African Journal of Biotechnology Vol. 10(3), pp. 433-438, 17 January, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.1318
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Nutritional evaluation of cookies produced from pigeon pea, cocoyam and sorghum flour blends

L. C. Okpala* and E. C. Okoli

Department of Food Science and Technology, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria.

Accepted 15 October, 2010

Cookies were produced from pigeon pea (*Cajanus cajan*), sorghum (*Sorghum bicolor*) and cocoyam (*Xanthosoma sagittifolium*) flour blends. Ten different cookie formulations were produced. The cookies were evaluated for proximate composition, antinutritional factors and protein quality. The protein content ranged from 6.40% for cookies from 100% cocoyam flour (CF) to 12.97% for cookies from 100% pigeon pea flour (PF). Only four out of the ten cookie formulations had the FAO/WHO minimum recommended protein content of 10%. Low levels of antinutritional factors such as tannins, oxalate, saponins, trypsin inhibitors, hydrogen cyanide and phytates were observed. Diets made from cookies with minimum protein content of 10% were similar to the casein diet in maintenance weight, food intake, digested nitrogen, nitrogen balance, biological value and net protein utilization when fed to rats. It is concluded that cookies from the flour blends showed promise in helping to combat protein malnutrition in those countries where protein malnutrition poses a threat.

Key words: Protein quality, cookies, antinutritional factors.

INTRODUCTION

Inadequate intake of protein in developing countries has led to various forms of malnutrition in both children and adults. It has been reported that in developing countries, protein malnutrition persists as a principal health problem among children below the age of five in Nigeria (UNICEF, 1996).

The need to find inexpensive sources of protein of good quality cannot be overemphasized. The dependency on plant proteins is however very high. These plant proteins are known to have limiting amino acids (Ihekoronye and Ngoddy, 1985) and it is therefore pertinent to combine these plant proteins in proportions that will improve the protein intake of such consumers.

Composite flour can be referred to as the mixture of non-wheat flours (such as flour from roots and tubers, legumes or cereals) that is created to satisfy specific functional characteristics and nutrient composition (Dendy, 1992). Usually, the aim of producing composite flour is to get a product that is better than the individual components. Better may mean improved properties or performances, or in some cases improved economies. The nutritional value of cereal flours that are poor in lysine but rich in the sulphur containing amino acids is improved by the addition of legume flours and the nutritional value of root and tuber flours which are poor in protein is sufficiently improved by the addition of cereal flours (FAO, 1990). Composite flour technology has been used as a means for extending scarce supplies of wheat or corn used in the production of bread or other baked goods (Milner, 1974). In selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potential (Akobundu et al., 1998). Cookies have been suggested as a better use of composite flour than bread due to their ready to eat form, wide consumption, relatively long shelf life and good eating quality (McWatters et al., 2003). The use of composite flours from cereals, legumes and tubers for cookie production is therefore expected to enhance the utilization of local crops as raw materials and improve the nutritive quality of cookies.

Pigeon pea (*Cajanus cajan*) is a legume; sorghum

*Corresponding author. E-mail: lcokpala@yahoo.com.

Abbreviations: TD, True digestibility; **BV,** biological value; **NPU,** net protein utilization; **N,** nitrogen; **CF,** cocoyam flour; **PF,** pigeon pea flour; **CF,** cocoyam flour; **BV,** biological value.

Table 1. Formulation of composite flour.

Formulation	Cocoyam (CF)	Pigeon pea (PF)	Sorghum (SF)
1	100	-	-
2	-	100	-
3	-	-	100
4	50	-	50
5	-	50	50
6	50	50	-
7	33.3	33.3	33.3
8	16.7	66.6	16.7
9	16.7	16.7	66.6
10	66.6	16.7	16.7

Table2: Recipe for digestive biscuits.

Ingredients	Quantity
*Flour	500.0g
Fat	200.0g
Sugar	125.0g
Salt	5.0g
Eggs	$2\frac{1}{2}$ whole eggs
Milk (powdered)	$7\frac{1}{2}$ teaspoonfuls
Nutmeg	1.5g
Vanilla flavouring	$2\frac{1}{2}$ teaspoonfuls
Baking powder	5.0g

*Wheat, cocoyam, pigeon pea, sorghum or composite flour (Okaka, 1997).

(*Sorghum bicolor*) is a cereal, while cocoyam (*Xanthosoma sagittifolium)* is a tuber. Pigeon pea and sorghum are both good sources of protein, while cocoyam has fine granular starch which has been reported to improve binding and reduce breakage of snack products (Huang, 2005). All the aforementioned crops are grown in large quantities in Nigeria but are underutilized. This work is aimed at producing cookies from sorghum, pigeon pea and cocoyam flour blends and evaluating the composition and nutritional quality of the cookies produced.

MATERIALS AND METHODS

The white variety of pigeon pea, the white variety of sorghum and the tannia variety of cocoyam were purchased from a retail outlet in Abakaliki, Ebonyi State. Wheat flour and all other baking ingredients such as eggs, baking powder, fat, milk and flavourings were also obtained from the same source. Corn starch was purchased from a retail outlet in Enugu, Enugu State; casein was bought from a chemical store in Nsukka, Enugu State, while vitamin and mineral premixes were bought from Bio-organics Nigeria Plc, Lagos.

Cocoyam flour preparation

Cocoyam flour was produced using the method described by Ijeoma (1983). The corms were washed, peeled, sliced and blanched at 80℃ for four minutes. They were dried and milled to pass through a 100 µm mesh sieve.

Pigeon pea flour preparation

The pigeon pea flour was produced as described by Echendu et al. (2004). The pigeon peas were cleaned and soaked in water for 38 h, after which they were manually dehulled. The loosened seeds were washed and sundried. During drying, the grains were stirred at time intervals to ensure uniform drying. The dried grains were milled to pass through a 100 µm mesh sieve.

Sorghum flour preparation

Washed and dried sorghum grains were milled into a flour to pass through a 100 µm mesh sieve.

Formulation of flour composites

Composite blends of pigeon pea, sorghum and cocoyam were formulated as shown in Table 1. The flours were thoroughly mixed to obtain homogeneous blends. Samples were stored in airtight containers at room temperature until ready for use.

Cookie preparation

Cookies were prepared using the modified recipe for digestive biscuits shown in Table 2 as described by Okaka (1997). The fat and sugar were mixed until fluffy. Egg and milk were added while mixing continued for about 40 min. Appropriate amounts of flour, baking powder, nutmeg, vanilla flavouring and salt were slowly introduced into the mixture. The dough was rolled and cut into circular shapes of 5 cm diameter. Baking was carried out at 160℃ for 15 min. Cookies were prepared from wheat flour to serve as a control.

Proximate composition of cookies

Protein, fat, ash and fibre were determined according to the methods described by AOAC (1990), while carbohydrates were determined by difference.

Evaluation of antinutritional factors

Phytic acid was determined using the method of Reddy and Love (1999). Hydrogen cyanide was determined using the alkaline picrate spectrophotometric method as described by Balagopalan et al. (1988), saponins were determined using the method of Birk et al. (1963) as modified by Hudson and El-Difrawi (1979), the tannin content was determined using the method of Folin-Denis (AOAC, 1990), trypsin inhibitor activity was determined using the spectro-photometric method described by Arntifield et al. (1985), while oxalate was determined using the method described by Ukpabi and Ejidoh

Table 3. Formulation of cookies and casein based diets fed to rats (dry weight basis g/100 g).

Ingredients	PF	PFSF	PFCFSF	PFCF	Casein
PF	771.0	-	-	-	
PFSF	-	930.20	-	-	-
PFCFSF	-	-	872.6	-	-
PFCF	-	-	-	945.0	-
Casein	-	-	-	-	100
Oil	50	50	50	50	50
Vitamin	2.5	2.5	2.5	2.5	2.5
Mineral	0.45	0.45	0.45	0.45	0.45
Cornstarch	176.05	16.85	74.45	2.05	847.05

PF, Cookies produced from 100% pigeon pea flour; PFSF, cookies produced from 50% pigeon pea flour and 50% sorghum flour; PFCFSF, cookies produced from 66.6% pigeon pea flour, 16.7% cocoyam flour and 16.7% sorghum flour; PFCF, cookies produced from 50% pigeon pea flour and 50% cocoyam flour.

(1989).

Formulation of diets

The diets were formulated to provide 10% level of protein, while other ingredients such as vegetable oil, vitamins, minerals and cornstarch were added to balance the diets (Table 3). The diets were thoroughly mixed, pelletized and stored in polyethylene bags labeled with designated names. The polyethylene bags were kept in airtight containers until ready for use.

Animal feeding experiment

Thirty male adult albino rats of the Wistar strain with average initial weight of 120 – 210 g were obtained from the Department of Veterinary Pathology, University of Nigeria, Nsukka. They were randomly divided into six groups of five rats each. The rats were housed in individual screened bottomed cages designed to separately collect faeces and urine. Experimental animals received corresponding group diets and water *ad libitum.* The temperature of the laboratory was 28 ± 1°C with alternate 12 h periods of light and dark. These animals were used to assess the true digestibility (TD), biological value (BV) and net protein utilization (NPU) of the diets based on casein. One group of 5 rats was fed a protein-free diet which consisted entirely of the basal diet; another group was fed a casein diet (control), while the remaining groups were fed the experimental diets. The diets were adequate with respect to vitamins and minerals. Following the method described by Al-Numair and Ahmed (2008), a 9-day balance study which included a four-day adjustment and five-day nitrogen (N) balance period was carried out. There was a preliminary feeding period of four days followed by a balance period of five days during which complete collection of faeces and urine was performed for each rat. Food intake was monitored daily and final body weights were recorded. Urine was collected in sample bottles, preserved in 0.1 N HCl to prevent loss of ammonia and stored in a refrigerator until analyzed for urinary nitrogen. Faeces of individual rats were pooled, dried at 85°C for 4 h, weighed before being ground into fine powder and stored for faecal N determination. The concentration of nitrogen in the diet, faeces and urine was estimated by the Kjeldahl method.

Data analysis

Data were analyzed using one-way analysis of variance (ANOVA). Mean separation was done by the Duncan's multiple range test using the Statistical Package for the Social Sciences (SPSS) 13.0 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Proximate composition of the cookies

The proximate composition of the cookies produced is presented in Table 4. The protein content ranged from 6.40 to 12.97%. Significant differences existed among all the cookie samples including the control (100% wheat) ($p < 0.05$). The protein content increased with increased substitution of pigeon pea flour. Only four cookie formulations conformed to the FAO/WHO minimum recommended protein of 10% (FAO/WHO, 1994). The fat content ranged from 5.10 to 6.36%; with cookies made with 50% cocoyam flour (CF): 50% pigeon pea flour (PF) having the highest value, while cookies with 100% cocoyam flour (CF) had the lowest. The values were generally low and could be desirable for weight watchers. The carbohydrate content ranged from 69.43% for cookies made with 100% PF to 76.44% for cookies with 100% CF.

Antinutritional factors in the cookies

The levels of antinutritional factors found in the cookies are shown in Table 5. The values obtained appeared to be low and in reasonable agreement with those reported by commonly consumed food articles (Ezeagu, 2005).

Nutritional evaluation

The maintenance body weight, food and nitrogen intake, faecal and urinary nitrogen, digested and retained nitrogen, biological value, true digestibility and net protein

Table 4. Proximate composition of cookies produced from cocoyam, sorghum and pigeon pea flour blends.

Blend (CF : SF : PF)	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
100:0:0	6.85^{c}	5.10^{a}	6.40^{a}	2.95^{d}	2.26^{cd}	76.44^{k}
0:100:0	7.35^{g}	6.26^{h}	7.35^{b}	3.06^{f}	2.24^{c}	73.73^{h}
0:0:100	7.13^{f}	5.24^{bc}	12.97^{k}	2.86^{c}	2.37^{e}	69.43^{a}
50:50:0	6.44^{a}	5.76^{f}	7.46^{c}	2.64^{b}	2.43^{f}	75.26^{j}
0:50:50	6.94^{d}	6.04^{g}	10.75^{i}	3.22^{i}	2.37^{e}	70.68^{b}
50:0:50	7.12^{f}	6.36^{i}	10.05^{h}	3.12^{g}	2.17^{a}	71.18^{d}
33.3:33.3:33.3	7.36^{g}	6.22^{h}	9.55^{f}	3.08^{f}	2.22^{b}	71.56^{e}
16.7:16.7:66.6	7.06^{e}	5.25^{c}	11.46^{j}	3.17^{h}	2.18^{a}	70.88^{c}
16.7:66.6:16.7	7.14^{f}	5.20^{b}	8.77^{e}	3.01^{e}	2.34^{e}	73.54^{g}
66.6:16.7:16.7	6.63^{b}	5.47^{d}	8.34^{d}	2.88^{c}	2.27^{d}	74.41^{i}
100% wheat	7.46^{h}	5.64^{e}	9.65^{g}	2.56^{a}	2.41^{f}	72.28^{f}

CF, Cocoyam flour; SF, sorghum flour; PF, pigeon pea flour. Means are of triplicate determinations. Means with different superscripts in the same column are significantly different ($p < 0.05$).

Table 5. Antinutritional factors present in cookies produced from untreated pigeon pea, sorghum and blanched cocoyam flour blends.

Blends (CF : SF : PF)	Saponins (mg/100g)	Hydrogen cyanide (mg/100g)	Phytic acid (mg/100g)	Tannins (mg/100g)	Oxalate (mg/100g)	Trypsin inhibitor (mg/100g)
100:0:0	0.04^{ab}	0.20^{b}	0.70^{a}	0.46^{cd}	0.57^{ab}	0.04^{bc}
0:100:0	0.03^{b}	0.18^{bc}	0.63^{e}	0.49^{abc}	0.53^{cd}	0.04^{bc}
0:0:100	0.04^{ab}	0.20^{b}	0.68^{bc}	0.39^{fg}	0.52^{de}	0.06^{a}
50:50:0	0.04^{ab}	0.18^{bc}	0.62^{e}	0.42^{ef}	0.50^{ef}	0.04^{bc}
0:50:50	0.03^{b}	0.23^{a}	0.67^{cd}	0.50^{ab}	0.52^{de}	0.03^{c}
50:0:50	0.04^{ab}	0.20^{b}	0.62^{e}	0.51^{a}	0.59^{a}	0.05^{ab}
33.3:33.3:33.3	0.04^{ab}	0.17^{cd}	0.59^{f}	0.39^{fg}	0.53^{cd}	0.04^{bc}
16.7:16.7:66.6	0.04^{ab}	0.16^{d}	0.56^{g}	0.36^{h}	0.48^{f}	0.03^{c}
16.7:66.6:16.7	0.05^{a}	0.18^{bc}	0.58f	0.44^{de}	0.51^{de}	0.05^{ab}
66.6:16.7:16.7	0.04^{ab}	0.24^{a}	0.66^{d}	0.44^{de}	0.48^{g}	0.04^{bc}
100% wheat flour	0.04^{ab}	0.16^{d}	0.69^{b}	0.47^{bcd}	0.55^{bc}	0.05^{ab}

CF, Cocoyam flour; SF, sorghum flour; PF, pigeon pea flour. Means with different superscripts in the same column are significantly different ($p < 0.05$). Means are of triplicate determinations.

digestibility of the test diets are shown in Table 6. Only those diets that conformed to the FAO/WHO minimum recommended protein content of 10% were fed to the rats. There was no significant difference in the food intake of the rats fed the formulated cookie diets ($p > 0.05$) in relation to those fed with casein-based diets. Since food intake can be influenced by palatability, it could suggest that the rats found all diets to be palatable. The results also revealed that all rats gained weight and there were no significant differences in gained weights of rats fed with test diets and casein-based diets ($p > 0.05$). This implies that the cookies have the potential for promoting growth. It was observed that, except for cookies formulated with 66.6PF: 16.7SF: 16.7CF, no significant differences existed between the test and casein-based diets ($p > 0.05$) for values of urinary nitrogen which were all low. Nwabueze (2008) reported that low urinary and faecal nitrogen indicates high protein quality of fed diets.

Biological value (BV) measures the efficiency of utilization of absorbed nitrogen (Hackler, 1977). For BV and Net Protein Utilization, 100% denotes the highest quality protein. There were no significant differences in the BV and NPU values among different test and casein-based diets ($p > 0.05$). The values obtained for BV and NPU ranged from 88.53 to 95.54% and 79.78 to 87.34%, respectively. The values suggest that the cookies were of high protein quality.

True digestibility for all the diets ranged from 88.28 to 95.22%. The cookie formulated with 50PF: 50CF had the highest TD of 95.22%, which was not significantly different from that of 92.63% TD in casein-based diets ($p > 0.05$). The cookie formulated with 66.6PF: 16.7SF: 16.7CF had the least TD of 88.28%, which was

Table 6. Maintenance body weight, food intake and nitrogen balance of rats fed cookies from flour blends of pigeon pea, sorghum and cocoyam.

Parameter	Casein	100 PF	50PF : 50CF	66.6PF : 16.7CF : 16.7SF	50PF : 50SF
Maintenance weight (g)	10.00[a]	8.33[a]	11.00[a]	8.33[a]	6.00[a]
Food intake (g)*	68.03[a]	63.90[a]	62.12[a]	51.98[a]	51.20[a]
Nitrogen intake (g)*	1.09[a]	1.02[a]	0.99[a]	0.83[a]	0.82[a]
Faecal nitrogen (g)	0.14[a]	0.12[ab]	0.07[c]	0.12[ab]	0.10[bc]
Digested nitrogen (g)	0.95[a]	0.91[a]	0.92[a]	0.71[a]	0.72[a]
Urinary nitrogen (g)	0.10[a]	0.08[a]	0.11[a]	0.03[b]	0.08[a]
Nitrogen balance	0.85[a]	0.83[a]	0.85[a]	0.68[a]	0.64[a]
BV (%)	89.84[a]	91.84[a]	86.88[a]	95.54[a]	88.53[a]
NPU (%)	83.20[a]	83.61[a]	82.74[a]	87.34[a]	79.78[a]
TD (%)	92.63[ab]	91.06[bc]	95.22[a]	88.28[c]	90.20[bc]

PF, Pigeon pea Flour; CF, cocoyam flour; SF, sorghum flour; BV, biological value; NPU, net protein utilization; TD, true digestibility. Means with different superscripts

significantly lower than that with casein ($p < 0.05$). High digestibility does not always mean high protein quality.

Digestibility is a measure of protein hydrolysis, whereas protein quality is a measure of the balance of the amino acids that are absorbed and utilized for growth and other purposes (Friedman and Cuq, 1988). The high protein digestibility of the test diets may be due to the low levels of tannins and trypsin inhibitors found in the cookies; since dietary trypsin inhibitors and tannins are often responsible for the poor digestibility of dietary proteins (Liener, 1980).

Conclusion

The results have shown that cookies made from pigeon pea containing at least 50% of pigeon pea flour had a protein content which conformed to the minimum FAO/ WHO recommended value of 10%. The results of the nitrogen balance study further revealed that these cookies were nutritionally comparable with a diet based on casein, indicating that the underutilized crops used in this study which are available in tropical countries could be used in producing cookies that promote the combat of malnutrition.

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