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Nutritional Evaluation of Sausages Containing Chick Peas and Faba Beans as Meat Protein Extenders

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ABSTRACT

The chemical compositions of three sausage meat products, having partial substitution of their emulsions with legumes, were studied. Sausage quality was evaluated on the basis of moisture:protein (MP) and fat:protein (FP) ratios. Ranges of values for these ratios were 3·02:1 to 3·48:1 and from 0·89:1 to 0·95:1, respectively.

Nutritional properties of sausage products are discussed in relation to amino acid composition, protein efficiency ratio (PER) and true digestibility (TD%). Comparison with the FAO/WHO reference patterns shows that all of the essential amino acids are present at high levels in all products. Chick pea and faba bean can be added to 20% of the formulation without any great effect upon digestibility, amino acid scores or PER.

INTRODUCTION

Production of animal proteins is relatively inefficient when contrasted with production of plant proteins; moreover, the animal proteins are an expensive source of dietary protein (Evans & Bandemer, 1967). The cost per unit of net utilizable protein from beef is ten times higher than that from the common vegetable sources (FAO, 1970). The use of plant proteins, such as soya, as ground meat extenders or in ground beef patties, was originally based upon substantial reductions in finished product cost (Judge *et al.*, 1974; Smith *et al.*, 1976; Seideman *et al.*, 1977). In a previous publication by Abo Bakr *et al.* (1986), six meat sausage products were prepared with

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partial substitution of their emulsion with legumes; it was found that products containing broad beans and chick peas received high scores for palatability and colour and also had good quality with regard to water-holding capacity, cooking losses and tenderness. Accordingly, the objectives of the present study were to evaluate the sausage products containing the legumes (faba beans and chick peas) based on amino acid composition and chemical score. Also, the nutritional values of these products were studied.

MATERIALS AND METHODS

Materials

The seeds of faba beans (*Vicia faba*) and chick peas (*Cicer oriatinum*), purchased on the local market, were cleaned, decorticated and ground to pass through a 60-mesh screen.

Sausage preparation

Samples of fresh beef were purchased from the local market, deboned and lean and fat were separated. The lean and fat were cut into cubes and ground separately through a plate with 1/3 mm holes. The ground meat was mixed with 30% ground fat, 5% gelatin, 0·4% soya lecithin, 1% spice mixture (500 g black pepper, 500 g coriander, 50 g cinnamon and 50 g cloves) and 2% salt. The mixing was made by passing twice through a grinder. The legumes (faba beans and chick peas) were included in the emulsion at a proportion of 20% of the meat; water was added (50 ml per kilogram of sausage mixture) to facilitate the mixing. Sausages were stacked in polyethylene bags (20 pieces). Samples from every formula were fried in margarine (5 g margarine/150 g sausages), then 50 ml of water was added and cooking was continued until the water in the pan was evaporated. Samples were dried at 60°C for 6 h, cooled and ground to pass through a 40-mesh screen and kept in the refrigerator until analyzed.

Methods

Moisture, total lipids, crude protein and ash were determined as described by the AOAC (1980).

A Beckman Automatic Amino Acid Analyzer (Beckman Model 120C) was used to determine the amino acids. Defatted samples were hydrolyzed with 6N HCl for 24 h at 110°C under vacuum. The product was cooled and

centrifuged. The supernatant was evaporated to dryness using a rotary evaporator. The residue was dissolved in sodium citrate buffer, pH 2·2, and filtered through Whatman No. 42 filter paper. The chemical scores A/E (milligrams of essential amino acids per gram of total essential amino acids of the same source) and A/T (each essential amino acid is expressed as a percentage of the same acid in whole egg) were calculated according to the methods suggested by the FAO/WHO (1973).

Protein efficiency ratios (PER) were determined as described by the AOAC (1980). Weanling albino male rats, 3–4 weeks old and in the 40–50 g weight range, were secured from the High Institute of Public Health (University of Alexandria). Each experimental group (six rats) was housed in individual wire-bottomed cages. Water and food were offered *ad libitum*. Uneaten and scattered foods were estimated daily and rats were weighed weekly during a 28-day feeding period.

The basal diet consisted of 80% corn starch, 10% corn oil, 5% non-nutritive cellulose, 4% salt mixture and 1% vitamin mixture from Nutritional Biochemicals Corp., Ohio, USA, the corn starch being replaced by the protein sources under test (sausage products) to provide a 10% protein level. Casein was fed to one group of rats as a control. At the end of the feeding period, faeces from each group were collected daily and composited for 5 days. Food intake and body weight were also recorded to calculate the true digestibility as described by Mitchell (1924). Correction of faecal nitrogen excretion was done by calculating the metabolic faecal nitrogen in rats receiving a nitrogen-free diet.

RESULTS AND DISCUSSION

Table 1 gives the proximate analysis of sausage formulas. Protein content of all sausage meat was higher than that of other products containing faba beans and chick peas, being 49·1%, 42·0% and 40·0% (on a dry weight basis), respectively. Total lipids ranged from 37·3% to 44·0% according to the sausage formula. These results are in agreement with those reported by other investigators (Baliga & Madaiah, 1971; El-Zalaki *et al.*, 1976).

Sausage quality was evaluated on the basis of moisture:protein (MP) and fat:protein (FP) ratios. Nutritionally balanced products should have an MP ratio of 4:1 and FP ratio of 0·8:1 (Shevchenko, 1981). From the results in Table 1 it is clear that MP ratios for sausage products ranged from 3·02:1 to 3·48:1 and FP ratios from 0·89:1 to 0·95:1. Accordingly, all sausage products prepared in this study could be considered nutritionally balanced. Also, the addition of legumes to the meat emulsion had no effect on the nutritional balance of sausage products.

TABLE 1
Proximate Composition of Various Sausage Products

Constituents	*Meat emulsion*					
	I		*II*		*III*	
	On wet basis	*On dry basis*	*On wet basis*	*On dry basis*	*On wet basis*	*On dry basis*
Moisture (%)	59·70	—	59·21	—	58·21	—
Crude protein (N × 6·25)	19·8	49·1	17·1	42·0	16·7	40·0
Total lipids	17·7	44·0	15·2	37·3	15·9	38·1
Total sugars[a]	0·53	1·32	5·29	12·96	5·32	12·73
Ash	2·28	5·66	3·13	7·67	3·83	9·16
Moisture:protein (MP)	3·02:1	—	3·45:1	—	3·38:1	—
Fat:protein (FP)	0·89:1	—	10·9:1	—	0·95:1	—

[a] By difference.
I: All meat (control).
II: Meat + 20% faba beans.
III: Meat + 20% chick peas.

The amino acid composition of sausage formulas is shown in Table 2. Sausage products contained glutamic and aspartic acids as the major components; also lysine, leucine and isoleucine were found at high levels. No great differences were noticeable between all-meat sausage (control) and the other two products containing legumes except that the control had more sulfur-containing amino acids (methionine plus cystine) than the other two formulas. Hegarty & Ahn (1976) reported that the meat analogs containing textured soy meal had a lower level of methionine than did ground beef. When comparing the essential amino acid levels of sausage products with those suggested by the FAO/WHO Provisional Pattern (1973), it could be seen that the three formulas of sausages had good levels of all essential amino acids and exceeded those of the FAO reference.

Chemical scores, evaluated by two methods as indicated in Table 3, revealed valine as the major limiting amino acid for sausage prepared from meat only or substituted with 20% legumes.

Nutritional value

Table 4 shows the results of weight gain and protein efficiency ratio (PER) of sausage products. Growth experiments with young rats revealed that the maximum growth was obtained in animals fed on sausage prepared from meat only, followed by that containing chick peas, then the product

TABLE 2
Amino Acid Composition of Various Sausage Products (g per 16 g nitrogen)[a]

Amino acid	*Meat emulsion*			*FAO*[b] *reference pattern*
	I	*II*	*III*	
Lysine	8·43	8·16	8·05	4·32
Histidine	3·62	3·52	3·41	
Arginine	6·95	6·10	5·95	
Aspartic acid	8·81	8·32	8·12	
Threonine	3·71	3·76	3·82	2·88
Serine	3·92	3·88	3·65	
Glutamic acid	17·1	16·5	17·6	
Proline	3·89	4·10	4·10	
Glycine	4·58	4·80	4·64	
Alanine	4·05	4·02	3·91	
Cystine	2·40	2·08	2·04	2·02
Valine	5·03	4·90	4·20	4·32
Methionine	2·77	2·62	2·58	2·30
Isoleucine	5·61	5·52	5·53	4·32
Leucine	7·91	7·62	7·82	4·89
Tyrosine	3·65	3·68	3·71	2·88
Phenylalanine	5·50	4·44	4·61	2·88
Total essential amino acids	44·91	42·77	42·37	30·82

[a] Excluding tryptophan, which was not estimated.
[b] FAO/WHO (1973).
I: All meat (control).
II: Meat + 20% faba beans.
III: Meat + 20% chick peas.

containing faba beans. The gains in weight were $49 \pm 1{\cdot}2$, $45{\cdot}3 \pm 1{\cdot}9$ and $38 \pm 1{\cdot}8$ g, respectively, while that of rats fed on the casein control diet was $41{\cdot}7 \pm 2{\cdot}3$ g.

Also, the results indicate that the PER value for all-meat sausage is higher than that of sausage containing either chick peas or faba beans. The PER values were 3·15%, 3·01% and 2·56%, respectively. On the other hand, the three formulas of sausages were superior to that of the casein control diet (PER of 2·5). The lower PER values for products substituted with legumes could be attributed to the fact that the sulfur-containing amino acids were the limiting essential amino acids in the legumes (Evans & Bandemer, 1967). These results are in agreement with the findings of Robinson (1972). Hegarty & Ahn (1976) showed that the PER value for ground beef is higher than the values for meat analogs containing textured soy.

TABLE 3
Chemical Score of Various Sausage Products

Essential amino acid (EAA)	*Whole egg*	*A/E*			*A/T*		
		Meat emulsion			*Meat emulsion*		
		I	*II*	*III*	*I*	*II*	*III*
Isoleucine	129	124	129	130	84	83	83
Leucine	172	176	178	184	89	86	88
Lysine	125	187	190	190	131	127	125
Methionine	61	61	61	60	88	83	82
Cystine	46	53	48	48	101	87	86
Total S-containing amino acids	107	115	114	109	93	88	83
Phenylalanine	114	122	104	109	94	76	79
Tyrosine	81	81	86	88	87	88	88
Threonine	99	82	87	90	73	74	75
Valine	141	112	114	99	69	67	58
Chemical score	100	79	80	70	69	67	58

I: All meat (control).
II: Meat + 20% faba beans.
III: Meat + 20% chick peas.
A/E ratio = milligrams of EAA per gram of total EAA of the same source.
A/T ratio = each EAA is expressed as a percentage of the same acid in whole egg.

Table 5 shows that the all-meat sausage had a high true digestibility (TD%, 94·2%) and was nearly like the casein (95·2%). Also it can be seen that the digestibilities of products with substituted faba beans and chick peas were high, being 90·1% and 93·5%, respectively. This indicates that the protein quality of sausages containing legumes is relatively high. These results are in agreement with those reported by Mitsyk & Dzhurik (1981) that products containing up to 10% pea meal had high nutritional value.

Finally, it could be concluded that the quality of sausage products

TABLE 4
Protein Efficiency Ratios of Various Sausage Products

Meat emulsion	*Weight gain (g)*	*Protein consumed (g)*	*PER*	
			Actual	*Corrected*
All meat (control)	49 ± 1·2	16·6 ± 4·5	2·95 ± 0·09	3·15
Meat + 20% faba beans	38 ± 1·8	15·8 ± 3·2	2·40 ± 0·03	2·56
Meat + 20% chick peas	45·3 ± 1·9	16·7 ± 2·9	2·82 ± 0·02	3·01
Casein	41·7 ± 2·1	17·8 ± 2·4	2·34 ± 0·12	2·50

TABLE 5
In vivo Digestibility of Various Sausage Products

Meat emulsion	*Digestibility* (%)	
	Apparent	*True*
All meat (control)	84·5	94·2
Meat + 20% faba beans	72·13	90·1
Meat + 20% chick peas	85·2	93·5
Casein	86·2	95·2

containing 20% legumes, regarding chemical composition, amino acid composition, PER and TD, was nearly as good as that of the all-meat sausage.

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