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Chemical composition and levels of non-meat proteins in meat brands extended with soy protein concentrate

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Soy protein concentrate (SPC) and four local meat brands extended with non-meat proteins (Beef Burger Meat, BBM, Beef Kofta Balls, BKB; Beef Cocktail Sausage, BCS and Beef Kofta Dawoud pasha, BKD), as well as raw (LBM) and stewed (SLB) beef, were analyzed as purchased for their protein, fat, starch, ash, iron and sodium chloride contents. Immunological blotting techniques revealed the presence of soy protein in all products, in concentrations varying from 10–25%; wheat gluten was present only in BCS at 0.5%. The % crude protein was lower and the % fat was higher in all meat brands than in the beef. All meat brands contained starch at levels ranging between 2.2 and 14.7 on a dry matter basis. Sodium chloride makes up 24.3–33.9% of the ash. © 1997 Elsevier Science Ltd

INTRODUCTION

High meat prices, prompted the meat industries in Egypt to produce various meat brands extended with soy proteins. Such products have been introduced recently as food commodities. The Federal Register USA (1978) states that meat extenders should contain a minimum protein level of 18% by weight. However, in Egypt there is still no government regulation which describes the specification of meat extenders. It is the aim of the present study to investigate the composition of some meat extenders commonly available as food commodities on the retail market. The relevance of the high fat and high sodium chloride contents in the extended meats is considered.

MATERIALS AND METHODS

All meat samples were ground in a meat chopper, weighed and dried in a freeze-drier (Heto-lyophilizer). The freeze-dried samples were weighed and finely ground in an electric mill to pass through a sieve of 100 micron mesh and kept in air-tight containers for analyses of protein, fat, ash and sodium chloride (AOAC, 1990). Table 1 summarizes the description and ingredients of the studied samples. All meat samples and SPC were analyzed for their iron (AOAC, 1990). The starch content, after extracting the samples at 60°C for 2 h with hot 0.1 M acetate buffer pH 5.0 to remove the soluble sugars, was assayed enzymatically using Termamyl followed by amyloglucosidase (Theander & Westerlund, 1986). Detection of non-meat protein in extended meat samples was determined by immunoelectrophoretic techniques (Janssen *et al.*, 1986).

Samples of soy protein, meat product or standard proteins were dissolved in a buffer consisting of 0.38 M-glycine and 50 mM-tris, pH 8.6 in which 1% of sodium dodecyl sulfate (SDS), 0.1% of dithioerythritol (DTE) and 20% of sucrose were dissolved. Samples were dissolved in a tenfold volume of the buffer, then the mixture was heated for 45 min in a boiling water bath, cooled to room temperature and centrifuged. Electrophoresis was carried out on vertical polyacrylamide slabs with a pore gradient of 8–18%. Soy products and reference samples (increasing concentration from 5–90%) were charged in 8 μl aliquots on the gel with dimensions 160×160×1.5 mm. The electrode buffer was used as lower (anode) buffer whereas the cathode buffer, containing in addition 0.2% of SDS, was kept in the

upper chamber. The electrophoretic run was performed at a constant power of 30 W and a low temperature of 10°C. Blotting was carried out electrically for 3 h at a voltage of 200 V and a temperature of 1°C by sandwiching the gel obtained from the preceding step on nitrocellulose foil. After the blotting step, the nitrocellulose (NC) blot was treated according to an immunoperoxidase-staining protocol (Table 2). The polyacrylamide gel was fixed with trichloroacetic acid and stained with Coomassie Brilliant Blue 250 to check transfer efficiency. The patterns of the unknown protein were compared with the respective patterns of the authentic proteins.

The statistical analysis was computed using an analysis of variance procedure and the significant mean differences between treatment means were separated by Duncan's Multiple Range Test (SAS, 1988).

Table 1. Description and ingredients of the studied soy protein concentrate, raw and stewed beef and extended meat with soy protein

Trade Name	Abbreviation	state processed	Manufacturer	Ingredients [Label]	price L.E./kg
Soybean	SPC	Powder	Brazil	Soybean	28.0
Lean beef	LBM	Raw	Consumer Cooperative	Whole lean beef	9.50
Lean beef	SLB	Cooked	Home-cooked	Stewed whole lean beef	9.50
Hamburger	BBM	Minced beef	Fresh Food Company	Beef, vegetable protein and spices	6.25
Kofta-Balls	BKB	Minced Beef	Fresh Food Company	Beef, vegetable protein, spice mixture, monosodium glutamate and sodium phosphate	9.75
Sausage	BCS	Canned beef	Beefy Company	Beef, vegetable protein, milk protein, starch, spices, salt and sodium nitrate	9.50
Kofta Dawoud Pasha	BKD	Minced beef	Queen Foods Company	Beef, petersilie and other unknowns	7.77

Table 2. Immunostaining of blots by Immunoperoxidase staining scheme

Procedure	Solution	PAP		Conjugate	
		Dilution	Time (min)	Dilution	Time (min)
Blocking of active sites	PBST[a]	—	50	—	50
Primary antiserum	Anti-soy serum	1/100 in[a]	60	1/100 in[a]	60
Wash	PBST[a]	—	10[b]	—	10[b]
Goat anti-rabbit HRP conj.	conjugate	—	—	1/200 in[a]	60
Linking antiserum	GAR	1/50 in[a,c]	60	—	—
Wash	PBST[a]	—	10[b]	—	—
PAP	PAP complex	1/200 in[a]	45	—	—
Wash	substrate buffer[d]	—	10[b]	—	10[b]
Substrate	4-chloro-1-naphthol[e]	—	5–10	—	5–10
Store	water[f]	—	—	—	—

[a]Phosphate-buffered saline with Tween-20 (PBST) pH 7.0: 7.2 mM Na_2HPO_4 4.2 aq, 2.79 mM-NaH_2PO_4 4.2 aq, 0.15 M-NaCl and 0.3% Tween 20 v/v. This buffer serves to inactivate absorptive sites on the NC foil.
[b]4 Changes.
[c]It is essential that the GAR is applied at a high concentration in order that only one of the F (ab) moieties of the IgG binds to the primary antiserum and another is still available for binding with the PAP complex.
[d]Substrate buffer: 0.01 M-Tris adjusted to pH 7.6 with HCl.
[e]Substrate: 25 mg of 4-chloro-1-naphthol dissolved in 5 ml of ethanol, mixed with 45 ml of substrate buffer and filtered. 1 ml of 3% hydrogen peroxide is added to the filtrate.
[f]For prolonged storage a preservative is added.

Table 3. Nutrient content of SPC, raw and stewed beef and beef extended with soy protein (as purchased)

	SPC	All beef		Extended meat			
		Raw LBM	Stewed SLB	BBM	BKB	BCS	BKD
Protein %	53.9±0.38	19.7±0.31	17.1±0.20	14.8±0.05	12.6±0.12	13.0±0.16	16.9±0.11
Fat %	10.92±0.36	1.10±0.11	0.96±0.10	13.50±0.05	12.10±0.3	13.02±0.03	19.13±0.05
Moisture %	10.27±0.18	81.35±0.11	84.30±0.25	72.61±0.16	69.20±0.14	71.07±0.66	60.17±0.15
Starch %	11.8±0.90	0	0	0.67±0.36	4.55±0.36	1.93±0.40	2.45±0.47
Ash %	6.50±0.29	0.43±0.05	0.61±0.05	2.28±0.07	2.41±0.04	2.21±0.08	2.33±0.29
Iron mg/100 g	0.88±0.05	0.30±0.01	0.21±0.01	0.31±0.02	0.37±0.02	0.29±0.00	0.28±0.01

RESULTS

Chemical analyses of SPC, extended meat and beef samples

Tables 3 and 4 present the proximate analyses of the meat samples. The protein contents in fresh extended meat ranged from 12.1–16.9%. It could be seen that, when the results were expressed on a dry matter basis, the beef was the richest source of protein followed by SPC. Most extended meats contained variable amounts of proteins, which made up less than 50% of the dry matter content. Beef was poorest in its crude fat content, with mean levels of 1.1 and 0.96% for raw (LBM) and cooked (SLB) meats, respectively. The product (BKD) was the highest meat brand in its crude fat content with a mean level of 19.1%. The ash content of raw beef averaged 0.43%, which was low compared with values found in other samples as shown in Fig. 1. The ash contents of the dried beef samples were the lowest whereas ash was highest in both the dried SPC and the simulated meat products, with a maximum level of 7.8%. Table 4 and Fig. 2 show the mean iron content in the meat samples in which the highest iron concentration was found in the dried raw beef.

The high ash content in the extended meat is due to the presence of sodium chloride which is incorporated during the different stages of manufacturing. Table 4 shows the low NaCl concentration in the raw and stewed beef, in contrast to the high sodium chloride level in the extended meat brands, particularly when the results are expressed per 100 g ash.

The presence of starch in the samples was tested by an enzymatic method, and the analysis showed that all extended meats contained starch, with levels ranging between 2.2 and 14.7% of the dry matter in BBM and BKB, respectively.

Detection of non-meat proteins

The immunological patterns of BBM, BKB, BCS are illustrated in Fig. 3. It shows the presence of SPC at a level of 25% of the dried Hamburger (BBM) protein whereas, in Kofta Balls, SPC made up 20% of the total protein. Gluten protein was detected in Beef Cocktail Sausage (BCS) at 0.5%, in which SPC was detected at a level of 10%. No milk proteins were detected in any of the studied meat brands.

DISCUSSION

The present results show that the % moisture content in the four raw meat extenders fluctuated between 60.2 and 72.6%; the highest level was found in BKD and BBM. These levels exceeded the respective levels of 58.5–60.5% reported previously in beef patties extended with 20% rehydrated soybean products (Miles *et al.*, 1984).

Published protein levels are 16.6% for beef patties extended with 20% rehydrated soy protein (Miles *et al.*, 1984), whereas, the values in the present study fluctuated from 12.6–16.9%. The Federal Register U.S.A. (1978) states that the product should contain a minimum protein level of 18%, when the substitute food is formulated to resemble meat.

The fat content in the four meat extenders ranged between 12.1 and 19.3%, i.e. below the reported value of 21.7% for raw beef patties extended with 20% rehydrated soy protein (Miles *et al.*, 1984).

Meats are normally rich in their contents of saturated fatty acids (SFA), compared to polyunsaturated fatty acids (PFA). Soybeans are rich sources of PUFA, though, processing and cooking may convert some of the PUFA to saturated fatty acids. The ratio of intakes of PFA to SFA, or the P/S ratio is considered a measure of the atherogenicity of the diet, the lower the estimated ratio, the more atherogenic is the diet (Goor *et al.*, 1985).

In the USA dietary goals have been formulated to make diets less atherogenic with equal contributions from PFA and SFA recommended, i.e. with a P/S ratio of 1.0, and maximum of 300 mg of cholesterol per day (Gordon *et al.*, 1982). The composition of the fat will be reported in a forthcoming publication. The local meats extended with soy protein are also characterized by their high ash content, which amounted to 2.2–2.4%, whereby, sodium chloride content per 100 ash varied for

Table 4. Nutrient content of SPC, raw and stewed beef and beef extended with soy protein (per 100 g Dry matter)

	SPC	All beef		extended meat			
		Raw LBM	Stewed SLB	BBM	BKB	BCS	BKD
Protein %	60.1 ± 0.42	$92.8^{d} \pm 0.74$	$91.3^{d} \pm 0.68$	$47.7^{c} \pm 0.19$	$40.8^{a} \pm 0.37$	$43.5^{b} \pm 0.95$	$40.4^{a} \pm 0.10$
Fat %	12.18 ± 0.43	$4.56^{a} \pm 0.54$	$5.46^{a} \pm 0.45$	$43.57^{c} \pm 0.18$	$39.15^{b} \pm 0.89$	$43.47^{c} \pm 0.10$	$45.88^{d} \pm 0.15$
Starch %	13.1 ± 1.01	0	0	$2.17^{a} \pm 1.17$	$14.8^{c} \pm 1.19$	$6.44^{b} \pm 1.25$	$5.88^{b} \pm 1.14$
Ash %	7.25 ± 0.33	$2.27^{a} \pm 0.33$	$3.48^{a} \pm 0.34$	$7.40^{b} \pm 0.40$	$7.80^{b} \pm 0.15$	$7.40^{b} \pm 0.28$	$5.58^{a,b} \pm 0.70$
Iron mg/100g	0.97 ± 0.03	$1.4^{d} \pm 0.01$	$1.06^{c} \pm 0.01$	$1.02^{c} \pm 0.03$	$1.10^{c,d} \pm 0.06$	$0.96^{b} \pm 0.01$	$0.67^{a} \pm 0.02$
NaCl g/100g	1.81 ± 0.02	$0.23^{a} \pm 0.02$	0.40 ± 0.03	$2.01^{c} \pm 0.03$	$1.89^{b} \pm 0.03$	$2.09^{c} \pm 0.30$	$1.89^{b} \pm 0.01$
NaCl g/100g ash	25.10 ± 0.20	$10.13^{a} \pm 1.20$	11.60 ± 0.80	$27.20^{c} \pm 0.50$	$24.30^{b} \pm 0.30$	$28.20^{c} \pm 0.40$	$33.90^{d} \pm 0.20$

Mean values are statistically different ($p < 0.05$), if they don't share the same alphabet within the same row (Duncan's Multiple Range Test).

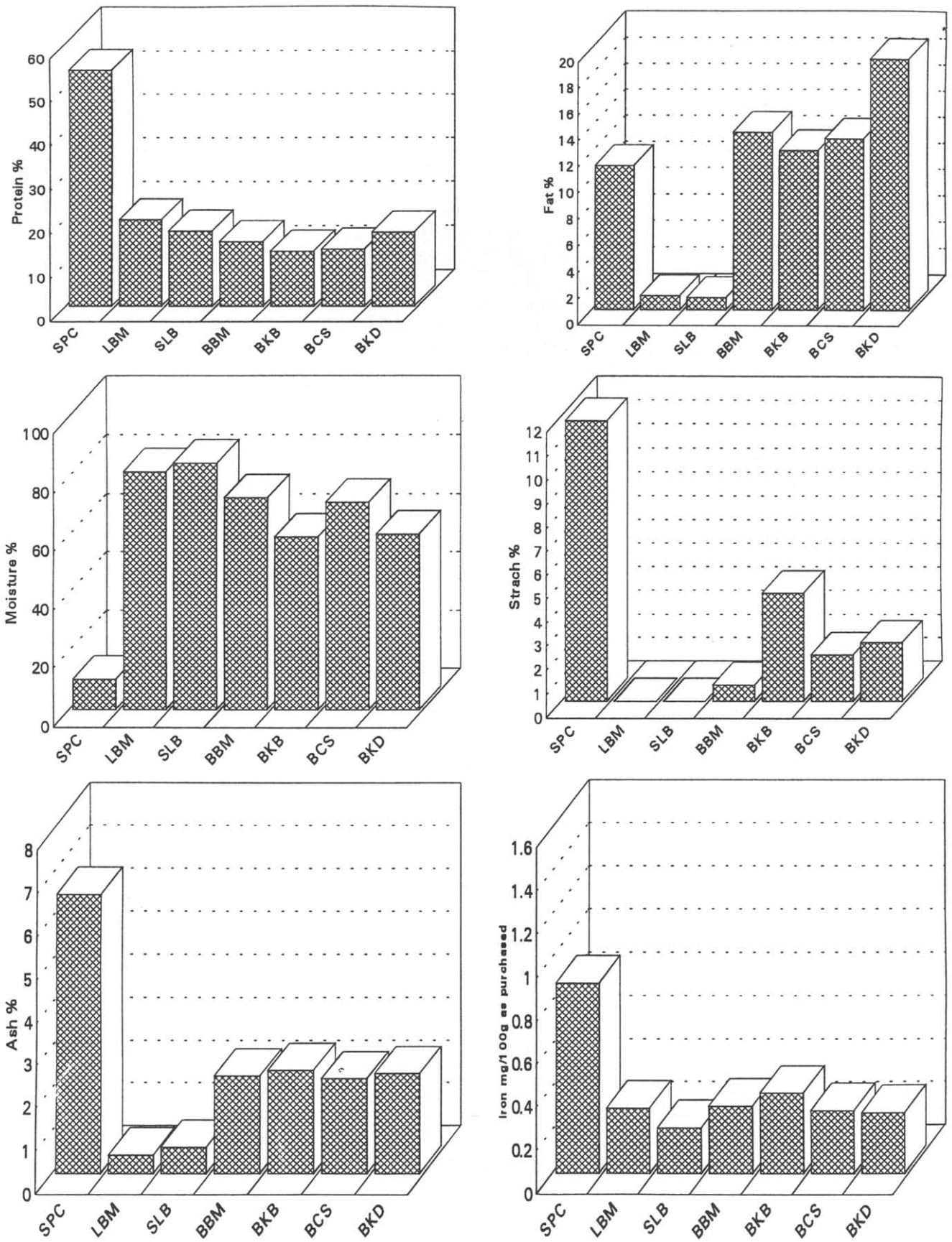

Fig. 1. Protein, fat, moisture, starch, ash and iron contents of SPC, raw and stewed beef and extended meat samples as purchased.

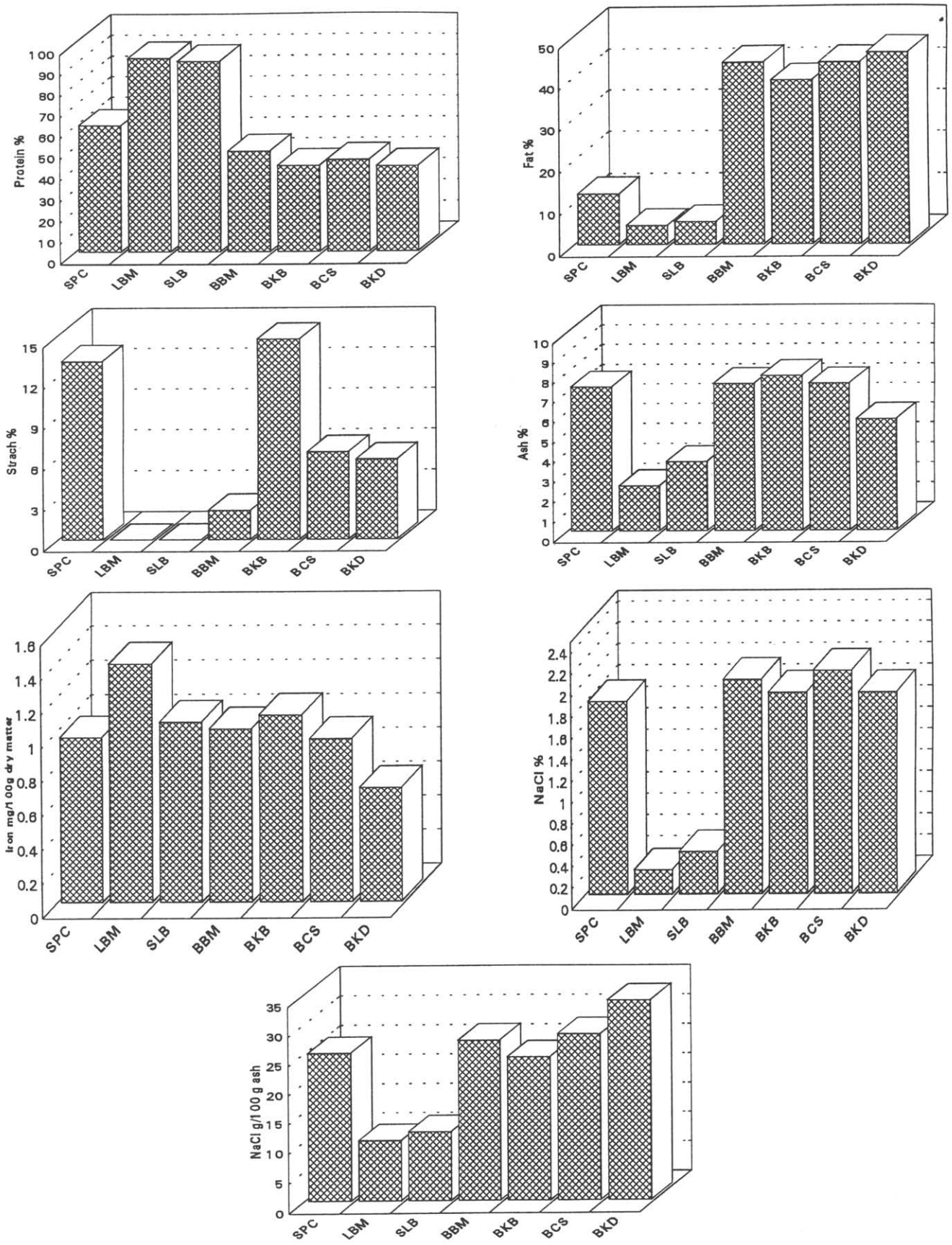

Fig. 2. Protein, fat, starch, ash, iron and NaCl contents of SPC, raw and stewed beef and extended meat samples in dry matter.

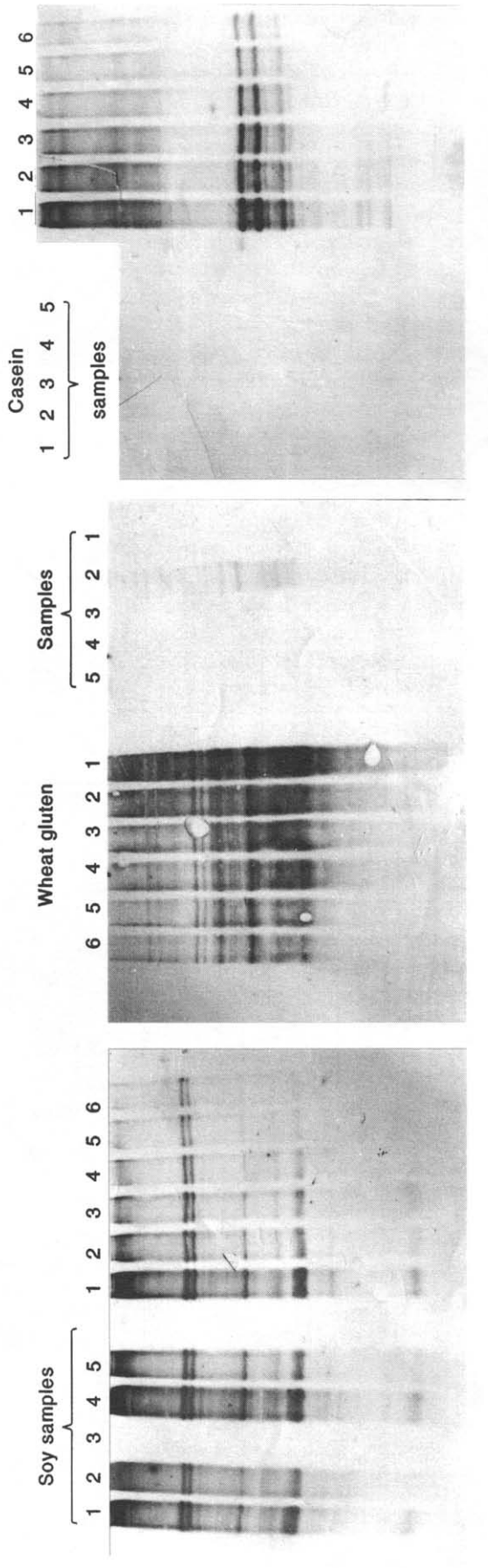

Fig. 3. Immunological patterns of some meat analogs as detected by the blotting technique.

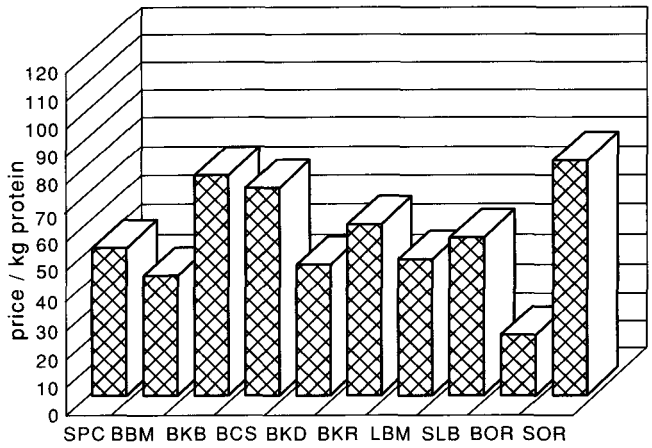

Fig. 4. Price in Egyptian pounds per kg of soy protein concentrate, raw and stewed all beef and extended meat samples.

24.3 to 33.9%. Miles *et al.* (1984) reported that levels ranged between 0.7 and 1.0% for the ash in raw beef patties extended with 20% rehydrated soy protein; the sodium chloride concentration in their products makes up 13.5–37% of the beef patties extended with 20% rehydrated soy protein. Detection of soy protein in the samples of extended meat using the immunological techniques coupled with a blot method indicated that the beef cocktail sausages had been extended with 10% soy protein. This level is within the acceptable levels which fall normally between 10 and 30% (Seideman *et al.*, 1977; Carlin *et al.*, 1978).

Based on the previous finding, a cost benefit effective study has been carried out to upgrade the different products. The following histogram (Fig. 4) illustrates the price expressed in Egyptian pounds per kilogram of protein. It is interesting to note that the prices of meat brands are comparable with those of all beef when protein units were the basis of evaluation.

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