

CHEMICAL, PHYSICAL AND SENSORY CHARACTERISTICS OF LOW-FAT BEEF MEAT SAUSAGE WITH MODIFIED LABLAB BEAN FLOURS AND PROTEIN CONCENTRATES.

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ABSTRACT:

This study focuses on the effect of adding germinated lablab bean seed flours (GLFs) and corresponding protein concentrates (GLPs) on chemical composition, physical analysis and sensory quality of low-fat sausages. Germination was carried out at different temperatures (25, 35 and 45°C).

All chemical parameters of ground lean beef meat significantly decreased compared to GLFs and GLPs. Acidic-butanol extraction used in preparation of GLPs improved OHC and WAI. F1, F2, P2 and P3 to possess the highest WHC and OHC values gave the best acceptable for low-fat sausages preparation.

These fat substitutes have been introduced to low-fat beef sausages (8, 12 and 15%) to make the texture and other sensory scores more acceptable. Quality characteristics of low-fat sausages were evaluated to select the best fat replacer type.

The increase in protein content of low-fat sausages was found to reach 16-40% of the control sausage. All low-fat sausage types had higher scores for water binding capacity and moisture and fat retention. Cooking loss of control sausage was significantly higher than all low-fat sausages.

All sensory characteristics scores were not significant difference from control sausage. Incorporation of GLFs and GLPs as fat-replacers at level of 5% could be used without causing significant changes in sausage quality.

Fat substitutes have been introduced to low-fat meat products to make the texture more acceptable.

Key Words: Lablab bean seed, germination, functional properties, low-fat sausage, flours, protein concentrate, organoleptic evaluation, cooking loss, water and fat retention, fat replacer

1. INTRODUCTION

The ever increasing cost of animal proteins has prompted food technologists, nutritionists and biochemists to search for alternative sources (Hemeida, 2003).

Although meat cuts have become leaner, products such as ground beef and coarse ground sausages have higher levels of fat. However, these products offer the greatest opportunity for fat reduction by reformation with fat substitutes (Keeton, 1994; Hemeida *et al.*, 2002; Hemeida, 2003; Mansour, 2003).

Fats are important sources of certain nutrients and food energy and also contribute to food texture, flavor and satiety after eating (Miller *et al.*, 1993 and Akoh, 1998). Increasing fat content caused a general increase in the volatile compound concentrations of the sausages (fat acted as a reservoir) (Carrapiso, 2007). High fat intake is associated with increased risk of obesity (AHA, 1996). Fat replacements should contribute a minimum of calories to a product and should not be detrimental to organoleptic qualities. Most substitutes can be categorized as: leaner meat, added water, protein-based substitutes, carbohydrate-based substitute, dietary fiber and synthetic compounds (Keeton, 1994; El-Magoli *et al.*, 1996; Lin and Keeton, 1998; Garica *et al.*, 2002). The major problem in acceptability of low-fat processed meat products is the decline of palatability with fat reduction (Anderson and Berry, 2000).

Legumes have been used as human foods more than 80 centuries and are still one of the most important and inexpensive source of dietary protein where the animal products are scarce (El- Rify *et al.*, 2000).

Recently, attention has been greatly focused on the use of new sources, particularly legume products such as flours and protein concentrates, to supplement or substitute many of foods. Because of high protein contents of these products and growing of protein shortage in many parts of the world, the demand for new plant protein sources is necessary (Moawad and Mohamed, 2002). Although legume seeds appear prominent in such objective, their beany flavor, digestion inhibitors and their high starch contents are some of their important defects. To over come these problems, a great deal of attention has been paid to the germination of seeds to decrease antinutritional factors (Deka and Sarkar, 1990; Enwere, 1998; El-Shimi, 2000; Fabyi, 2006).

The genus *Dolichos* (family leguminosae, subfamily poplionaceae) consists of a number of plants among which *Dolichos lablab var. lignosus* (field bean) and *Dolichos lablab var. lignosus Dolichos lablab var. typicus* (lablab bean) are grown fairly widely in India, Australia and some African countries for various food uses (Sivakumar and Rajagopal Rao, 1986 and Lawal, 2005). Unlike the lablab bean whose pods are used as a vegetable in Yemen.

Several studies have been carried out in order to replace legume flours and their proteins in sausage and other meat products (Anderson and Berry, 2000; Hemeida *et al.*, 2002; Fabyi, 2006)

The objective of this study was to evaluate the chemical, physical and sensory characteristics of low-fat (8, 12 and 15%) beef sausages formulated by replacing different levels of fat in sausages formulation with germinated lablab bean flours and their protein concentrates as fat replacer at different levels in order to decrease the cost of sausage and improve the nutrition value without deteriorous effect on quality.

2. MATERIALS AND METHODS

2.1. Materials:

Lablab bean seed was obtained from the harvesting season 2007, from local market .

Fresh lean beef meat and fat were obtained from the slaughterhouse in Ibb, Yemen. The lean meat was trimmed of separable fat and loose connective tissue, cut into small cubs and minced with a meat grinder and exposure to air during mincing. The obtained ground beef meat used for analysis and for preparation of different sausage formulas.

Fat tissue (cheep tail) was cleaned and cut in small pieces, minced with a meat grinder, packaged, stored at -4°C and used for preparation of different sausage formulas.

2.2. Methods:

2.2.1. Germination of lablab seed:

The method of Abou-Samaha, (2007) was followed to germination of lablab bean seeds. Germination was carried out at different temperatures (25, 35 and 45°C). Germinated seeds were dehulled, dried at 50°C for 30 hrs., ground to pass a 100-mesh sieve. The resulting called flours (F1 for 25°C ; F2 for 35°C and F3 for 45°C).

2.2.2. Preparation of protein concentrates from germinated flour:

Lablab bean seed protein concentrates were prepared from the corresponding flours prepared before. Acidic n-butanol method (Abo El-Neil and Atia, 1990) was followed in which pH adjusted to their isoelectric points (pH 4.8) using 0.5N HCl.

The resulting protein concentrates are : P1 from F1; P2 from F2 and P3 from F3).

2.2.3. Proximate analyses

Germinated lablab flours and corresponding protein concentrates, lean beef meat and sausage samples were analyzed for protein, ether extract (using petroleum ether extraction), moisture, ash and carbohydrate using standard AOAC (1985). Dietary fiber was estimated by difference. All results were expressed as g/100 g of sample at wet weight basses.

2.2.4. Functional properties of lablab bean preparations:

Water holding capacity (WHC) was measured according to the procedure of Leterme et al., (1996). WHC was expressed as amount of water retained by 100 g. The method described by Anderson et al., (1969) was used to estimate the water

absorption index (WAI) of samples. The WAI was calculated as ml/g. The method of Sosulski and Gerratt (1976) was followed to estimate the oil holding capacity (OHC) of samples as amount of oil retained by 100g.

2.2.5. Preparation of sausage formula:

Sausage making was prepared according to Hemeida et al, (2002). Each formula of sausage was prepared by mixing the minced fresh beef with other ingredients for 8-10 minutes into the emulsifier, using laboratory emulsifier.

The following formula was used according to Hemeida et al., (2002):

<i>Sausage formulation Ingredients</i>	<i>%</i>
Minced fresh meat	56.92
Mince fat tissues	23.64
Skim milk	1.40
Corn starch	4.00
Sodium chloride	1.60
Fresh garlic	1.22
Spices mixture	1.22
Water, as ice fakes	10.00

The obtained emulsion was stuffed in previously cleaned and prepared natural mutton casing. Other formulas of sausage were prepared to contain three different levels of fat (8, 12 and 15%) and each formula with each level of fat contained (5% of lablab seed flour or protein concentrate). After preparing each formula the sausage samples were packaged in polyethylene bags and stored frozen at -4 °C.

According to results obtained from functional properties of lablab bean flours and corresponding protein concentrates, flours germinated at 35 and 45°C and protein concentrate extracted from germinated flours at 25 and 35°C were used in manufacture of low-fat sausage samples under study.

2.2.6. Physical analysis:

2.2.6.1. Determination of cooking loss:

Total cooking losses of prepared samples were determined and calculated as described by El-Nemer (1979). This measurement was determined after boiling in water for 15 minutes, then frying in corn oil at 110°C for 5 minutes. Total cooking losses were calculated as follows:

$$\% \text{ Cooking loss} = \frac{\text{Fresh sample weight} - \text{Boiling sample weight}}{\text{Boiled sample weight}} \times 100$$

$$\% \text{ Frying loss} = \frac{\text{Boiled sample weight} - \text{Fried sample weight}}{\text{Boiled sample weight}} \times 100$$

$$\% \text{ Total cooking losses} = \% \text{Cooking loss} + \% \text{Frying loss}$$

2.2.6.2. Determination of water binding or holding capacity of raw sausages:

Water binding capacity of raw control and low-fat sausages was measured by the press technique described by Tsai and Ockerman (1981).

2.2.6.3. Determination of fat and moisture retention:

The moisture retention value represents the amount of moisture retained in the cooked product per 100 g of raw sample and it was determined according to the equation adopted by El-Magoli et al., (1996) as follows:

$$\% \text{ Moisture retention} = \frac{\% \text{ yield} \times \% \text{ moisture in cooked product}}{100} \times 100$$

$$\% \text{ Fat retention} = \frac{\text{Cooked weight} \times \% \text{ fat in cooked product}}{\text{raw weight} \times \% \text{ fat in raw product}} \times 100$$

2.2.7. Sensory evaluation of sausage:

All the cooked sausage samples were subjected to panel testing using 10 trained members from the Faculty staff and graduate students. Small cubes were prepared from the sausage samples and were coded with random numbers. Panelists then evaluated the sausage cubes for color, aroma, texture, taste and overall palatability as recommended by Stell and Torrie, (1980).

2.2.8. Statistical analysis:

An analysis of variance (SAS, 1995) was conducted to analyze the chemical, physical and sensory properties of raw materials and raw control and low-fat sausages. When a significant main effect was detected, the means were separated with the Student-Newman-Keuls test. Significant differences were determined at the $P < 0.05$ level for all comparisons.

RESULTS AND DISCUSSION

Chemical composition of ground lean meat and fat-replacers:

Table (1) shows and compares major chemical constituents of ground lean beef meat (GBM) and germinated lablab bean flours (GLFs) and corresponding protein concentrates (GLPs) under study. All values are expressed on wet weight basis.

It was clear from results that the gross contents of chemical composition of ground lean beef meat are in agreement with those found by Hemeida et al., (2002). Also all chemical parameters of GBM significantly ($P < 0.05$) decrease compared to GLFs and GLPs except for moisture content.

Concerning to fat content, it was noticed that there was slight difference between GLP samples. On the other hand, GLF samples had lower values of protein content compared to corresponding GLPs.

Carbohydrate content of GLP samples was lower than those of corresponding GLF samples. This decrease in carbohydrate content is expected and due to acidic-butanol extraction at isoelectric point (pH 4.8). Removal of soluble carbohydrate components increased the protein, fat and dietary fiber contents of GLPs. These results are agreement with that reported by Trugo et al., (2000); Kuo et al., (2004) and Fabiyi (2006).

Referring to the same Table (1), it could be observed that ash level in GLP samples was higher than those of corresponding GLF samples. This attributable to the addition of HCl and NaOH for pH adjustment, this finding is in accordance with those published by Dawoud et al., (1998).

Regarding the dietary fiber content of GLFs and corresponding GLPs, it was noticed that F3 had the highest value, also, there was slight difference between GLFs and corresponding GLPs.

Table (1): Chemical analysis of ground lean beef meat and fat replacers (on wet weight basis).

<i>Sample</i>	<i>Moisture</i>	<i>Fat</i>	<i>Protein</i>	<i>Ash</i>	<i>Carbohy-drat</i>	<i>Dietary fiber^a</i>
<i>GBM^b</i>	72.34	2.98	21.95	0.87	1.86	-
<i>F1^c</i>	7.15	6.61	34.52	2.83	46.87	2.02
<i>F2^c</i>	8.16	7.28	37.77	2.01	42.23	2.55
<i>F3^c</i>	6.45	6.67	40.51	3.35	38.62	4.40
<i>P1^d</i>	11.19	5.71	56.42	4.74	18.91	3.03
<i>P2^d</i>	10.70	7.53	54.72	5.86	17.98	3.21
<i>P3^d</i>	9.96	8.83	53.97	6.89	16.27	4.08
<i>LSD^e</i>	0.96	0.50	1.49	0.52	1.13	0.38

a Dietary fiber was estimated by difference.

b GBM: Ground lean beef meat.

c F1, F2 and F3: germinated lablab bean flours at 25, 35 and 45°C, respectively.

d P1, P2 and P3: protein concentrates extracted from F1, F2 and F3, respectively.

e LSD: Least Significant Difference. Any two mean differ by more LSD are significantly different.

Functional properties of fat replacers:

Data in Table (2) shows that water and oil holding capacity (WHC and OHC, respectively) and water absorption index (WAI) of GLF and corresponding GLP samples.

Water holding capacity can be related to sausage characteristics such as juiciness, driploss, cooling shrink and yield on processing (Caldironi and Ockerman, 1982). The ability of protein to bind water is a very important in some food formulation like meats, sausages, bread and cake (Satterlee, 1981).

WHC, WAI and OHC of GLF and corresponding GLP samples seem to be close correlated with protein content. All GLPs were superior to corresponding GLFs in OHC and WAI, which P3 shows the highest values.

Table (2): Functional properties of fat-replacers under study.

Samples	Functional properties of lablab bean preparations		
	WHC ^a	WAI ^b	OHC ^c
	G water/100g sample	ml/g sample	g oil/100g sample
<i>F1^d</i>	220.64	0.91	182.28
<i>F2^d</i>	259.00	1.87	150.46
<i>F3^d</i>	270.40	2.13	128.09
<i>P1^e</i>	261.20	4.48	216.80
<i>P2^e</i>	249.47	4.46	232.37
<i>P3^e</i>	225.18	3.13	240.52

^a WHC: Water holding capacity

^b WAI: water absorption index.

^c OHC: Oil holding capacity.

^d F1, F2 and F3: germinated lablab bean flours at 25, 35 and 45°C, respectively.

^e P1, P2 and P3: protein concentrates extracted from F1, F2 and F3, respectively.

In general, acidic-butanol extraction improved OHC and WAI of protein concentrate samples. The F2, F3 P1 and P3 to possess the highest WHC and OHC values gave the best acceptable sausage manufacture. Consequently, protein functionality may play key role in terms of determining some of the quality and sensory characteristics for the supplemented products studied.

Physical changes of raw control and low-fat meat sausages:

Ground beef is popular meat purchase. It is one of the least expensive beef products available a consumers. However, it has been reported that consumers discriminate against ground beef with high fat content because of excessive shrinkage during cooking. It implication as cause of obesity and its greasy taste (Bruhn et al., 1992).

Table (3) shows the physical changes of raw control and low-fat (8, 12 and 15% fat content) sausages as affecting by using 5% of GLFs and corresponding GLPs.

Table (3): Physical changes of raw control and low-fat sausages as affected by fat replacers.

Fat replacement treatment	Level of fat %	<i>Physical characteristics</i>			
		cooking loss %	Moisture retention %	Water binding %	Fat retention %
<i>Control</i>	25	24.78	41.52	70.09	63.87
<i>F2</i>	8	15.27	55.18	85.45	84.26
	12	17.13	52.39	83.14	81.23
	15	22.86	47.16	78.72	79.12
<i>F3</i>	8	16.02	55.49	86.06	82.64
	12	20.86	50.06	84.74	77.92
	15	23.97	46.58	83.05	75.59
<i>P1</i>	8	15.64	55.37	85.82	83.85
	12	17.08	52.84	83.81	82.78
	15	21.85	46.95	82.39	81.69
<i>P2</i>	8	17.07	53.83	85.82	81.39
	12	20.03	50.96	83.57	78.26
	15	22.95	46.29	79.39	76.03
<i>LSD*</i>		1.93	7.65	2.08	2.23

F2 and F3: germinated lablab bean flours at 35 and 45°C, respectively.

P1 and P2: protein concentrates extracted from F1 and F2, respectively.

*LSD: Least Significant Difference. Any two mean differ by more LSD are

significantly different.

Results tabulated in Table (3) indicate that there was insignificant ($P < 0.05$) differences in cooking loss of raw control and low-fat (15%) sausages containing F2, F3 and P2. on the other hand, other low-fat sausages had low cooking loss value compared to raw control sausage.

It was clear from the results that all low-fat sausages had higher moisture retention as compared to raw control sausage, except for all low-fat (15% fat content) sausages.

Concerning to water binding capacity and fat retention of sausages, it was found that all low-fat sausages had higher ($P < 0.05$) scores for both water binding capacity and fat retention compared to control sausage. These results are in good agreement with those obtained by Hemeida et al., (2002) and Mansour (2003).

The high moisture and fat retention and water binding capacity of all low-fat sausages is probably due to ability of GLFs and GLPs as fat replacers to bind both water and oil.

Effect of fat replacers on chemical composition of low-fat sausages:

Table (4) includes the proximate composition of raw control and low-fat sausages containing 5% of GLFs and GLPs as fat replacers.

Moisture content of all low-fat sausage types was elevated. The increase in moisture content was related to increase of water absorption when GLFs and GLPs were used at level of 5%.

It could be noticed that crude protein of all low-fat sausages was significantly ($P < 0.05$) higher than their corresponding control. The increase in protein content of low-fat sausages was found to reach 16-40% of the control sausage, which agree well with the finding of Hemeida et al., (2002). High protein content of produced low-fat sausage containing 5% GLFs or GLPs around 40% of sausage containing P1 would help to meat animal shortage and would provide an opportunity to enhance the nutritional quality of low-fat sausages especially for people in developing countries.

From the results it could be observed that ash content of low-fat sausages was also increased with increasing fat level. On the other hand, carbohydrate and dietary fiber contents were decreased by increasing fat level of low-fat sausages.

Organoleptic evaluation of raw control and low-fat sausages:

Table (5) shows the sensory scores obtained from control sausage (25% fat content) and nine types of low-fat sausage formulated with different fat levels (8, 12 and 15%) and fat replacers (GLFs and GLPs).

It could be observed that the incorporation of fat replacers under study at different level of fat in low-fat sausages had insignificant effect ($P > 0.05$). All sensory characteristics scores were not significant ($P > 0.05$) difference from control sausage.

No differences were found for overall acceptability except in the low-fat (15% fat content) sausage containing P1, but these differences were not large enough to be statistically different from control.

Low-fat (8% fat content) sausage containing P1 and all low-fat sausages containing P2 displayed more intensive texture, also low-fat (8% fat content) sausage containing P1 and low fat (12% fat content) sausage containing P2 had more intensive color and overall acceptability than respective control. These differences were not statistically significant ($P > 0.05$) from control sausage.

CONCLUSION:

By a sensory panel, nonsignificant differences from control were obtained for all low-fat sausages, some objection to overall acceptability was expressed with low-

fat (15% fat content) sausage containing P1 which resulted in a large least significant differences.

Incorporation of fat-replacers (GLFs and GLPs) at level of 5% could be used without causing significant changes in sausage quality. The most desirably tasted and flavored sausages were those low-fat (8% fat content) containing P1 and P2, respectively.

Table (5): Sensory scores of raw control and low-fat sausages as affected by fat replacers.

Fat replacement treatment	Level of fat %	Sensory characteristics				
		Texture (10)	Taste (10)	Flavor (10)	Color (10)	Overall acceptability
Control	25	7.44	7.33	7.44	7.33	7.77
F2	15	7.66	7.44	7.55	7.66	7.77
	12	7.33	7.33	7.66	7.44	7.77
	8	7.66	7.88	7.55	7.55	7.55
F3	15	7.44	7.22	7.55	7.66	7.77
	12	7.77	7.55	7.66	7.44	8.00
	8	7.55	7.66	7.33	7.88	7.55
P1	15	6.55	7.11	7.00	7.33	6.66
	12	7.77	7.44	7.44	7.33	7.77
	8	8.00	8.11	7.55	8.55	8.33
P2	15	8.22	7.55	7.44	7.66	7.44
	12	8.00	7.88	7.88	8.22	8.44
	8	8.00	7.55	8.00	7.88	7.88
LSD*		0.96	1.09	1.05	1.01	1.04

F2 and F3: germinated lablab bean flours at 35 and 45°C, respectively.

P1 and P2: protein concentrates extracted from F1 and F2, respectively.

* LSD: Least Significant Difference. Any two mean differ by more LSD

are significantly different.

REFERENCES

- Abo El-Neil, E. A. K. and Atia, A. M. (1990). Extraction of gossypol and oligosaccharides from oilseed meals. *Egypt J. Food Sci.*, Vol. 54, No. 4, 1088-1098.
- Abou-Samaha, O. R. (2007). Effect of germination of two varieties of mung bean seeds (*Vigna radiatus L.*) on their free sugars, anti-nutritional factors and nutritional quality. *Minufiya J. Agric. Res.* Vol., 32, No.4, 991-1002.
- AHA (1996). Dietary guidelines for healthy Americans. *Circulation*, 49, 1795-1800.
- Akoh, C. C. (1998). Fat replacers. *Food Technology*, Vol. 52, 47-53.

- Anderson, E. T. and Berry, B. W. (2000). Sensory shear and cooking properties of low-fat beef patties made with inner pea fiber. *J. Food Sci.*, Vol. 56, 805-810.
- Anderson, R. A.; Conway, H. F.; Pfeifer, V. F. and Griffin, E. L. (1969). Roll and extraction cooking of grain sorghum grits. *Cereal Sci. Today*, Vol. 14, 372-379.
- AOAC (1985). *Official Methods of Analysis*, 14th ed. Association of Official Agriculture Chemists, Washington D. C.
- Bruhn, C. M.; Cotter, A. H.; Dioz-Knouf, F.; Sutherland, J.; West, E.; Wightman, N.; Williamo, E. and Jaffee, M. (1992). Consumer attitudes and market potential for foods using fat substitutes. *Food Technology*, Vol. 46, 81-86.
- Caldironi, M. A. and Ockerman, H. W. (1982). Bone and plasma protein extracts in sausages. *J. Food Sci.*, Vol. 47, 1622-1625.
- Carrapiso, A. I. (2007). Effect of fat content on flavour release from sausages. *Food Chem.*, Vol. 103, No. 2, 396-403.
- Dawoud, F. M.; El-Bedawey, A. A.; Ibrahim, N. A. and Rabie, T. M. (1998). Comparative studies on nutritional value, antinutritional factors and functional properties of some cottonseed and sunflower preparations. *Annals of Agric. Sci. Moshtohor*, Vol. 36, No. 1, 429-446.
- Deka, R. K. and Sarkar, C. R. (1990). Nutrient composition and anti-nutritional factors of Dolichos lablab seeds. *J. Food Chem.*, Vol. 38, No. 4, 239-246.
- El- Rify, M. N.; El- Geddawy, M. A. H.; El-Fishawy, F. A. and Abdel-Rahman, E. A. (2000). Effect of processing on the amino acid composition and protein quality of mung bean seeds. 1st Mansoura Conference of Food Sci. and Dairy Tech., 17-19 October 2000.
- El-Magoli, S. B.; Laroia, S. and Hansen, P. M. T. (1996). Flavor and texture characteristics of low-fat ground beef patties formulated with whey protein concentrate. *Meat Sci.*, Vol. 42, 179-193.
- El-Nemer, S. E. (1979). Studies on meat substitutes. M. Sc. Thesis, Faculty of Agric., Zagazig Univ., Zagazig, Egypt.
- El-Shimi, N. M. A. (2000). Effect of germination on the nutritive value of fenugreek seeds and prospective technological use. Ph. D. Thesis. High Institute of Public Health, Alexandria, Egypt.
- Enwere, N. J. (1998). In "Foods of Plant Origin: Processing and Utilization With Recipes and Technology Profiles. Afro-Oribs Publications LTd., Nsukka.
- Fabiyi, E. F. (2006). Soybean processing, utilization and health benefits. *Pakistan J. Nutrition*, Vol. 5, 453-457.
- Garica, M. L.; Dominguez, R.; Galvez, M. D.; Casas, C. and Selgas, M. D. (2002). Utilization of cereal and fruit fibers in low-fat dry fermented sausages. *J. Meat Sci.*, Vol. 60, 227-236.
- Hemeida, H. H. (2003). Improving quality and shelf life of camel meat sausages pre-blending with natural anti-oxidant vitamins during refrigerated storage. *J. Bull. Fac. Agric., Cairo Univ.*, Vol. 54, 509-530.
- Hemeida, H. H.; El-Naggar, S. M. and El- Magoli, S. B. (2002). Utilization of some fat substitutes in processing of low fat sausages. *J. Bull. Fac. Agric., Cairo Univ.*, Vol. 53, 595-612.
- Keeton, J. T. (1994). Low-fat meat products-technological problems with processing. *J. Meat Sci.*, Vol. 36, No. 1-2, 261-276.

- Kuo, Y. H.; Rozan, P.; Lambein, F.; Frias, J and Vidal-Valverde, C. (2004).** Effect of different germination conditions on the contents of free protein and non-protein amino acids of commercial legumes. *J. Food Chem.*, Vol. 86, 537-545.
- Lawal, O. S. (2005).** Functionality of native and succinylated lablab bean (*lablab purpureus*) protein concentrate. *J. Food Hydrocolloids*, Vol. 19, No. 1, 63-72.
- Leterme, P.; Thewis, A.; Leeuwen, P.; Monmart, T. and Huisman, J. (1996).** Chemical composition of pea fiber isolates and their effect on the endogenous amino acid flow at the ileum of the pig. *J. Sci. Food Agric.*, Vol. 72, 127-134.
- Lin, K. W. and Keeton, J. T. (1998).** Textural and physicochemical properties of low-fat, precooked ground beef patties containing carrageenan and sodium alginate. *J. Food Sci.*, Vol. 63, 571-574.
- Mansour, E. H. (2003).** Effect of carbohydrate-based fat replacers on the quality characteristics of low-fat beef burgers. *J. Bull. Fac. Agric., Cairo Univ.*, Vol. 54, 409-430.
- Miller, M. F.; Andersen, M. K.; Ramsey, C. B. and Reagan, J. O. (1993).** Physical and sensory characteristics of low-fat ground beef patties. *J. Food Sci.*, Vol. 58, 461-463.
- Moawad, R. K. and Mohamed, G. F. (2002).** Chemical, physical, nutritional and sensory evaluation of ostrich sausage. *Minufiya J. Agric. Res.* Vol. 27, No. 2, 321-336.
- SAS. (1985).** In "SAS Users Guide Statistics. SAS Institute Inc., Cary, N. C., USA.
- Satterlee, L. D. (1981).** Proteins for use foods. *Food Technology*, Vol. 35, No. 6, 53-70.
- Sivakumar, N. and Rajagopal Rao, D. (1986).** The natural of lactins from *Dolichos lablab*. *J. Biosci.*, Vol. 10, No. 1, 95-109.
- Sosulski, F. W. and Gerratt, H. D. (1976).** Functional properties of the legume flours. *Can Inst. J. Food Sci. Technol.*, Vol. 66, 323-329.
- Stell, R. C. D. and Torrie, J. H. (1980).** In "Principles and Procedures of Statistics" McGraw-Hill Book Co., New Yourk, U. S. A.
- Tasi, T. C. and Ockerman, H. W. (1981).** Water binding measurement of meat. *J. Food Sci.*, Vol. 46, 697-701.
- Trugo, L. C.; Donangelo, C. M.; Trugo, N. M. and Kundesn, K. E. B. (2000).** Effect of heat treatment on nutritional quality of germinated legume seeds. *J. Agric. Food Chem.*, Vol. 48, 2082-2086.