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Effect of Cooking and Drum Drying on the Nutritive Value of Sorghum-Pigeon Pea Composite Flour

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Abstract: The study was conducted to evaluate changes during cooking and drum drying on the chemical composition, amino acids composition, amino acids scores and digestibility of sorghum-pigeon pea composite flour. Both cooking and drum drying in the presence of 1% ascorbic acid were found to improve the energy value of the final products and the *in-vitro* protein digestibility of sorghum-pigeon pea composite flour significantly ($p \leq 0.05$). In fact, drum drying without pre-cooking slightly increased the protein digestibility of the composite flour from 76-77%, while pre-cooking before drum drying of the composite flour increased the protein digestibility of the drum-dried product to about 80%. Drum drying after pre-cooking reduced lysine and methionine levels by 3.5 and 22.5%, respectively. Also, drum drying significantly ($p \leq 0.05$) decreased the fat content in the two drum dried products (with or without pre-cooking). Moreover, drum drying without pre-cooking increase the ash content while the ash decreased when sorghum-pigeon pea composite flour was drum dried after cooking.

Key words: Sorghum, cooking, drum drying, digestibility

INTRODUCTION

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, frying and cooking processes substantially reduce the phytate contents in red sorghum and some other African stable foods (Marfo *et al*., 1990). Heat during drum 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).

Bach Kundsen *et al*. (1988) suggested that cooking might increase the amount of dietary fiber due to formation of polyphenols protein complexes in brown sorghum. Drum drying of sorghum-bean composite flour resulted in a decrease of fat, ash and caloric value but the protein content remained unchanged. The chemical scores of lysine, histidine and threonine as well as water retention capacity, bulk density and viscosity were also found to decrease after drum drying (Makki, 1998 and Makki and Emmerich, 2006). The main objective of this study was to investigate the effect of heat processing (cooking and drum drying) on the chemical composition, amino acids composition, amino acids scores and digestibility of sorghum-pigeon pea composite flour.

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.

Table 1: The processing conditions of Sorghum-pigeon pea drum dried products

Product	A	B
Blend wt (kg)	4.6242	4.6242
Water wt (kg)	30.828	30.828
Slurry dry solids (w/v)	15%	15%
Ascorbic acid (g)	50	50
Total wt (kg)	35.828	35.828
Cooking time (min)	----	15
Drum temp. (°C)	150	150
Drum speed (rpm)	4.6	4.6

A = drum dried without pre-cooking. B = cooked before drum drying

Table 2: Effect of drum drying on the chemical composition of sorghum-pigeon pea composite flour

	Sorghum-pigeon pea native composite flour (65/35) (% DM, n = 3 ± SD)	Sorghum-pigeon pea drum dried products (% DM, n = 3 ± SD)	
Sample Code	SPNCF	SPDF-A	SPDF-B
Chemical Composition			
Dry matter [%]	92.84±0.01[a]	92.68±0.02[b]	93.62±0.11[c]
Ash	1.78±0.03[a]	1.92±0.01[b]	1.74±0.02[c]
Fat	2.13±0.01[a]	1.00±0.02[b]	0.88±0.01[c]
Protein	16.24±0.08[a]	16.22±0.10[b]	16.20±0.05[c]
Crude fibre	1.24±0.01[a]	1.11±0.04[b]	1.54±0.05[c]
Total sugars	2.76±0.00[a]	2.82±0.02[b]	3.06±0.06[c]
Reducing sugars	0.83±0.00[a]	0.77±0.00[b]	0.97±0.01[c]
Non-reducing sugars	1.93±0.02[a]	2.05±0.00[b]	2.12±0.01[c]
Available carbohydrates	78.96±0.01[a]	79.76±0.11[b]	79.64±0.03[c]
Protein digestibility%	82.06±0.10[a]	76.15±0.10[b]	77.14±0.10[c]
Caloric value:			
[Kcal /100g DM]	391.76[a]	399.69[b]	398.17[c]
[Kj /100g DM]	1639.11[a]	1672.31[b]	1665.95[c]

SPNCF = sorghum-pigeon pea native composite flour. SPDF = sorghum-pigeon pea drum dried products. A = drum dried without pre-cooking. B = cooked before drum drying. *Mean values having different superscript letters in each row differ significantly ($p \leq 0.05$).

Protein and moisture content 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), then the caloric values of the different samples were calculated as indicated by Leung (1968). Crude fibre contents in the different samples were determined after Scharrer and Kürchner as described by Schomüller (1967).

The amino acids profile of all samples was detected by using performic acid oxidation-sodium metabisulfite method according to 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. *In-vitro* apparent enzymatic protein digestibility of the various samples was calculated as described by Saunders *et al.* (1973) and caloric value as indicated by Leung (1968).

Experimental processing methods: Water slurries of sorghum-pigeon pea composite flour (15% DM, w/v) were drum dried with two different methods by using a pilot double drum drier (Blaw-Knox, Bufalo- New York, USA). The surface temperature and the speed of the drums were 150°C and 4.6 rpm, respectively. The two different methods used for production of sorghum-pigeon pea drum dried products were as follows:

- Slurry of 15% DM (w/v) of decorticated sorghum-pigeon pea composite flour (65:35) was drum dried without pre-cooking in the presence of 1% ascorbic acid to act as a reducing agent.
- A slurry of sorghum-pigeon pea composite flour (15% DM, w/v) prepared as described above was cooked before drum drying in a stainless steel kettle (50 kg) under a direct steam injection and continuous stirring for 15 min with an electric mixer (Lightning, Rochester, New York, U.S.A). The processing conditions and methods used are presented in (Table 1).

RESULTS AND DISCUSSION

For production of drum-dried products from sorghum-pigeon pea composite flour (65:35%), water slurries with 15% flour were drum dried without pre-cooking or after cooking in the presence 1 % ascorbic acid. Table 2 compares the chemical composition and energy values of sorghum-pigeon pea composite flour with those of the drum dried products. Both cooking and drum-drying processes are found to increase the energy value of the final product. However, drum drying without pre-cooking increased the ash content by 7.8%, whereas drum-drying after cooking decreased the ash level by 2.24%. The low levels of fat in the two drum-dried products (with or without pre-cooking) could be attributed to the formation of starch-lipids complexes during the drum-drying process as reported by Johnson (1988).

On the other hand, Table 3 indicates the effect of cooking and drum drying on the amino acids composition of sorghum -pigeon pea native composite flour. In general, the drum drying process is found to decrease both essential and non-essential amino acids. A reduction of about 22.5 and 3.6% is noticed in the levels of methionine and lysine amino acids, respectively after drum drying without pre-cooking. However, pre-cooking before drum drying also decreased methionine and lysine by 1.25 and 4.8%, respectively. These results are

Table 3: Effect of drum drying on the amino acids composition of sorghum-pigeon native pea composite flour

	Sorghum-pigeon pea native composite flour [65/35] (g /100g protein)	Sorghum-pigeon pea drum dried products (g /100g protein)	
Sample Codes	SPNCF	SPDF-A	SPDF-B
Essential Amino Acids [EAA]			
Histidine	3.08±0.00[a]	3.02±0.00[b]	2.90±0.00[c]
Isoleucine	4.19±0.00[a]	3.88±0.00[b]	3.95±0.00[c]
Leucine	12.19±0.00[a]	10.91±0.00[b]	11.42±0.00[c]
Lysine	4.99±0.00[a]	4.81±0.00[b]	4.75±0.00[c]
Methionine	0.80±0.00[a]	0.62±0.00[b]	0.79±0.00[c]
Cystine	4.68±0.00[a]	3.95±0.00[b]	4.20±0.00[c]
Met + Cys	5.60±0.00[a]	4.57±0.00[b]	4.99±0.00[c]
Phenylalanine	7.94±0.00[a]	5.92±0.00[b]	7.53±0.00[c]
Threonine	3.76±0.00[a]	3.58±0.00[b]	3.64±0.00[c]
Valine	4.64±0.00[a]	4.55±0.00[b]	4.51±0.00[c]
None Essential amino acids [NEAA]			
Alanine	8.81±0.00[a]	7.71±0.00[b]	8.52±0.00[c]
Arginine	3.33±0.00[a]	3.02±0.00[b]	4.26±0.00[c]
Aspartic acid	9.98±0.00[a]	9.56±0.00[b]	9.01±0.00[c]
Glutamic acid	24.69±0.00[a]	22.87±0.00[b]	24.07±0.00[c]
Glycine	3.26±0.00[a]	3.14±0.00[b]	2.96±0.00[c]
Serine	5.11±0.00[a]	4.75±0.00[b]	4.88±0.00[c]

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

Table 4: Effect drum drying on the amino acids chemical score of sorghum-pigeon pea decorticated native composite flour

	Sorghum-pigeon pea native composite flour [65/35] [amino acids score, %]	Sorghum-pigeon pea drum dried products [amino acids score, %]		Recommended levels*
Sample Code	SPNCF	SPDF-A	SPDF-A	[g /100g protein]
Essential Amino Acids [EAA]				
Histidine	220[a]	215[b]	207[c]	1.40
Isoleucine	100[a]	97[b]	98[c]	4.00
Leucine	173[a]	154[b]	162[c]	7.04
Lysine	91[a]	88[b]	87[c]	5.44
Methionine	……..	……..	……	……
Cystine	…….	…….	……	……
Met + Cys	159[a]	134[b]	141[c]	3.52
Phenylalanine	…….	…….	…….	……
Phe + Tyr	…….	……	……	6.80
Threonine	110[a]	89[b]	91[c]	4.00
Tryptophan	…….	……	…..	0.96
Valine **	132[a]	135[b]	137[c]	3.50 **
First limiting amino acid	Lysine	None	Lysine	……..
Protein score	91[a]	88[b]	87[c]	…….
Protein %	16.24	16.22	16.20	……

*Dendy (1995), **Recommended levels for children FAO/WHO/UN (1985), *** Mean values having different superscript letters in each row differ significantly ($p \leq 0.05$).

Table 5: Effect of Pigeon pea supplementation, cooking and drum-drying on Sorghum *in vitro* protein digestibility

	Sorghum native flour (decorticated 70%)	Sorghum-pigeon pea native composite flour [65/35]		Sorghum-pigeon pea drum dried products
Sample Code	SNF	SPNCF	SPDF-A	SPDF-A
Protein digestibility%	82.06 ± 0.10	76.15 ± 0.10	77.14 ± 0.10	80.34 ± 0.10

SNF = Sorghum decorticated native flour. A = drum dried without precooking. B = cooked before drum drying.

in agreement with those reported by Makki (1998). The chemical scores of sorghum -pigeon pea native composite flour and its drum-dried products are presented in Table 4. Sorghum-pigeon pea composite flour as a slurry of 15% dry solids was drum dried with or without pre-cooking. Pre-cooking before drum drying resulted in a reduction in lysine and histidine chemical scores by 5.9 and 4.4% respectively. But, drum drying without pre-cooking decreased the chemical scores of histidine and lysine by only 2.3 and 3.3%, respectively.

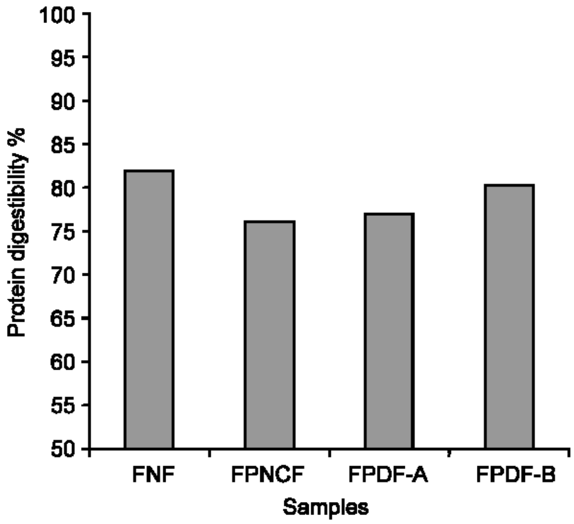

Fig. 1: Effect of pigeon pea supplementation, cooking and drum drying on feterita *in-vitro* protein digestibility

Key: FNF: Feterita decorticated native flour
FPNCF: Feterita-pigeon pea native composite flour
FPDF-A: Feterita-pigeon pea drum dried without precooked
FPDF-B: Feterita-pigeon pea precooked drum dried product

Lysine is found to be the first limiting amino acid after drum drying. These results are in agreement with those reported by Makki and Emmerich (2006).

In general, incorporation of pigeon pea flour into sorghum flour (35:65) resulted in a decrease of about 7.2% in the *in-vitro* protein digestibility of sorghum native flour as indicated in (Table 5) and Fig. 1. On the other hand, drum drying with or without pre-cooking in the presence of 1% ascorbic acid is found to increase the in-vitro protein digestibility of sorghum-pigeon pea composite flour by 5.50 and 1.30%, respectively. The increment may be due to the decrease of antinutritional factors as a result of heat processing as reported by Marfo *et al.* (1990). That is to say, pre-cooking and drum-drying in the presence of 1% ascorbic acid enhance the *in-vitro* protein digestibility of the drum dried products compared to their native composite flours. The results obtained in this study agree well with those reported by Hamaker *et al.* (1987) Oria *et al.* (1995) and Makki (1998).

Conclusion: From the results obtained in this study it can be concluded that pre-cooking and drum-drying of sorghum-pigeon pea processes have great beneficial effect on the nutritive value of sorghum-pigeon pea composite flour, specially on adding ascorbic acid to the blend.

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