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Effect of processing on nutritional quality of finger millet - cowpea formulations

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Abstract

Fingermillet (*Eleusine coracana*) and cowpea (*Vigna unguiculata*) were blended in proportions of 100:0, 70:30, 60:40 and 50:50, millet to cowpea, respectively. Incorporation of cowpea to millet flour increased the protein, phosphorus and sodium content of the flour. Malting of the millet and roasting of cowpea prior to blending led to reduction in paste viscosity and improvement in gruel acceptability. It was concluded that a process consisting of malting of cereals followed by blending with an appropriately processed legume could serve as a simple, low cost technology for improving the protein and energy density of cereal based gruels.

Key words: Cereal utilisation, *Eleusine coracana*, nutrient density, *Vigna unguiculata*, weaning food

Introduction

The Uganda demographic and health survey of 1995 showed that 38% of children below the age of three years are stunted, 26% underweight and 5% wasted (UNFNC, 1996). The widespread occurrence of protein energy malnutrition (PEM) in developing countries has been linked to low nutrient and energy density of cereal gruels given to children (Uwaegbute, 1991). These gruels are also very low in protein and lack the essential amino acids lysine and tryptophan. Children are therefore unable to consume adequate quantities of such gruels to meet their energy and nutrient requirements, especially after their sixth month of birth.

Available commercial weaning foods such as Cerelac are expensive and are out of the reach of most families. As such many children are likely to continue relying on cereal based gruels for their nourishment. In order to address the problem of malnutrition, there is need to address the problems of high paste bulk, low protein and unbalanced amino acid profile of cereal gruels. There is also need to develop low cost formulations using locally available foods and simple and low cost technologies that are applicable within homes or at small commercial scale. Malting (Chandrasekhar *et al.*, 1988; Livingstone *et al*, 1993; Weaver, 1994), blending with high energy or/and protein food materials (Dahiya and Kapoor, 1993; Kikafunda *et al.*, 1998), and heat pregelatinisation (Okaka and Potter, 1979; Chandrasekhar *et al.*, 1988; Livingstone *et al.*, 1993) have been applied to reduce paste bulk and improve nutritional quality of starchy gruels.

Roasting leads to reduction in antinutritional factors (Igbedioh *et al.*, 1995; Chitra *et al.*, 1996; Apata and Ologhobo, 1997). Soaking prior to heat treatment has a positive effect in elimination of these factors (Gustafsson and Sandberg, 1995; Igbedioh *et al.*, 1995). During malting, starch is hydrolysed by amylases, producing sugars. Since increase in viscosity during cooking of starchy gruels is due to starch gelatinisation, starch hydrolysis results in reduction in gruel viscosity. Weaning formulations made from malted millet (Chandrasekhar *et al.* , 1988) and wheat (Livingstone *et al.*, 1993) for example exhibit lower viscosity than formulations made without malting. Malting has been reported to increase protein digestibility in wheat. This can be attributed to reduction in antinutritional factors during germination. Malting of legumes increases carbohydrate (Kelkar *et al.*, 1996) and protein digestibility (Chitra *et al.*, 1996; Griffith *et al.*, 1998), reduces antinutritional compounds (Igbedioh *et al.*, 1995; Chitra *et al.*, 1996), total dietary fiber (Chitra *et al.*, 1996) and dietary bulk (Livingstone *et al.*, 1993; Griffith *et al.*, 1998).

Blending of cereals with other food materials boosts the protein and/or energy content of weaning formulations. Because of their high protein and energy content, pulses and oil seeds are suited for use as supplements in cereal based weaning foods. Groundnuts (Griffith *et al.*, 1998; Dahiya and Kapoor, 1993), Greengram (Dahiya and Kapoor, 1993), Cowpea (Griffith *et al.*, 1998), soybeans (Mensah *et al.*, 1995) and chickpea (Livingstone *et al.*, 1993) have been used to boost the nutrient density of cereal based weaning foods.

The objective of the study was to develop a weaning formulation from finger millet (*Eleusine coracana* L. Gaerta) and cowpeas (*Vigna unguiculata* L Walp) and to determine the effect of a treatment consisting of malting of millet and soaking, dehulling and roasting of cowpeas on the nutritional, sensory and physicochemical properties of gruels made from the developed formulation.

Materials and Methods

Preparation of formulations

Cowpea and finger millet were winnowed and sorted to remove the mouldy, shriveled, broken seeds, chuff and other impurities. The seeds were then washed 3 times in distilled water. The cowpeas were further processed by steeping for 12 hours with water just covering the seeds in a bucket. This allowed enough imbibition of water. The seed coats were then removed by rubbing the seeds between the palms. The dehulled seeds were dried at 60°C for 12 hours, and were roasted for 15 minutes while stirring with a wooden stirrer.

The washed millet grains were steeped in enough water to cover them completely and then kept in the dark for 12 hours. The water was then drained and the grains thinly spread between wet cotton cloth and left to germinate for 48 hours at room temperature (24°C). The sprouted seeds were dried overnight in hot air oven (size 2, SG 93/B6/95 Gallenkamp, UK) at 60°C. The vegetative portions were detached from the dry grains by rubbing between hands and separated out by winnowing. The millet and cowpea were then blended in proportions of 70:30, 60:40 and 50:50, millet:cowpea. The millet and cowpea blends were milled (whole grain) using a laboratory mill (type 4142, 041 Braun, Germany). Some of the millet and cowpea prepared as described above were retained for analysis. Flour was also made by directly milling a 70:30 millet:cowpea blend, without the above described treatment. This served as a control in the determination of the effect of the treatment on paste viscosity and sensory acceptability.

Chemical analysis

Moisture and crude protein were determined by AOAC (1997) methods 4.1.03 and 955.04, respectively. Ash, crude fiber and crude fat were determined by methods described by Ranganna (1986). Ash determination was by dry ashing at 450°C and crude fat by soxhlet extraction. Carbohydrate was determined by difference and energy by calculation. Iron, magnesium, potassium and sodium were determined using a Perkin Elmer atomic absorption spectrometer (U.S. Instrument Division, Norwalk, CT.) on digest of ash from ash determination. Magnesium and iron were determined by absorption spectrometry (Ihnat, 1981) at wavelengths of 248.3 and 285.2 nm, respectively. Potassium and sodium were determined by emission spectrometry at 766.5 and 589 nm, respectively. Phosphorus was determined by the colorimetric method, described by Kirk and Sawyer (1991). Nutrient density for a gruel containing 6% flour and anticipated nutrient intakes by children consuming 750 ml per day were calculated from the nutritional composition.

Viscosity determination

Viscosity was determined for gruels prepared from the 70:30 millet:cowpea treatment and control blends. The flour was mixed with water in a beaker to give suspensions containing 1, 1.5, 2.0, 2.5 and 3% flour. The beakers containing the mixtures were placed in a water bath and heated while stirring to reach 95°C within 10 minutes. The gruels were then held at room temperature until the temperature dropped to 40°C, which is approximately, the temperature at which children consume gruels.

Viscosity of the gruels were then determined using a Haake viscotester (Haake Mess-Technik, Kansruhe, Germany) with a SCII profile measuring system and a shear rate of 54 rpm. The gruel concentrations used were limited by the viscosity range which could be determined by this viscotester.

Sensory evaluation

Gruels containing 8% solids were prepared from the 70:30 blend (treatment and control) flours and evaluated for sensory acceptability. After weighing out the flour and measuring the volume of water required, the flour was mixed into a minimal amount of cold water (drawn from the measured volume) to allow complete suspension. The remaining water was heated to boiling and the suspension of flour in water added. The mixture was heated while stirring until it boiled for 5 minutes. It was left to cool to approximately 50°C before serving to panelists for evaluation.

Sensory evaluation was conducted by a 30 member untrained panel. Panelists were requested to score the gruels based on a 9 point hedonic scale, with 1 representing like extremely and 9 dislike extremely. The attributes evaluated included taste, aroma, consistency, and overall acceptability .

Replication and data analysis

The experiment was duplicated and for each experiment, each chemical or viscosity measurement was done a minimum of two times. Data for nutritional composition of the flours was analysed by Analysis of Variance (ANOVA) using M-STAT C package (Freed *et al.*, 1988) and means separated using the Least Significant Difference (LSD) test at 5% probability level. Viscosity and sensory evaluation data were compared using t-test.

Results and Discussion

Nutritional composition of finger millet-cowpea blends

The blends of millet and cowpeas were significantly higher in proteins than the millet flour (Table 1). Generally, incorporation of legumes into cereal based formulations increases their protein contents. It also leads to improvement of the quality of the proteins and an amino acid profile superior to both legume and cereal proteins. This is because cereals lack the essential amino acids lysine and tryptophan while legumes lack methionine. When combined, the two protein sources complement each other. Of the blends studied, the protein content of the 70:30 millet-cowpea blend of 14% (15.9% on dry basis) was closest to protein content of cerelac (15.82% on dry basis and 15.5% on wet basis). The protein content of the 70:30 millet-cowpea blend also satisfies the requirements by FAO for weaning formulations, i.e., minimum of 14% proteins. This blend may therefore be adequate to meet the protein requirements of weanlings. Daily protein intake would generally increase significantly by substituting millet porridge by 70:30 millet:cowpea blend, even without reduction in viscosity (Table 2). Further analysis is, however, required to determine the protein quality.

In terms of energy, there was no significant difference between the blends (Table 1) and the daily energy intake did not improve when the same level of solids of 70:30 millet-cowpea blend was used instead of millet, flour alone (Table 2). It is important, however, to note that the energy supplied by starchy gruels, is limited not only by the energy content of the flours from which they are prepared but solid content of the gruels. The starch in cereal based gruels gelatinise during heating in presence of water resulting in rapid viscosity increase (Whistler and BeMiller, 1997). Since infants normally consume gruels with a relatively light consistency, this tends to limit the proportion of flour in the gruels. According to Lorri (1993), the dry matter content of gruels served to children is in the range 5 -10%. A child aged 6 -24 months requires 810 -1150 kCal of energy daily and if 1/3 of this energy (270 - 383 kcal) is to be supplied by a gruel containing 6% (this approximately corresponds to 5% dry matter) of a flour whose energy density is 340 kcal/100g, such a child would need to consume 1.3 - 1.9 L of the gruel daily. In practice, a child within this age range is hardly able to consume 750 ml of porridge a day. There is therefore a need to increase the energy density of cereal based gruels.

The process used in this study combines different techniques known to increase the energy density of gruels. This process led to reduction of paste viscosity by up to 50% (Figure 1). The reduction in paste viscosity is attributable to hydrolysis of millet starch during malting and pregelatinisation of cowpea starch during roasting. The sugars produced during hydrolysis unlike the starch from which

Table 1. Nutritional composition per 100 g of finger millet-cowpea bends in comparison to cerelac.

	Millet:Cowpea					
	100:0	70:30	60:40	50:50	0:100	Celerac
Energy (Kcal)	340.6a	340.3a	339.3a	338.9a	334.4a	417
Protein (g)	8a	14.5b	16.8a	18.5d	29.8c	15.5
Fat (g)	1.4a	1.4a	1.3a	1.3a	1.2a	6.0
Fiber (g)	2.7a	3.3b	3.8c	4.1a	5.3c	4.5
Ash (g)	4.7b	4.3ab	4.1a	4.1a	3.9a	2.5
Water (g)	9.3a	9.1a	8.9a	8.7a	8.7a	2.5
Carbohydrate (g)	74.2c	67.4b	65.1b	63.3b	51.1a	69
Iron (mg)	7.0a	7.5b	7.5b	7.7bc	8.3c	7.5
Calcium (mg)	375a	325bc	300b	350c	245a	455
Phosphorous (mg)	250a	340b	370c	380c	440a	365
Magnesium (mg)	45.3a	42.3a	40.8a	44.8a	40.5a	-
Potassium(mg)	481a	550b	615c	640c	800a	550
Sodium (mg)	30.5a	55.0b	48.6b	43.3b	66.1a	210

Means within a row with the same letter are not significantly different ($P \leq 0.05$)

Table 2. Nutrient density of gruels containing 6% four and anticipated daily intakes.

	Nutrient Density /ml		Anticipated intake /day#		
	100% Millet	70:30 Millet:Cowpea	70:30 Millet: cowpea	%100 Millet	Cerelac
Energy (Kcal)	0.20436	0.20418	153.27	153.135	213.5 -417
Protein (g)	0.0048	0.0087	3.6	6.525	7.75 - 15.5
Fat (g)	0.00084	0.00084	0.63	0.63	3.0 -6.0
Fiber (g)	0.00162	0.00198	1.215	1.485	2.25 -4.5
Ash (g)	0.00282	0.00258	2.115	1.935	1.25 - 2.5
Iron (mg)	0.0042	0.0045	3.15	3.375	3.75 - 7.5
Calcium (mg)	0.225	0.195	168.75	146.25	227.5 -455
Phosphorous (mg)	0.15	0.204	112.5	153	182.5 -365
Magnesium (mg)	0.02718	0.02538	20.385	19.035	-
Potassium (mg)	0.2886	0.33	216.45	247.5	225 - 550
Sodium (mg)	0.0183	0.033	13.725	24.75	105 -210

Assuming intake of 750 ml of porridge per day or 50-100g of cerelac.

millet-cowpea gruel since this blend is low in lipids and may actually be deficient in the essental fatty acids which are required for proper growth.

Sensory acceptability

Gruels made from malted millet and roasted cowpeas generally received scores superior (like slightly - like moderately) to those for gruels made from the control flour (dislike slightly - neither like nor dislike). The low scores (Table 3) for the control samples may be due to the beany flavour resulting from cowpeas and the high viscosity of the gruels. Soaking of cowpeas leads to reduction in the beany flavour while roasting introduces a roasted flavour. The better taste scores for the malted samples were probably due to the sweetness from the sugars resulting from starch hydrolysis. The consistency of the gruels was affected by the malting of millet and roasting of cowpeas and from the sensory acceptability results, panelists preferred the less viscous gruels.

Conclusion

Blends of legumes and cereals have potential for serving as good low cost sources of proteins and may be consumed in form of porridge or even as solid pastes. Treatment such as soaking, dehulling and roasting of cowpea and malting could be used to improve organoleptic properties of such blends and to enhance the energy and nutrient density of gruels prepared therefrom. Unlike technologies such as extrusion, the aforementioned treatments have potential for application in domestic settings or at very low scale commercial level since they are simple and inexpensive.

References

AOAC. 1997. *Official Methods of Analysis*. 16th Edn. AOAC International. Gaithersberg, Maryland, USA.

Apata, D.F. and Ologhobo, A.D. 1997. Trypsin inhibitor and other antinutritional factors in tropical legume foods. Tropical Science 37 : 52-59.

Chandrasekhar, U., Bhooma, N. and Reddy, S. 1988. Evaluation of a malted weaning food based on low cost locally available foods. Indian Journal of Nutrition and Dietetics 25: 37-43.

Chitra, U., Singh, U. and Venkateswaka Rao, P. 1996. Phytic acid, *in vitro* protein digestibility, dietary fiber and minerals of pulses as influenced by processing methods. Plant Foods for Human Nutrition.49 : 307-316.

Colonna, P., Doublier, J.L., Melcoin, J.P., de Monredon, F. and Mercier, C. 1984. Extrusion cooking and drum drying of wheat starch I. Physical and macromolecular modifications. Cereal Chemistry 62: 538-543.

Dahiya, S. and Kapoor, A.C. 1993. Nutritional evaluation of home processed weaning foods based on low cost locally available foods. Food Chemistry 48 : 179-182.

Freed, R., Einsensmith, S.P., Goezt, S., Smail, D. and Wolberg, P. 1988. MSTAC. A micro computer programme for the design , management and analysis of agricultural experiments. Michigan State University

Griffith, L.D., Casteli-Perez, M.E. and Griffith, M.E. 1998. Effects of blend and processing method on the nutritional quality of weaning foods made from select cereals and legumes. Cereal Chemistry 75 : 105-112.

Gustafsson, E.L. and Sandberg, A.S. 1995. Phytate reduction in brown bean (*Phaseolous vulgaris* L.). Journal of Food Science 60 : 149-152.

Igbedioh, S.O., Shaire, S. and Aderiye, B.J.I. 1995. Effects of processing on total phenols and proximate composition of pigeon pea (*Cajanus cajan*) and climbing bean (*Vigna umbellata*). Journal of Food Science and Technolology 32 : 497-500.

Ihnat, M. 1981. Atomic Absorption Spectrometry V. Techniques and Instrumentation. Pages 139-210. In: Cantle, J.E. (Ed.), Analytical Chemistry. Elsevier, Amsterdam

Kelkar, M., Shatri, P. and Rao, B. Y. 1996. Effect of processing on the in-vitro carbohydrate digestibility of cereals and legumes. Journal of Food Science and Technology 33: 493-497.

Kikafunda, J.K., Walker, A.F. and Gilmour, S.G. 1998. Effect of refining and supplementation on the viscosity and energy density of weaning maize porridges. International Journal of Food Science and Nutrition 49 : 295-301.

Kirk, R.S. and Sawyer, R. 1991. *Pearson's Composition and Analysis of Foods*. 9th Edition. Longman Scientific & Technical, New York.

Livingstone, A.S., Feng, J.J. and Malleshi, N.G. 1993. Development and nutritional evaluation of weaning foods based on malted, popped and roller dried wheat and chickpea. International Journal of Food Science and Technology 28 : 35-43.

Lorri, W. S. M. 1993. Nutritional and microbiological evaluation of fermented cereal weaning foods. PhD Thesis, Chalmers University of Technology, Goteborg; Sweden.

Mensah, P., Ndiokwelu, C.I., Uwaegbute, A., Ablordey, A., VanBoxtel, A.M.G.A., Brinkman, C., Nout, M.J.R. and Ngoddy, P.O. 1995. Feeding of lactic-fermented high nutrient density weaning formula in paediatric settings in Ghana and Nigeria: acceptance by mothers and infant and performance during recovery from acute diarrhoea. International Journal of Food Science and Nutrition 46 : 353-362.

Okaka, J.C. and Potter, N.N. 1979. Physico chemical and functional properties of cowpea powders processed to reduce beany flavor. Journal of Food Science 44 : 1235-1240.

Ranganna, S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products.* Second Edition. Tata McGraw Publishing Company Ltd. New Dehli.

UNFNC. 1996. *Uganda national plan of action for nutrition.*

Uwaegbute, A.C. 1991. Weaning practices and weaning foods of the Hausas, Yorubas and Ibos of Nigeria. Ecology of Food and Nutrition 26 : 139-153.

Weaver, L.T, 1994. Feeding the weanling in the developing world: problems and solutions. Journal of Food Sciences and Nutrition 45 : 127-134.

Whistler, R.L. and BeMiller, J.N. 1997. *Carbohydrate Chemistry for Food Scientists.* Eagen Press, St. Paul, Minnesota, USA.