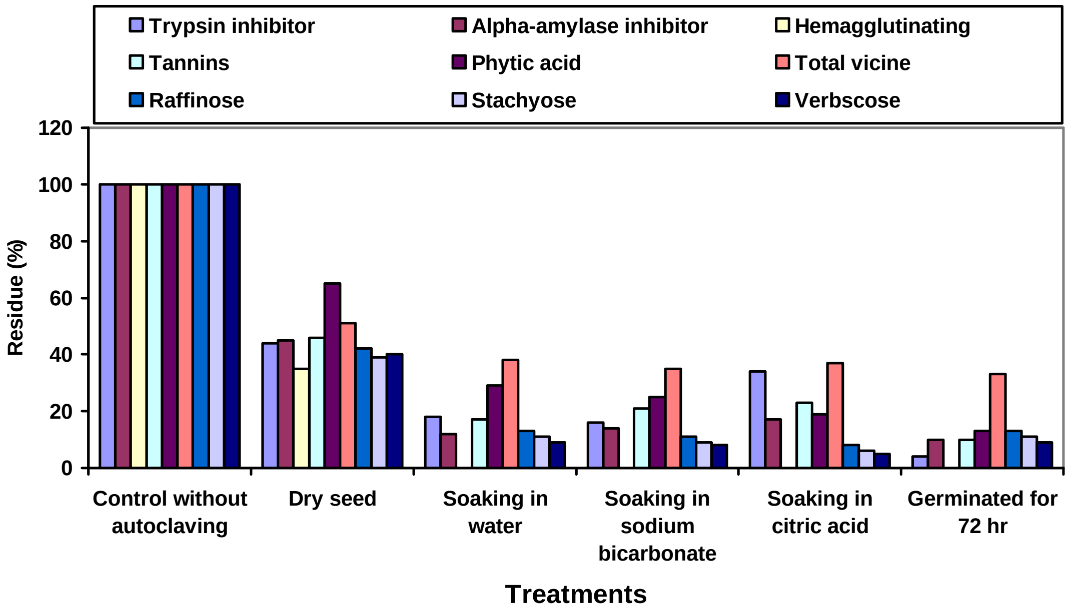

Fig. (3): Effect of autoclaving on antinutritional matters.

Effect of processing on in-vitro protein digestibility:

In-vitro protein digestibility of raw and treated mung bean seeds was performed and results are shown in Table (6). Soaking resulted a slight improvement in protein digestibility which was calculated to be 74.6, 73.9

and 75.2% after soaking for 12 h in water, citric acid and sodium bicarbonate solution, respectively compared to 72.4% of raw seeds.

Table (6): Effect of treatments on protein digestibility index

Treatments	Digestibility (%)
Raw sseds	72.4
Soaking in water (12 h)	74.6
Soaking in bicarbonate (12 h)	75.2
Soaking in citric acid (12 h)	73.9
Germination seeds (12 h)	77.7
Raw seeds + Autocl.	76.3
Soaking in water + Autocl.	79.1
Soaking in bicarbonate + Atocl.	79.8
Soaking in citric + Autocl.	76.8
Germination seeds + Autocl.	83.4

Germination improved the protein digestibility of mung bean seeds than autochlaved raw seeds however, germinated-autoclaved seeds showed the highest in-vitro protein digestibility of 83.4%. The improvement in digestibility could be induced by the combined effect of decrease in TI content and/or a greater susceptibility to enzyme attack of the degraded proteins formed during germination as described by Liener (1994).

Chemical and sensory evaluation of prepared beef sausage and beef burger by adding rehydrated mung bean flour:

a) Beef sausage:

Data in Table (7) show the moisture, crude protein, ether extract, ash and total carbohydrates contents in beef sausage prepared in laboratory. Moisture content of fresh sausage ranged from 58.92 to 62.61%, while, it was from 49.27 to 52.57 % after frying. Mositure, crude protein and ether extract contents decreased by increasing the level of replacement with mung bean while, ash and total carbohydrates took the opposite direction. This is mainly due to the lower content of protein and fat content in the replace ingredients. On the contrary, ash and total carbohydrates increased by increasing the supplementation levels. These results are in agreement with those reported by Faheid *et al.* (1998).

Also, results in the same table indicated that moisture and ether extract decreased after frying, while crude protein, ash and total

carbohydrates increased. Crude protein decreased in all treatments by increasing the levels of replacement for meat by prepared mung bean seeds. The percentage of decrease reached 10.22% for crude protein at level 35% replacement. However, increase of crude protein after frying may be due to decrease in ether extract content due to escape of some fats in cooking process and/or lowering of meat with increasing the level of replacement as mentioned by Nuzhat *et al.* (2002).

Data in Table (8) indicate the physico-chemical properties of beef sausage with series levels of mung bean replacement besides changes in TVN, TBA, pH value, WHC, plasticity and cooking loss in prepared beef sausage. TVN amounted to 9.60 mg/100 g in fresh beef sausage and increased after frying to 9.80 mg/100 g. Adding treated mung bean seeds at levels from 5 to 35% in fresh or fried beef sausage decreased TVN to 5.95 and 6.60 mg/100 g respectively. TBA took the same trend and revealed 0.64 and 0.65 mg/kg in fresh and fried beef sausage and decreased to 0.33 and 0.36 mg/kg respectively. On the contrary pH value was 5.87 and 5.95 in fresh and fried beef sausage and increased gradually to 6.06 and 6.08, respectively. Concerning W.H.C. it was 1.25 cm^2/0.3 g in fresh beef sausage and decreased gradually to 0.50 cm^2/0.3 g, while plasticity decreased from 3.20 to 1.70 cm^2/0.3 g. Cooking loss % was 8.51 in fresh beef sausage and decreased gradually to 2.06. These results are in agreement with Faheid *et al.* (1998) and Modi *et al.* (2003).

Data in Table (9) indicate the sensory evaluation (color, aroma, taste, texture, palatability and total scores) in beef sausage prepared in laboratory with replacement by mung bean (0 to 35%). Results show that there are significant differences ($P<0.05$) for color, taste, texture and palatability between control and all treatments, except there was no significant differences ($P>0.05$) in aroma between control and treatments with replacement level of 5, 10 and 15% rehydrated mung bean.

Anyhow, the mung bean added to sausage samples could be separated into two groups, hence there is no significant differences ($P>0.05$) between any two samples with the same group. The first group includes sausage treatments replacement levels 5, 10, 15 and 20% of mung bean.

The second group includes sausage treatments replacement with 25 to 35% mung bean. In the same time there is significant difference (P<0.05) between the two groups.

Table (9): Sensory evaluation of beef sausage with rehydrated mung bean.

Replacement with mung bean (%)	Color	Aroma	Taste	Texture	Palatability	Total score
Control	9.8 ± 0.13^{a}	9.6 ± 0.16^{a}	9.8 ± 0.13^{a}	9.9 ± 0.10^{a}	9.8 ± 0.13^{a}	48.9 ± 0.38^{a}
5	9.2 ± 0.30^{b}	9.3 ± 0.16^{ab}	9.2 ± 0.13^{b}	9.3 ± 0.17^{b}	9.2 ± 0.15^{b}	46.2 ± 0.59^{ab}
10	9.2 ± 0.39^{b}	9.3 ± 0.21^{ab}	9.1 ± 0.10^{b}	9.2 ± 0.16^{bc}	9.1 ± 0.00^{b}	45.9 ± 0.53^{ab}
15	9.0 ± 0.46^{bc}	9.1 ± 0.13^{abc}	9.0 ± 0.16^{bc}	9.2 ± 0.18^{bc}	9.0 ± 0.15^{b}	45.3 ± 0.59^{b}
20	8.8 ± 0.30^{bc}	8.7 ± 0.26^{bc}	8.8 ± 0.10^{bc}	9.0 ± 0.16^{bc}	8.9 ± 0.21^{bc}	44.2 ± 0.63^{b}
25	8.6 ± 0.38^{c}	8.4 ± 0.28^{c}	8.5 ± 0.22^{c}	8.7 ± 0.15^{c}	8.4 ± 0.16^{c}	42.6 ± 0.52^{b}
30	7.4 ± 0.40^{d}	7.6 ± 0.31^{d}	6.6 ± 0.22^{d}	6.9 ± 0.18^{d}	6.7 ± 0.21^{d}	35.2 ± 0.68^{c}
35	6.4 ± 0.40^{e}	6.9 ± 0.41^{d}	5.7 ± 0.26^{e}	5.9 ± 0.28^{e}	5.5 ± 0.27^{e}	30.4 ± 0.92^{d}
LSD	0.57	0.72	0.50	0.51	0.50	3.76

a, b, c, d & e: There is no significant difference between any two means, with the same attribute, have the same letter (P > 0.05).

b) Beef burger:

Data in Table (10) show the moisture, crude protein, ether extract, ash and total carbohydrate contents in beef burger prepared in laboratory with replacement levels of mung bean. Moisture content of fresh beef burger was 67.12%, while it ranged from 64.34 to 66.01% in all treatments. Moisture content decreased after frying in all treatments, where it ranged from 53.57 to 56.44%.

Crude protein and ether extract contents decreased with increasing the level of replacement by mung bean seeds, while, ash and total carbohydrates content increased with increasing replacement levels (0 to 35%).

Also, results in the same table indicate that moisture, crude protein, ash and total carbohydrate contents decreased after frying, wherever ether extract content increased.

The percentage of decrease reached to 9.25 and 7.05% for crude protein at level 35% compared to fresh and fried one, respectively. Decrease of crude protein after frying may be due to increase in ether

extract. These results are in agreement with those reported by Abd El-Salam and Hassanin (1987), Mansour and Khalil (1999) and El-Mansy *et al.* (2002).

Data in Table (11) indicate the physico-chemical properties of beef burger with series levels of mung bean replacement besides changes in TVN, TBA, pH value, WHC, plasticity, cooking loss and shrinkage in prepared beef burger. TVN amounted to 10.40 mg/100 g in fresh beef burger and increased after frying to 11.70 mg/100 g. Adding treated mung bean seeds at levels from 5 to 35% in fresh or fried beef burger decreased TVN to 5.80 and 7.40 mg/100 g respectively. TBA took the same trend and revealed 0.56 and 0.59 mg/kg in fresh and fried beef burger and decreased to 0.33 and 0.35 mg/kg respectively. On the contrary pH value was 5.40 and 5.64 in fresh and fried beef burger and increased greadually to 5.78 and 5.95 respectively. Concerning W.H.C. it was 4.90 cm^2/0.3 g in fresh beef burger and decreased gradualy to 3.30 cm^2/0.3 g, while plasticity increased from 1.70 to 2.00 cm^2/0.3 g. Cooking loss % and shrinkage after frying reached 13.26 and 13.42 fresh beef burger and decreased gradually to 3.54 and 6.75, respectively. Similar findings were reported by Lecomte *et al.* (1993) and Modi *et al.* (2003).

Data in Table (12) indicated the sensory evaluation (color, aroma, taste, texture, palatability and total scores) in prepared beef burger with replacement by mung bean (0 to 35%). Results indicated that there were no significant differences (P>0.05) for all properties tested except total score between control sample and all treatments for 10% replacement levels.

Anyhow, the treatment of beef burger samples could be separated into two groups, hence there is no significant differences (P>0.05) between any two samples with the same group. The first group includes beef burger treatments replacement levels 5, 10, 15 and 20% of mung bean.

The second group includes beef burger treatments replacement with 25 to 35% mung bean. In the same time there is significant difference (P<0.05) between the two groups.

So, it could be recommended to apply replacement level with 20% mung bean from meat used in prepared sausage and beef burger products.

Table (12): Sensory evaluation of beefburger with rehydrated mung bean.

Replacement with mung bean (%)	Color	Aroma	Taste	Texture	Palatability	Total Score
Control	9.5 ± 0.21^{a}	7.2 ± 0.19^{a}	9.6 ± 0.24^{a}	9.7 ± 0.25^{a}	7.3 ± 0.17^{a}	43.3 ± 1.06^{a}
5	9.2 ± 0.19^{ab}	6.8 ± 0.13^{ab}	9.2 ± 0.24^{abc}	9.3 ± 0.24^{ab}	6.9 ± 0.21^{abc}	41.4 ± 0.93^{ab}
10	9.1 ± 0.25^{ab}	6.8 ± 0.14^{ab}	9.2 ± 0.19^{abc}	9.1 ± 0.33^{ab}	6.8 ± 0.23^{abc}	41.0 ± 1.02^{ab}
15	8.9 ± 0.21^{bc}	6.6 ± 0.08^{bc}	9.0 ± 0.13^{bc}	8.8 ± 0.30^{bc}	6.8 ± 0.21^{abc}	40.1 ± 0.72^{b}
20	8.8 ± 0.13^{bcd}	6.4 ± 0.07^{bc}	9.0 ± 0.13^{bc}	8.7 ± 0.23^{bc}	6.7 ± 0.14^{abc}	39.6 ± 0.40^{bc}
25	8.7 ± 0.13^{bcd}	6.3 ± 0.14^{c}	8.8 ± 0.15^{c}	8.6 ± 0.25^{bc}	6.6 ± 0.18^{bc}	39.0 ± 0.72^{bc}
30	8.5 ± 0.17^{cd}	5.8 ± 0.23^{d}	8.1 ± 0.20^{d}	8.3 ± 0.30^{c}	6.4 ± 0.20^{bc}	37.1 ± 0.90^{cd}
35	8.3 ± 0.23^{d}	5.6 ± 0.24^{d}	7.9 ± 0.25^{d}	8.2 ± 0.29^{c}	6.3 ± 0.35^{c}	36.3 ± 1.14^{d}
LSD	0.55	0.46	0.56	0.78	0.60	2.51

a, b, c, & d: There is no significant difference between any two means, with the same attribute, have the same letter ($P > 0.05$).

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Table (7): Chemical composition of beef sausage with rehydrated mung bean.

Replacement with mung bean (%)	Moisture (%)		Crude protein* (%)		Ether extract* (%)		Ash* (%)		Carbohydrate* (%)	
	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying
0	62.61	52.57	38.94	42.16	44.16	38.99	7.59	7.98	9.31	10.87
5	62.08	51.64	38.65	41.32	43.88	38.43	7.61	7.63	9.86	12.62
10	61.55	51.70	37.77	39.27	43.53	38.67	7.65	7.71	11.05	14.35
15	60.89	51.98	35.79	38.88	43.20	37.48	7.70	7.78	13.31	15.86
20	60.12	51.67	33.94	37.90	42.86	37.51	7.74	7.82	15.46	16.77
25	59.93	51.50	32.20	36.78	42.60	37.27	7.77	7.83	17.43	18.12
30	59.39	49.99	30.48	35.27	42.35	37.00	7.82	7.90	19.35	19.83
35	58.92	49.27	28.72	34.77	42.08	36.44	7.88	7.95	21.32	20.84

*** On dry weight basis.**

Table (8): Physico-chemical properties of beef sausage with rehydrated mung bean.

Replacement with mung bean (%)	TVN (mg/100 g)		TBA (mg/kg)		pH value		W.H.C.		Plasticity		Cooking loss (%)	
	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying
0	9.60	9.80	0.64	0.65	5.87	5.95	1.25	-	3.20	-	8.51	-
5	9.45	9.70	0.59	0.62	5.89	5.99	1.15	-	3.05	-	7.72	-
10	8.40	9.10	0.53	0.59	5.93	6.01	0.95	-	2.80	-	7.54	-
15	7.80	8.90	0.50	0.52	5.95	6.03	0.95	-	2.65	-	6.94	-
20	7.50	8.10	0.45	0.46	6.02	6.05	0.80	-	2.45	-	5.89	-
25	6.80	7.50	0.38	0.42	6.03	6.06	0.75	-	1.95	-	4.68	-
30	6.30	7.00	0.35	0.38	6.04	6.07	0.60	-	1.75	-	2.66	-
35	5.95	6.60	0.33	0.36	6.06	6.08	0.50	-	1.70	-	2.06	-

TVN: Total volatile nitrogen **TBA: Thiobarbituric acid** **WHC: Water holding capacity**

Table (10): Chemical composition of beef burger with rehydrated mung bean.

Replacement with mung bean (%)	Moisture (%)		Crude protein* (%)		Ether extract* (%)		Ash* (%)		Carbohydrate* (%)	
	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying
0	67.12	54.81	51.81	44.52	14.97	22.59	6.52	6.31	26.70	26.58
5	64.34	55.28	49.06	43.06	13.84	22.52	6.59	6.48	30.51	27.94
10	65.89	56.44	48.53	42.71	13.61	22.44	6.70	6.53	31.15	28.32
15	65.19	54.57	47.29	41.46	13.20	21.31	6.77	6.60	32.75	30.64
20	66.01	54.74	46.11	40.72	12.71	20.74	6.96	6.66	34.23	31.89
25	65.60	56.40	44.72	39.46	11.91	20.83	6.96	6.70	36.41	33.01
30	65.33	56.16	43.54	38.42	11.77	21.09	6.98	6.73	37.71	33.77
35	65.65	53.57	42.56	37.47	11.24	20.51	6.96	6.84	39.24	35.09

*** On dry weight basis.**

Table (11): Physico-chemical properties of beef burger with rehydrated mung bean.

Replacement with mung bean (%)	TVN (mg/100 g)		TBA (mg/kg)		pH value		W.H.C.		Plasticity		Cooking loss (%)		Shrinkage after frying (%)
	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	Fresh	After frying	
0	10.40	11.70	0.56	0.59	5.40	5.64	4.90	-	1.70	-	13.26	-	13.42
5	9.90	11.00	0.53	0.56	5.42	5.54	4.50	-	1.75	-	12.49	-	12.95
10	9.30	10.60	0.50	0.53	5.48	5.62	4.45	-	1.75	-	9.49	-	12.18
15	8.50	9.90	0.48	0.51	5.55	5.66	4.25	-	1.95	-	7.36	-	10.86
20	7.80	9.20	0.45	0.49	5.59	5.75	4.08	-	1.85	-	6.59	-	9.24
25	6.90	8.50	0.42	0.44	5.65	5.82	3.75	-	1.90	-	4.84	-	8.87
30	6.20	8.00	0.38	0.40	5.71	5.90	3.50	-	1.95	-	3.72	-	7.38
35	5.80	7.40	0.33	0.35	5.78	5.95	3.30	-	2.00	-	3.54	-	6.75

TVN: Total volatile nitrogen TBA: Thiobarbituric acid WHC: Water holding capacity