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Production of Cereal-Based Infant Food from Sorghum [Sorghum *bicolor* (L) Moench] and Pigeon Pea (*Cajanus cajan*)

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Abstract: The objectives of this study were to produce and evaluate sorghum-based infant food using cooking and drum drying methods. The product was made from sorghum flour, pigeon pea flour, milk, vit. C and other ingredients. The cooked materials were then drum dried. The dried product was found to provide adequate amounts of protein (15.15%) and energy values (414.25 Kcal/100 g DM) capable to meet the international standards for infants protein quality as recommended by the FAO/WHO/UN (1985). The protein digestibility was found to be improved by cooking and drum drying. The produced sorghum-based infant food physical and functional properties tested showed that the product has low water retention capacity and low viscosity. When comparing the prepared sorghum-based infant food with the commercial infant foods available in the market, this product proved to provide more protein and energy value. In conclusion the use of decorticated sorghum and pigeon pea flours in infants food, produced a product with high nutritional value and of better functional properties.

Key words: Cereal based infant food, sorghum, amino acids

INTRODUCTION

Protein-energy Malnutrition (PEM) is a serious problem in developing countries. In Sudan it's the most severe problem among the Sudanese infants (MOH, 2006). Sorghum is the stable food in the Sudan, although its proteins are low in lysine, but have adequate amounts of sulfur amino acids. In contrast, legume proteins are rich source of lysine (Singh, 1991). Therefore, supplementation of sorghum with legumes has been advocated as away of combating Protein-calorie Malnutrition (PCM). Wheat, rice sorghum and legumes were recommended as good ingredients for production of cereal-based baby foods (FAO, 1979). Feeding the weaned child in Sudan depends equally on the availability of milk and sorghum and millet (Dirar, 1993). In developing countries, drum drying as a method for food processing is considered a simple, economic and fairly common technology used, especially for cooking, texturing and production of cereal or legumes instant flours with high nutritional values and acceptable functional properties (Johnson, 1988; Makki and Emmerich, 2006). Drying was mentioned to affect moisture content, protein and vitamins (Potter, 1978; Makki and Emmerich (2006). Also, an acceptable loss in lysine was noticed in Ogi as a result of drum drying (Adeniji and Potter, 1978). Cooking was found to decrease sorghum tannins and protein digestibility (Price *et al.*, 1980, Maclean *et al.*, 1981 and Mertz *et al.*, 1984). The decrease in sorghum protein digestibility after cooking was attributed to the disulfide linkage formation during cooking between β- and γ-kafirins, which protect α-kafirins from the digestion enzymes. Addition of a reducing agent was found to reverse the effect of cooking but not completely (Hamaker *et al.*, 1987; Oria *et al.*, 1995 and Makki, 1998).

MATERIALS AND METHODS

Whole grains of sorghum (*Sorghum bicolor* (L) Moench) *Feterita variety* and pigeon pea (*Cajanus cajan*) were purchased from Khartoum North local market. The grains were cleaned, decorticated (Type 800 H, Schule, Hamburg, Germany), finely ground in a hammer mill (Schule, Hamburg, Germany), tightly packed in polyethylene bags and stored at -20°C untill needed for investigations.

Experimental Processing Methods

Suitability of sorghum-pigeon pea composite flour as slurry for drum drying

Formulation: Based on protein content of the starting materials, sorghum and pigeon pea flours were formulated in order to meet the recommended daily intake for infants, which ranged from 14-16 g according to the FAO (1979).

Table 1 presents the basic formula used for production of drum dried product from sorghum and pigeon pea.

Processing conditions: Water slurry of 15% DM (w/v) of decorticated sorghum-pigeon pea composite flour (65:35) was pre-cooked (100°C) in stainless steel kettle

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Table 1: Formulation of sorghum-pigeon pea composite flour for drum drying

Decorticated native flour	Blend ratio (%)	Weight (on wet bases) (Kg)	Dry matter (Kg)	Protein Content (kg, DM)	Protein Content (%, DM)
Sorghum	65	3.25	3.0299	0.4055	13.3833
Pigeon pea	35	1.75	1.5943	0.3447	21.6208
Total blend*	100	5.00	4.6242	0.7502	16.2233

*calculated figures

Table 2: The Nutritive Value of Sorghum-based instant infant food compared with Sorghum-pigeon pea composite flour

Samples	Sorghum-pigeon pea composite flour (65/35)	Sorghum-based instant infant food
	[% DM, n = 3±SD]	
Chemical composition		
Dry matter [%]	92.84±0.01[a]	93.15±0.01[b]
Ash	1.78±0.03[a]	2.67±0.02[b]
Fat	2.13±0.01[a]	4.62±0.01[b]
Protein	16.24±0.08[a]	15.15±0.10[b]
Crude fibre	1.24±0.01[a]	0.64±0.01[b]
Total sugars	2.76±0.00[a]	5.42±0.00[b]
Reducing sugars	0.83±0.00[a]	2.81±0.00[b]
Non-reducing sugars	1.93±0.02[a]	2.61±0.02[b]
Available carbohydrates	78.96±0.01[a]	76.91±0.03[b]
Protein digestibility%	82.06±0.10[a]	83.83±0.10[b]
Caloric value		
[Kcal/100 g DM]	391.76[a]	414.25[b]
[Kj/100 g DM]	1639.11[a]	1733.20[b]

*Mean values having different superscript letters in each row differ significantly ($p \leq 0.05$)

(50 kg), under a direct steam injection and continuous stirring for 15 min with an electric mixer (Lightning, Rochester, New York, U.S.A.) in the presence of 1% ascorbic acid. After that, skimmed milk powder, sugar, coconut, caramel, vanillin, salt and Ca-carbonate were added and the mixture was well homogenized with an electric mixer and drum-dried with a pilot drum drier. The surface temperature and the speed of the drums were 150^{0}C and 4.6 rpm, respectively. Finally, the drum-dried product was finely ground (1.0 mm) with an attrition mill, tightly packed in polyethylene bags and defined as sorghum-based instant infant food.

Dry matter and crude protein contents were determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 1990). Fat and ash were investigated according to the standard method of the Member Companies of Corn Refiners Association (MCCRA) Inc. (1995). While, total sugars, reducing and non-reducing sugars were determined following Shaffer-Samogyi method as described by the AOAC (1980). Starch and available carbohydrates were calculated by difference as described by West *et al.* (1988) and then the caloric values of the different samples were calculated as indicated by Leung (1968). Crude fibre contents in the different samples were determined according to Scharrer and Kürchner method as described by Schomüller (1967).

The amino acids profile of all samples was detected by using performic acid oxidation-sodium metabisulfite method as described by the official method of the AOAC (1997) and the chemical scores of the essential amino acids were calculated based on the FAO/WHO/UN (1985) protein pattern for pre-school children. Apparent enzymatic *In-vitro* protein digestibility of the various samples was measured as described by Saunders *et al.* (1973).

RESULTS AND DISCUSSION

For production of drum-dried product from sorghum-pigeon pea composite flour (65:35 %), water slurry of 15% (w/v) was drum dried with pre-cooking in the presence 1% ascorbic acid. Table 2 shows the chemical composition, energy value and *in-vitro* protein digestibility of sorghum-based instant infant food compared with sorghum-pigeon pea native composite flour. The product was found to be easily digested and contain appreciable amounts of protein (15.15%) and energy value (414 kcal/100 g DM), which rendered the product to be as valuable and suitable to satisfy the criteria of infants foods that was recommended by FAO/WHO (1976); FAO (1979) and Valencia *et al.* (1988). The amino acids composition of sorghum-based instant infant food in comparison with the recommended levels for infants is presented in (Table 3). The product was very rich in lysine (6.01%), sulphur containing amino acids (5.41%) and histidine (3.04%). All the essential amino acids scored more than hundred per-cents compare to the reference protein of the FAO/WHO/UN (1985).

Also as shown in (Fig. 1) the infant food, which is developed in this study, is found more easily digested than sorghum- pigeon pea native composite flour, but significantly ($p \leq 0.05$) lower than that of casein by 6.01%. Further more, Table 4 indicates the functional properties

Table 3: Amino acids composition of Sorghum-based Instant Infant Food in comparison with the recommended levels for infants

Samples	Sorghum-based instant infant food	Recommended levels	Amino acids scores
	[g/100 g protein]		
Essential Amino Acids [EAA]			
Histidine	3.04	1.40	217
Isoleucine	4.69	4.00	117
Leucine	12.08	7.04	171
Lysine	6.01	5.44	110
Methionine	1.25	......	......
Cystine	4.16	......	......
Met + Cys	5.41	3.52	153
Phenylalanine	7.52	......	......
Phe+Tyr	....	6.80	......
Threonine	4.09	4.00	......
Tryptophan	ND	0.96	......
Valine	5.61	3.50*	......
Protein score	....	......	100
Protein %	15.15	......	......

*Dendy (1995); **Recommended levels for children FAO/WHO/UN (1985)

Table 4: Functional properties of Sorghum-based Instant Infant Food

Parameters	Sorghum-based instant infant food [n = 3±SD]
Hydrogen ion concentration [pH]	6.06±0.01
Water retention capacity [ml HO/100 g DS]	483.10±0.10
Viscosity [cp]	500.00±0.00
Bulk density [g/ml]	0.60±0.00

Table 5: Chemical characteristics of Sorghum-based instant infant food in comparison with commercial products

Products	Sorghum-based instant infant food	Milk-fruit-based	Cereal-milk-based	
[1]Code	SBIF	Milopa	Robinson	Cerelac
	[g in 100 g DM]			
Contents				
Protein	15.15	11.70	13.20	11.10
Fat	4.62	7.30	3.00	7.80
Available carbohydrates	76.91	73.30	71.5	77.70
Caloric value				
[kcal/100 g DM]	414	406	349	391
[kj/100g DM]	1733	1715	1460	1636

SBIF = Sorghum-based Instant Infant Food, [1]Akmal Khan and Kissana (1985)

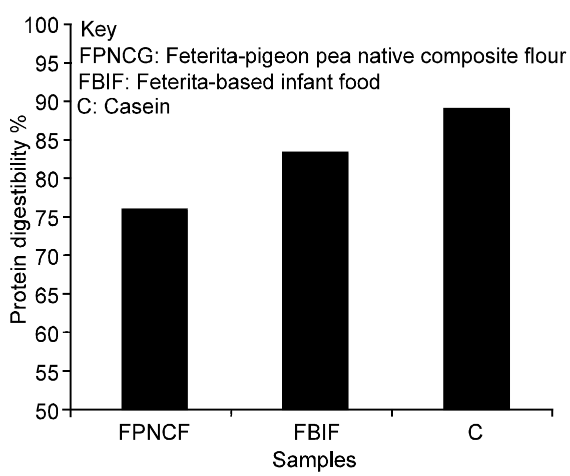

Fig. 1: *In-vitro* protein digestibility of feterita-based infant food in comparison with feterita-pigeon pea native composite flour and casein.

of sorghum-based instant infant food. From the results, the product prepared to be of good functional properties as infant food with low water retention capacity, high bulk density and low viscosity. High bulk density is a desirable characteristic when powder food materials of high nutrients contents are to be packed in a limited space or area. Mosha *et al.* (1983) prepared a weaning food with a low bulk density and low viscosity (less than 1000 cp) from sorghum and legumes.

Moreover, when comparing sorghum-based instant infant food with commercial products such as Milopa, Robinson and Cerelac as shown in Table 5, sorghum-based instant infant food appeared to provide more protein and energy value than the fore mentioned commercial products. The highest energy value (414 kcal/100 g DM) is found in sorghum-based instant infant food followed by Milopa milk-fruit-based formula (406 kcal/100 g DM) However, the recommended daily intakes of protein and energy for babies below 2 years old are between 14-16 gram and 820-1360 kilocalorie, respectively (FAO, 1979).

Conclusion: The use of decorticated sorghum and pigeon pea in weaning food formulation yielded a product with improved functional characteristics and high nutritive value.

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