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Evaluation of the Nutritional Quality of Flakes made of Banana Pulp and Full-Fat Soya Flour

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ABSTRACT

The full-fat soy flour (FFSF) obtained by extrusion from whole dehulled soybeans was mixed with pulp from ripe bananas (60:40 dry basis) and dried in a drum-drier. The protein content of the banana-soy flakes (22·0% TS) was many times higher than that of the fresh bananas (2·7% TS). The amount of starch in the product, and the total dietary fibre were determined, and the contents of calcium, magnesium, iron, copper and zinc were assayed. The fat content and fatty acid composition of the banana-soy flakes and the content of vitamin A, vitamin E, thiamin and riboflavin were also determined. The amino acid composition showed that the chemical score of banana-soy flakes was 89. The limiting amino acid was lysine. The quality of protein was also assayed by animal feeding experiments. The net protein utilization (NPU) of the banana-soy flakes was 55·9, the biological value (BV) was 67·9, and true digestibility (TD) was 83·1. The nutritional density of a beverage made of rehydrated banana-soy flakes (water solution of 17·5% flakes plus 3·5% sugar) in relation to nutritional requirements of children between 7 and 10 years of age was evaluated.

INTRODUCTION

Ecuador produces about 30% of all the bananas exported from Latin America. The annual production is about 2·2 million tons. Besides this, a

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special variety of banana, which is used extensively for cooking, called plantain, is also grown in Ecuador (Stonehouse, 1985).

According to the United Nations *Statistical Yearbook* (1985) the average intake of calories, per capita, per day in Ecuador was 2100 between 1975 and 1980. And during the last 20 years the average protein intake, per capita, per day was 50 g. As such, due to the intake of foods with low protein content or poor quality protein, malnutrition during the weaning period continues to be a very serious problem. There is a recognized need for development of foods with an adequate amount and quality of essential nutrients. One of the ways to improve the nutritional status is to enrich or supplement the traditional foods available in the country (Mitzner *et al.*, 1984).

In Ecuador large quantities of surplus bananas are available throughout the year after export. Bananas are eaten and are well liked, expecially by children. Even though it is difficult to retain the typical (original) organoleptic characteristics of banana during processing, several banana products have been produced (Brekke, 1967; Brekke, 1969; Palmer 1979; Screekantiah *et al.*, 1970; Shemer *et al.*, 1973; Ferrier *et al.*, 1975; Velu *et al.*, 1978; Diaz, 1981). The present paper deals with the nutritional quality of the flakes produced with full-fat soy flour (FFSF) and pulp from ripe bananas.

MATERIALS AND METHODS

Raw materials

The soybean seeds (var. Iniap Jupiter) were obtained from Indugrasa, Guayaquil, Ecuador. Bananas (var. Gross Michel) with 7–8 degree of ripening according to the Von Loesecke scale, were purchased from the local market.

Production of full fat soy flour (FFSF)

The whole soy beans were first cracked in a disc mill, and the hulls were removed using a blower. The soy grits (16–40 mesh) were then roasted for 10 min at 104°C to inactive lipoxidase and to adjust the moisture content to a level suitable for further treatment in the extruder. The soy grits were pre-cooked in a Brabender extruder 20 DN, model 825602 under the conditions of feed moisture 17·5%, screw speed 70 rpm, screw compression ratio 1:1, and die diameter 4 mm. The temperature at the feed section was 75°C, at the compression section 150°C and at the metering section 150°C. The pellets were dried to 7% moisture, cooled to room temperature (20°C) and milled to a particle size of 80 mesh in a pin-mill Condux D 6450 Hanu 11/Wolfgang GM 280 F II at 9000 rpm (Hervas, 1985).

Production of flakes by drum drying

Bananas were peeled and washed with an antioxidant solution of ascorbic acid (0·3%) and citric acid (0·3%). They were then mixed with full fat soy flour (FFSF) in the proportion 60:40 on a dry weight basis. A solution of ascorbic acid (0·25%), citric acid (0·25%), sucrose (5%), and sodium chloride (0·1%) was added to adjust the water content of the blend to 75%. Bananas and soy flour were blended, disintegrated, and homogenized in a colloid mill (Fryma MZ 80/R). The drying process was carried out in a GF Double drum dryer, model 215 (Mathis Machine Co.) under conditions shown in Table 1. Banana flakes were stored at 4°C. The taste of the product was improved with the addition of extra banana flavour (250 mg/kg), maltol (8 mg/kg), or vanilla (10 mg/kg) (Hervas, 1985).

Moisture

Moisture was assayed according to the AOAC (Association of the Official Analytical Chemists, Virginia, USA), method 18023 of 1984.

Fat and fatty acids

Fat analysis was performed gravimetrically according to the method described by Croon & Fuchs (1980). Fatty acids were analysed as methyl esters on a gas chromatograph (Varian Model 3700), equipped with a flame ionization detector and fused silica capillary column (30 m × 0·25 mm), having OV-351 as the stationary phase and helium as the carrier gas (Ruales *et al.*, 1988).

Carbohydrates

Determination of the quantity of starch was performed by an enzymatic and colorimetric method described by Holm *et al.* (1986). The content of dietary

TABLE 1
Operation Conditions of Drying Process for the Mixture of Banana Pulp and Soy Flour 60/40 (Dry Basis)

Initial moisture	75·00%
Final moisture	4·20%
Distance between rollers	0·02 cm
Height of feed	5·00 cm
Roller speed	4·20 rpm
Steam pressure	3·5–4·0 kg/cm^2

fibre was analysed gravimetrically after solubilization of protein and starch with enzymes as described by Asp *et al.* (1983).

Minerals

Ash was analysed following the AOAC method 18025 of 1984. Mineral composition (Ca, Mg, Fe, Zn and Cu) was assayed by atomic absorption spectrophotometry (Varian Techtron) after wet digestion (Abdulla, 1986).

Vitamins

To analyse vitamin A, the sample homogenized with ascorbic acid was saponified with potassium hydroxide in ethanol and water, and was extracted with hexane. The separation and the determination of the retinol content was performed by HPLC (LDC, Model 1204 A, equipped with a UV (325 nm) detector) using a reverse-phase RP C18 column of 25 cm length and 4·6 mm diameter. The stationary phase was Nucleosil of particle size 5 μm. The column was eluted with methanol.

The content of vitamin E was quantified as α-tocopherol. The saponification, extraction and HPLC separation of vitamin E in the sample was done in the same way as for analysis of vitamin A. The α-tocopherol was detected at 292 nm. The quantity of α-tocopherol was calculated using DC-α-tocopherol (Fluka AG, Basel, Switzerland) as the internal standard.

Assay of thiamin (vitamin B_1) was carried out spectrofluorimetrically as thiochrome after acid hydrolysis (HCl 0·1 M) and enzymatic digestion (Clara-Diastasa, Clarase 300, Fluka) of the sample to release the thiamin. The vitamin was separated by filtration and then oxidized to thiochrome using 0·1 M NaOH and 0·03 M $K_3[Fe(CN)_6]$. The separation and detection was performed by HPLC with a fluorescence detector (Schimadzu, Spectrofluorometer RF-530). The excitation wavelength was at 365 nm and the emission wavelength at 510 nm. The column was an RP C18, of 25 cm in length and 4·6 mm in diameter. The stationary phase was Nucleosil of 5 μm particle size. The column was eluted with PIC:methanol 70:30. PIC was prepared as an aqueous solution of 0·01 *N* hexane sulphuric acid–sodium salt ($CH_3(CH_2)_5SO_3Na$) and 0·01N citric acid. The quantity of thiamin in the sample was calculated using thiamin as the internal standard.

The assay of vitamin B_2 (riboflavin) was performed after the sample was first hydrolyzed (HCl 0·1 M) and then treated with enzyme (Clara-Diastasa. Clarase 300, Fluka AG, Basel, Switzerland) to release the riboflavin. After filtration through a millipore filter 0·5 μm, the sample was analysed directly by HPLC, using a reverse-phase column RP18. The separation conditions on the HPLC were the same as that for vitamin B_1.

Protein and amino acids

Nitrogen was assayed by the Kjeldahl method (Kjeltec, Tecator AB, Höganäs, Sweden) and the amount of protein was calculated as 6·25 × N. The amino acid composition was analysed by ion-exchange chromatography (Amino acid analyser Biotronic LC 5001, Instrument AB, Lambda, Stockholm, Sweden) after acid hydrolysis with 6N HCl, at 116°C for 20 h. The sulphur amino acids, such as cystine and methionine, were determined as cysteic acid and methionine sulfone, after performic acid oxidation followed by acid hydrolysis. Tryptophan was analyzed spectrofluorimetrically after incubation with papain in urea (Öste *et al.*, 1976). The chemical score was estimated using the FAO/WHO (1985) reference protein. The values of nutrient density of some essential nutrients were calculated according to Hansen (1973) and FNB (Food and Nutrition Board, National Research Council) (1980), Washington, DC, USA.

Animal experiments

The nitrogen balance experiments were performed with weanling male Sprague–Dawley rats with an initial weight of 75–80 g. The rats were placed individually in metabolic cages in an air-conditioned room maintained at a temperature of 23°C and 50–60% relative humidity. The food intake was restricted to 10 g dry weight per day. Water was given *ad libitum*. After a 4-day adaptation period, feed residues, urine and faeces were collected during a 5-day balance period. Urine and faeces were collected in 5% sulphuric acid and analyzed for nitrogen by the Kjeldahl method. Crude protein was calculated as N × 6·25. The True Digestibility (TD), Biological Value (BV), and Net Protein Utilization (NPU) were calculated using the Thomas-Mitchell equations (Eggum, 1973).

Diets

The composition of the basal diet was casein (Casein ANRC 30 M) 10%, sucrose (Swedish Sugar Company) 10%, maize starch (AB Stadex Malmö, Sweden) 64·2%, cellulose 5%, maize oil 5%, mineral blend 4·8%, vitamin blend 0·8% and choline chloride 0·2%. The composition of the vitamin blend and of the mineral blend as reported before in Nyman & Asp (1982), was from the pharmacy of the University Hospital, Lund, Sweden.

All the chemicals used in this study were of analytical grade, and the analyses were performed in duplicate.

TABLE 2
Proximate Composition of Flakes of Banana and Soy and Fresh Peeled Bananas (%)

	Banana-soy flakes	*Fresh bananas*[a]
Moisture	10·5	74·0
Protein	19·7	1·0
Ash	1·3	0·8
Fat	7·6	0·5
Carbohydrates	60·9	23·5

[a] Data from literature: the food composition tables of Sweden, Livsmedelstabeller, The Swedish National Food Administration, Uppsala, Sweden (1986).

RESULTS AND DISCUSSION

Chemical composition

The proximate composition of banana-soy flakes is presented in Table 2. The average moisture content was 10·50%.

The protein content of banana-soy flakes was 19·7%. The main advantage of mixing banana with soy is to increase the protein content in the blend. The protein content of banana-soy flakes was twenty-two times more than that of the fresh bananas on a dry weight basis. The recommended dietary allowance (RDA) of the protein is 18 g per day for infants aged from 6 to 12 months. Besides this, the fat content in the banana-soy blend was fifteen times more than the fat content of fresh bananas.

Carbohydrates

The amount of carbohydrates was 60·9%, mainly composed of sugars present in ripe bananas (Shemer *et al.*, 1973; Adisa & Okey, 1987). The amount of starch was 11·7% of the total dry matter, and the dietary fibre

TABLE 3
Content of Starch and Total Dietary Fibre in the Banana-Soy Flakes (% of TS)

Starch	11·7
Dietary fibre	3·3

TABLE 4
Contents of Some Minerals (Zn, Fe, Ca, Mg and Cu) in Flakes of Banana and Soy (mg/kg Dry Matter)

Zinc	50·2
Iron	16·2
Calcium	522·7
Magnesium	1 299·0
Copper	7·6

content was 3·3% (dry matter) of the banana-soy flakes (Table 3). The dietary fibre content in relation to energy content of the banana-soy flakes was 6·9 g/1000 cal.

Minerals

The contents of some minerals—calcium, magnesium, zinc, copper, and iron—are reported in Table 4. The values for all the minerals analysed in the banana-soy flakes were many times more than the mineral content of fresh bananas.

Vitamins

Amount of vitamin E as α-tocopherol is reported in Table 5.

During the process, soybeans were heat-treated first by extrusion to obtain FFSF and then again together with bananas in a drum drier. In this study only the amount of vitamin E after extrusion cooking and drum drying has been determined. Håkansson *et al.* (1987) reported low retention rates (12–37%) of α-tocopherol, α-tocotriol, β-tocopherol and β-tocotriol after heat-treatment of wheat flour by extrusion or by drum drying. Mustakas *et al.* (1964) reported losses of up to 15% vitamin E when the retention time was 2 min. However, under shorter residence times, tocopherols were not destroyed during extrusion cooking (residence time 0·5–2 min, moisture of feed 15–30%, and temperature of the barrel

TABLE 5
Content of Vitamin A, Vitamin E, Vitamin B1 and Vitamin B2 in Banana-Soy Flakes

Vitamin A	<96 μg RE/kg
Vitamin E	14·6 mg/kg
Vitamin B1	3·7 mg/kg
Vitamin B2	0·4 mg/kg

121–149°C). The recommended daily allowance (RDA) of vitamin E for infants between 6 months and 1 year of age is 3–4 mg; for children between 1 and 10 years of age it is 5–8 mg (FNB, 1980).

The content of vitamin A of the banana-soy flakes is reported in Table 5. It was less than 96 μg RE/kg. The stability of vitamin A during extrusion cooking and during storage were investigated. Short residence times (high screw speed) did not very much affect any forms of vitamin A (Björck & Asp, 1986). Further, it seems that the porosity of the extruded products may increase the oxidative sensitivity to light (Cheftel, 1986). The RDA for infants aged 6–12 months and for children between 1 to 10 years of age is 400 and 400–700 μg RE, respectively.

The thiamin content in banana-soy flakes is also reported in Table 5. No fortification of any B-vitamin was done prior to the process. Mustakas *et al.* (1964) reported that thiamin seemed to be more thermostable than riboflavin during extrusion cooking of full-fat soy flour (FFSF) at a barrel temperature of 139°C to 153°C, moisture content of the feed 9–12%, and residence time 1 min. Mustakas *et al.* (1964) also reported in another study that for FFSF, treated in a pilot-plant extruder (temperature within the barrel 121–149°C, moisture 15–30%, and residence time 0·5–2 min) the average thiamin recovery was 79%. On the other hand, Håkansson *et al.* (1987) reported thiamin losses of 18% in wheat flour after drum drying. The content of thiamin in the banana-soy flakes was 3·7 mg/kg, several times more than the thiamin content in fresh bananas. The riboflavin content of banana-soy flakes was 0·4 mg/kg sample. The retention of vitamins in the foods can be affected in major or minor degree by the combined conditions during extrusion: moisture of the feed, screw speed, residence time, shear and temperature (Lorenz & Jansen, 1980; Harper, 1979). Besides this, Cheftel (1986) reported changes in the availability of vitamin B after extrusion that may not change the vitamin content. The RDA of thiamin for infants is 0·3 mg, and for children between 1 to 10 years of age it is 0·7–1·2 mg. The RDA of riboflavin for infants is 0·6 mg per day, and for children between 1 to 10 years of age it is 0·8 to 1·4 mg per day.

Fat and fatty acids

The content of fat of the banana-soy flakes was 8·5% of the TS. The composition of the fatty acids of banana-soy flakes is presented in Table 6. The most saturated fatty acid of banana-soy flakes was palmitic acid (11·4%) and the corresponding unsaturated fatty acid was linoleic acid, with 56·5% of the total fat.

Linoleic acid provides 38 kcal/100 g in the flakes. Three per cent of total

TABLE 6
Fatty Acid Composition (% of the Total) of Banana-Soy Flakes

Fatty acid		*%*
Myristic acid	(C 14)	0·1
Palmitic acid	(C 16)	11·4
Palmitoleic acid	(C 16:1)	0·1
Stearic acid	(C 18)	3·1
Oleic acid	(C 18:1)	19·3
Linoleic acid	(C 18:2)	56·5
Linolenic acid	(C 18:3)	7·6
Arachidic acid	(C 20)	0·3
Eicosenic acid	(C 20:1)	0·1

energy content as linoleic acid has been suggested to be the minimum recommended intake for groups of low fat intake (FNB, 1980).

Protein and amino acids

The content of amino acid of banana-soy flakes is reported in Table 7. The chemical score based on the amino acid content was 89, and the limiting amino acid was lysine. The data are in accord with those reported by Velu *et al.* (1978). The content of essential amino acids is high. Except for lysine, they are comparable to the scoring pattern given by FAO/WHO (1985).

The values for Net Protein Utilization (NPU), Biological Value (BV), and True Digestibility (TD) are shown in Table 8.

The net protein utilization (NPU) of the banana-soy flakes was 60% of the value for the diets prepared using casein as source of protein. The biological value (BV) and total digestibility (TD) of the banana-soy flakes were 71% and 84%, of the respective values of the casein diet. Earlier studies of a weaning food prepared with banana and soybeans (1:1 ratio dry basis) reported values of NPU as 63% of the value of the casein diet. Further, Shemer *et al.* (1973) and Velu *et al.* (1978) reported adjusted PER (casein 2·5) for the same banana blend values of 1·95 and 1·4.

The nutrient density

The nutrient density of the banana-soy flakes is as shown in Table 9. A reference of 2000 kcal has been taken. The value of 1 indicates that the amount of studied nutrient per energy unit is enough to cover the

TABLE 7
Amino Acid Composition of the Banana-Soy Flakes (mg/kg Sample)

Amino acid	*mg/g Sample*
Cystine	3·9
Aspartic acid	22·3
Methionine	5·8
Threonine	7·3
Serine	9·6
Glutamic acid	33·1
Proline	7·3
Glycine	8·2
Alanine	8·2
Valine	9·7
Isoleucine	7·6
Leucine	15·8
Tyrosine	8·0
Phenylalanine	9·9
Lysine	9·6[a]
Histidine	6·2
Tryptophan	2·5
Arginine	13·0
Total	188·0
Chemical score	89

[a] Limiting amino acid.

requirement. Calcium, magnesium, and some iron have to be supplied from other sources. The product can also be fortified with vitamin A and riboflavin. Table 9 shows also the nutrient density of the cow's milk.

The energy density calculated on the basis of 2000 kcal is 0·8 kcal/g for the banana-soy beverage, which is higher than the energy density of the milk (fat 3·5%) which has 0·6 kcal/g.

TABLE 8
Nitrogen Balance in the Banana-Soy Flakes NPU, BV, and TD

	Banana-soy flakes	*Casein*
TD	83·0 (+/−) 1·52	98·8 (+/−) 1·34
BV	67·4 (+/−) 1·81	94·5 (+/−) 2·86
NPU	55·9 (+/−) 1·36	93·4 (+/−) 2·28

TABLE 9
Nutrient Density of the Banana-Soy Flakes

Nutrients		*RDA*[a]	*Cow's milk*[b]	*Banana-soy beverage*[c]
Energy	kcal	2000	1·0	1·0
Protein	g	34	3·3	2·5
Vitamin A	μg RE	700	1·2	0·1
Vitamin E	mg	7	0·3	0·9
Vitamin B1	mg	1·2	1·1	1·2
Vitamin B2	mg	1·4	4·3	0·1
Calcium	mg	800	4·4	0·3
Iron	mg	10	0·2	0·7
Magnesium	mg	250	1·5	0·2
Zinc	mg	10	1·0	0·1
Copper	mg	2·2	—	1·5

[a] RDA for children between 7 to 10 years of age (RDA, 1980).
[b] Data from Livsmedelstabeller, Swedish Food Administration, Uppsala, Sweden, 1986.
[c] Beverage: 17·5% banana-soy flakes, 3·5% sugar and 79% water.

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REFERENCES

Abdulla, M. (1986). Inorganic Chemical Elements in Prepared Meals in Sweden. PhD thesis, Department of Clinic Chemistry, University of Lund, Sweden.

Adisa, V. A. & Okey, E. N. (1987). Carbohydrate and protein composition of banana pulp and peel as influenced by ripening and mold contamination. *Food Chem.*, **25**, 85–91.

Asp, N.-G., Johansson, C.-G., Hallmer, H. & Siljeström, M. (1983). Rapid enzymatic assay of insoluble and soluble dietary fiber. *J. Agric. Food Chem.*, **31**, 476–82.

Association of Official Analytical Chemists (AOAC) (1984). *Official Methods of Analysis.* (14th edn), Virginia, DC, USA.

Björck, I. & Asp, N.G. (1986). The effects of extrusion cooking on the nutritional value. A literature review. *J. Food Engineering*, **2**, 281–308.

Brekke, J. E. (1967). Dehydrated bananas. *Food Technology*, **10**, 101–5.

Brekke, J. E., Tonaki, K. I., Cavaletto, C. G. & Frank, H. A. (1969). Stable banana pureè for long-term refrigerated storage. *J. Sci. Food Agric.*, **20**, 376–8.

Cheftel, J. C. (1986). Nutritional effects of extrusion-cooking. *Food Chem.*, **20**, 263–83.

Croon, L-B. & Fuchs, G. (1980). Fetthatsbestämning i mjöl och mjölprodukter. *Vår Föda.*, **32**, 425–7.

Diaz, J. (1981). Produccion de une mezcla alimenticia de banano y soya deshidratada en secador de rodillos. Thesis Chemical Engineer, Escuela Politecnica Nacional, Quito, Ecuador.

Eggum, B. O. (1973). A Study of Certain Factors Influencing Protein Utilization in Rats and Pigs. Dissertation, Copenhagen.

FAO/WHO/UNU. Expert Consultation (1985). Energy and protein requirements. Technical Report Series 724, p. 121.

Ferrier, L. K., Bird, D., Wei, L. & Nelson, A. I. (1975). Weaning food prepared from whole soybeans and bananas by drum drying. *Archivos Latinomericanos de nutricion. Special ed.*, 281–5.

FNB (Food and Nutrition Board, National Research Council) (1980). *Recommended Dietary Allowances*, 9th edition. National Academy of Sciences, Washington DC, USA.

Hansen, R. G. (1973). An index of food quality. *Nutr. Rev.*, **37**, 1–7. FNB (Food and Nutrition Board), National Research Council.

Harper, J. (1979). Food extrusion. *Crit. Rev. Food Sci. Nutr.*, **11**(2), 155–215.

Hervas, M. (1985). Production de una Mezcla Alimenticia de Banano y Soya deshidratada en secado de rodillos. II Parte. Thesis Chemical Engineer, Escuela Politecnica Nacional, Quito, Ecuador.

Holm, J., Björk, I., Drews, A. & Asp, N-G. (1986). A rapid method for the analysis of starch. *Starch/Stärcke*, **38**(7), 224–6.

Håkansson, B., Jägerstad, M., Öste, R., Åkesson, B. & Jonsson, L. (1987). The effects of various thermal processes on protein quality, vitamins and selenium content in whole-grain wheat and white flour. *J. Cereal Sci.*, **6**, 269–82.

Lorenz, K. & Jansen, G. R. (1980). Nutrient stability of full-fat soy flour and corn–soy blend produced by low-cost extrusion. *Cereal Foods World.*, **25**(4), 161–2, 171–2.

Mitzner, K., Scrimshaw, N. & Morgan, R. (1984). Improving the nutritional status of children during the weaning period. A manual for policymakers, program planners, and fieldworkers. International Food and Nutritional Program, Massachusetts Institute of Technology, MA, USA, pp. 55–187.

Mustakas, G. C., Griffin, E. L., Allen, L. E. & Smith, O. B. (1964). Production and nutritional evaluation of extrusion cooked full fat soy flour. *J. Am. Oil Chem. Soc.*, **41**, 607–14.

Nyman, M. & Asp, N-G. (1982). Fermentation of dietary fibre components in the rat intestinal tract. *Br. J. Nutr.*, **47**, 357–66.

Öste, R., Nair, B. M. & Dahlqvist, A. (1976). A simple method for determination of tryptophan in food samples. *J. Agric. Food Chem.*, **24**, 1141–4.

Palmer, J. K. (1979). Banana products. In *Tropical Foods: Chemistry and Nutrition.* Vol. 2, ed. G. E. Inglett & G. Charalambous, pp. 625–35.

Ruales, J., Pólit, P. & Nair, B. M. (1988). Nutritional quality of blended foods of rice, soy and lupins processed by extrusion. *Food Chem.*, **29**, 309–21.

Shemer, M., Wei, L. S. & Perkins, E. G. (1973). Nutritional and chemical studies of three processed soybean foods. *J. Food Sci.*, **38**, 112–15.

Sreekantiah, S. A., Jaleel, S. A. & Ramachandra, Rao. (1970). Utilization of fungalenzymes in the liquefaction of soft fruits and extraction and clarification of fruit juices. *J. Food Sci. Technol. (India)*, **8**, 201–4.

Stonehouse, B. (1985). *Philips' Pocket Guide to the World.* Butler & Tanner Ltd, Frome and London, pp. 402–5.

The Swedish National Food Administration (1986). Livsmedelstabeller, Uppsala, Sweden.

United Nations (1985). *Statistical Yearbook.* Thirtieth issue, New York.

Velu, J. G., Rindsig, R. B., Brennan, M. & Harshbarger, K. E. (1978). Protein nutritive value of drum dried soy, soy–cereal and soy–banana blends. *Nutr. Report. Int.*, **17**(5), 537–49.