

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/236840333>

Nutritional and sensory properties of amala supplemented with distiller's spent grain (DSG)

Article in *Journal of Food Agriculture and Environment* · July 2010

CITATIONS

18

READS

1,945

4 authors:



Wasiu Awoyale

Kwara State University

102 PUBLICATIONS 870 CITATIONS

SEE PROFILE



L. O. Sanni

University of Agriculture, Abeokuta

216 PUBLICATIONS 4,777 CITATIONS

SEE PROFILE



Busie Maziya-Dixon

International Institute of Tropical Agriculture

246 PUBLICATIONS 5,319 CITATIONS

SEE PROFILE



Taofik Shittu

University of Agriculture, Abeokuta

113 PUBLICATIONS 2,009 CITATIONS

SEE PROFILE



Nutritional and sensory properties of *amala* supplemented with distiller's spent grain (DSG)

Wasiu Awoyale ¹, Busie Maziya-Dixon ^{2*}, Lateef Sanni ^{1, 2} and Taofik Akinyemi Shittu ¹

¹ Department of Food Science and Technology, University of Agriculture Abeokuta, PMB 2240, Ogun State, Nigeria.

² International Institute of Tropical Agriculture (IITA), PMB 5320, Oyo Road, Ibadan, Oyo State, Nigeria.

*e-mail: b.dixon@cgiar.org

Received 28 July 2010, accepted 4 November 2010.

Abstract

The effect of distiller's spent grain supplementation on the nutritional and sensory properties of *amala*, a popular traditional thick paste of yam (*Dioscorea alata* or *D. rotundata*) consumed with preferred soup, was investigated. Pre-treated distiller's spent grain was used to replace 5%, 10%, 15%, 20%, 25%, 30% and 35% of yam flour as a protein and dietary fibre supplement. Processing of the flour blends to *amala* significantly ($p \leq 0.05$) increased its fat, total sugar, starch and total content of dispensable and indispensable amino acids while the ash content was slightly reduced. Addition of distiller's spent grain to the flour blends quantitatively and qualitatively increased the protein content of the *amala* products. Quantitatively, the protein content increased from 6.86% for 100% yam to 14.69% for 65% yam:35% distiller's spent grain, with a mean of 10.77%. Qualitatively, the tryptophan content increased from 0.08 g/100 g sample for 90% yam:10% distiller's spent grain to 0.14 g/100 g sample for 65% yam:35% distiller's spent grain. The methionine content increased from 0.09 g/100 g sample for 95% yam:5% distiller's spent grain to 0.25 g/100 g sample for 65% yam: 35% distiller's spent grain. The insoluble dietary fibre content of the *amala* products increased while the soluble dietary fibre content was reduced as distiller's spent grain increased in the blends. The mean insoluble dietary fibre content of the *amala* products was 9.17% with a range from 7.56% (100% yam) to 11.54% (65% yam:35% distiller's spent grain). The mean soluble dietary fibre content was 0.75% with a range from 0.62% (65% yam:35% distiller's spent grain) to 0.85% (100% yam). However, sensory evaluation indicated that *amala* from 5%, 10% and 15% distiller's spent grain substitution levels was well accepted and compared favourably with that of whole yam flour.

Key words: Distiller's spent grain, *amala*, sensory properties, amino acids, yam, *Dioscorea alata*, flour blends.

Introduction

Yam (*Dioscorea* sp.) serves as one of the staple foods for millions of people in Africa, especially Nigeria ¹. Yam flour, eaten as a cooked paste (*amala*) with vegetable sauce, is the principal processed form in which tubers of *Dioscorea rotundata* and *D. alata* are consumed. *Amala* is a popular starchy food that is prepared by reconstituting (cooking and stirring with boiling water) fermented or unfermented yam flour (*elubo*), produced traditionally from the processed tuber flesh of white yam (*D. rotundata* or *D. alata*) ²⁻⁴. *Amala* primarily contains carbohydrates and as a result does not provide adequate nutrients ⁵. Protein energy malnutrition (PEM) is therefore prevalent, particularly among rural women and children in developing countries where yam serves as the staple food and could be reduced by the availability of cheap, nutritious foods based on simple processes through supplementation ⁶.

Food supplementation is the process of increasing the level of specific nutrients previously identified as inadequate using a particular source rich in those nutrients. This is usually done to prevent malnutrition in the developing countries ⁷. The levels of food supplementation depend on the nutritional needs of the consumers and on the estimated consumption of the supplemented food as well as the availability of the supplement and the regulations in the country ⁸. The supplementation of staple root and tuber-based foods with legumes shows that there is

higher protein content and better protein quality and a nutritional value similar to products based on animal protein ⁹. According to Akingbala *et al.* ¹⁰, supplementing yam flour with 40% of soybean flour resulted in a protein content of 23.0% (full fat soybean flour) and 25.5% (defatted soybean flour).

The potential to utilize distiller's spent grain (DSG) products from wheat and other cereals as an ingredient high in protein and fibre in formulated foods has received increasing attention ¹¹⁻¹³. DSG is a by-product of fermentation in the production of alcoholic beverages. It contains large amounts of protein, ranging from 23 to 35% and total dietary fibre ranging from 27 to 55% ¹⁴. Similarly it contains yeast cells, vitamin B-complex and other nutrients formed during the fermentation and distillation processes ¹⁵. DSG has been used in animal feed to prevent waste but in recent times, it has also been utilized in human foods ¹¹. For instance, DSG has been added up to 35% by weight in brownies, chocolate chips and spice and lemon molasses cookies; about 30-50% in bread made from yeast and 30% in quick breads to produce highly acceptable products ¹⁴. Tsen and colleagues ¹⁶ reported that chocolate chip cookies containing 15% DSG residues were as acceptable as those containing no DSG. Emin *et al.* ¹⁷ also reported that the supplementation of frankfurters with brewer's spent grain (BSG) increased the total dietary fibre content of the product.

Therefore, the possibility of producing an acceptable traditional yam flour paste (*amala*), with enhanced nutritional quality was investigated.

Materials and Methods

Materials: *Dioscorea alata* tubers (TDd98/01166) were obtained from the yam barn of the International Institute of Tropical Ariculture, Ibadan, Oyo State, and the DSG from United State Department of Agriculture-Agricultural Research Service (USDA-ARS), North Dakota, USA.

Treatment of DSG: A suspension was made from 100 g of DSG containing alcohol and residual sugar in 400 ml of water and fermented with yeast (0.8 g) for 1 h to convert its residual sugar to alcohol. That was removed from the suspension by distillation. The pH of the suspension was then adjusted to about 6.0 to 7.0 by adding sodium hydroxide (7 ml). The resulting suspension was dried to about 5-10% moisture content ¹⁴.

Yam flour production: The yam tubers were peeled, washed, sliced into cubes and dried in hot air oven at a temperature of 65°C for 48 h. The dried yam chips were milled with an attrition mill to obtain a fine powder and packaged in polyethylene bags for further analysis, as described by Udensi *et al.* ¹⁸.

Formulation of DSG-yam flour mixes into elubo: Yam flour and DSG were weighed and mixed in ratios 100%:0%, 95%:5%, 90%:10%, 85%:15%, 80%:20%, 75%:25%, 70%:30% and 65%:35%. The various mixes obtained were thoroughly blended with a laboratory blender, packed and sealed in low density polythene bags until required ¹⁹.

Preparation of amala: The *elubo* was made into *amala* by mixing one part with approximately 1.5 parts of boiling water (v/v) in a stainless steel pot. The paste was heated (with stirring for 3 min), with an electric cooker set at medium temperature until it has properly cooked.

Determination of chemical composition: The moisture, ash and fat contents were determined using standard laboratory procedures ²⁰. The protein content was determined by Kjeldahl method using Kjeltec™ model 2300 protein analyzer ²¹. A conversion factor of 6.25 was used to convert total nitrogen to crude protein percentage. The analyses were carried out in duplicates.

The total sugar and starch contents were analyzed in duplicate, according to the method described by Dubois *et al.* ²².

Samples were analyzed for soluble (SDF) and insoluble dietary fibre (IDF) fractions using the enzymatic-gravimetric procedure ²³.

Total dietary fiber (TDF) was

calculated as the sum of SDF and IDF.

Amino acids were identified and quantified by reverse phase liquid chromatography (Waters 1500 Series HPLC; Milford, MA) with UV detection at 254 nm ²⁴ at the South African Grain Laboratory, Pretoria, South Africa.

Sensory evaluation: A 9- point hedonic preference scale and a multiple comparison test were used to assess the acceptability of *amala* made from yam/DSG flour blends against whole yam *amala* using 10 trained panelists. Panelists were selected from the staff and graduate students of IITA, Ibadan, and screened with respect to their interest and ability to differentiate food sensory properties, as described by Iwe ²⁵. Selection tests included an odor and color identification test and a series of texture tests in which panelist's abilities to assess smoothness was measured. The trained panelists were then presented with coded samples to evaluate the effect of the different supplementation ratios on taste, smoothness, color, odor and overall acceptability using the 9-point hedonic scale, where 1 corresponds to like extremely and 9 corresponds to dislike extremely.

Statistical analysis: Data were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) package (version 9.1, SAS Institute, Inc., Cary, NC) ²⁶. Means were separated using Fischer's protected Least Significant Difference (LSD) test.

Results and Discussion

Chemical composition: The results indicate that ash content of the *amala* products ranged between 3.41% and 3.54% with a mean of 3.48%. A significant difference ($p \leq 0.05$) was observed in the ash content, with *amala* from 85% yam:15% DSG having the lowest and those from 100% yam and 75% yam:25% DSG had the highest ash content (Table 1). This implies that *amala* from 100% yam and 75% yam:25% DSG blend has the highest amount of total mineral content.

The *amala* moisture content ranged from 70.92% to 73.75% with a mean of 72.54% on wet basis. *Amala* from 80% yam:20% DSG had the lowest moisture content while 75% yam:25% DSG had the highest one. Some levels of significant difference ($p \leq 0.05$) were observed in the *amala* products (Table 1).

The total sugar content of *amala* ranged between 2.85% and

Table 1. Chemical composition (%) of *amala* from different ratios of yam flour and Distiller's Spent Grain (DSG) Blends.

Samples	Ash	Moisture	Protein	Sugar	Starch	Fat
100yam:0DSG	3.54±0.02 ^a	73.21±0.14 ^a	6.86±0.03 ^b	3.41±0.09 ^d	79.16±0.03 ^a	0.05± 0.02 ^h
95yam:5DSG	3.51±0.01 ^{ab}	73.26±0.04 ^c	7.81±0.03 ^g	4.80±0.04 ^a	77.74±0.63 ^b	0.28± 0.01 ^g
90yam:10DSG	3.42±0.04 ^{cd}	72.05±0.14 ^b	9.10±0.07 ^f	3.94±0.01 ^b	78.14±0.42 ^b	0.38±0.02 ^f
85yam:15DSG	3.41±0.01 ^d	73.26±0.11 ^c	10.24±0.01 ^c	3.81±0.01 ^c	72.94±0.05 ^c	0.74±0.02 ^e
80yam:20DSG	3.48± 0.04 ^b	70.92±0.13 ^d	11.23±0.00 ^d	3.87±0.04 ^{bc}	71.73±0.17 ^d	1.04±0.01 ^d
75yam:25DSG	3.54± 0.03 ^a	73.75±0.22 ^c	12.56±0.03 ^c	3.38±0.01 ^d	68.93±0.06 ^c	1.18±0.01 ^c
70yam:30DSG	3.47±0.03 ^b	72.27±0.01 ^d	13.65±0.01 ^b	3.43±0.01 ^d	67.93±0.06 ^f	1.71±0.02 ^b
65yam:35DSG	3.47±0.02 ^{bc}	71.58±0.04 ^c	14.69±0.06 ^a	2.85±0.04 ^c	65.50±0.07 ^g	2.21±0.04 ^a
Mean	3.48	72.54	10.77	3.69	72.76	0.95
Minimum	3.41	70.92	6.86	2.85	65.50	0.05
Maximum	3.54	73.26	14.69	4.80	79.16	2.21
CV (%)	0.83	0.17	0.32	1.11	0.38	2.21
P level	*	*	*	*	*	*

Mean values in the same column with different letters are significantly different at $p \leq 0.05$. Mean ± Standard deviations from triplicate samples; * = $P < 0.05$.

4.80% with a mean of 3.69%. *Amala* from 65% yam:35% DSG had the lowest sugar content and 95% yam:5% DSG had the highest one (Table 1). This implies that the total sugar content of *amala* was reduced as the supplementation ratio with DSG increased in the blends. Cooking the flour blends also had significant effects on the sugar content of the final product, depending on the ratios of supplementation with DSG.

The starch content of the *amala* products with a mean of 72.76% ranged from 65.50% to 79.16%. The lowest starch content was in *amala* from 65% yam:35% DSG; the highest one was in *amala* from 100% yam (Table 1). This could be attributed to the low starch content of DSG. Significant differences ($p \leq 0.05$) were observed among the starch content of *amala* products.

The mean fat content of *amala* was 0.95% with a range from 0.05% to 2.21%. *Amala* from 100% yam had the lowest fat content while 65% yam:35% DSG had the highest one (Table 1). This could be attributed to the high fat content of DSG (9.63%) compared to that of yam flour (0.43%). There were significant differences ($p \leq 0.05$) among the fat contents of the *amala* products. The fat content of the *amala* products decreased significantly compared to their respective flour blends. This implies that cooking the flour blends had a negative effect on the fat contents of the final product.

Protein is essential in the human diet for growth and the repair of worn-out tissue²⁷. The protein content of the *amala* products, with a mean of 10.77%, ranged from 6.86% to 14.69%. *Amala* from 100% yam had the lowest protein content while 65% yam:35% DSG had the highest one (Table 1). This could be attributed to the high protein content of DSG (29.80%) compared to that of yam flour (7.15%). Significant differences ($p \leq 0.05$) were observed among the protein contents of the *amala* products. The results indicate that the protein content of the product decreased significantly compared to that of their respective flour blends. This implies that cooking the flour blends has a slightly negative effect on the protein content of the final products.

Amino acid composition: The amino acid analysis of foodstuffs is an important index of their food quality and can provide useful information on the nutritional quality and authenticity of food products and the sources of raw materials used in food manufacture²⁸. The results of the amino acid analysis shows that total indispensable amino acids with histidine in the *amala* products ranged from 1.93 to 5.04 g/100 g sample and those without histidine ranged from 1.78 to 4.65 g/100 g sample (Table 2). *Amala* from 100% yam had the lowest values of total indispensable amino acids while 65% yam:35% DSG has the highest values (with and without histidine). Leucine contributed the highest amount and tryptophan the lowest one (Table 2). This implies that *amala* from 65% yam:35% DSG blend contains the highest amount of essential amino acids that must be supplied to the human body from a food or supplement²⁹.

The results of the total conditionally dispensable amino acids of the *amala* products ranged between 0.60 and 1.25 g/100 g sample (Table 2). The 100% yam *amala* has the lowest values of total conditionally dispensable amino acids while 65% yam:35% DSG has the highest value. Arginine contributed the highest amount and tyrosine the lowest one (Table 2). This implies that *amala* from 65% yam:35% DSG blend contains the highest amount of those amino acids that depend on the ability of the human body to actually synthesize them from other amino acids²⁹.

The values of the total dispensable amino acids of the *amala* products ranged from 2.67 to 7.17 g/100 g sample (Table 2). The 100% yam *amala* had the lowest values of total dispensable amino acids while 65% yam:35% DSG had the highest values. Glutamic acid contributed the highest amount and glycine the lowest one (Table 2). This implies that *amala* from 65% yam:35% DSG blend contains the highest amount of amino acids that can be synthesized by the human body from other amino acids²⁹.

The indispensable and dispensable amino acid compositions of *amala* (with high protein content) were slightly lower than in their respective flour blends. This implies that processing the

flour blends to *amala* increased the quantity of protein while the quality was slightly reduced.

Mixing DSG with yam flour for *amala* production increased the content of both methionine and tryptophan (limiting amino acids of yam) (Table 2). The methionine content of the *amala* products ranged from 0.09 to 0.25 g/100 g sample while the tryptophan content ranged between 0.08 and 0.14 g/100 g sample. The 95% yam:5% DSG *amala* had the lowest methionine content while 65% yam:35% DSG had the highest value. Similarly, the 90% yam:10% DSG *amala* had the lowest tryptophan content; 70% yam:30% DSG and 65% yam:35% DSG has the highest values (Table 2). This implies

Table 2. Amino-acid composition (g/100 g sample) of *amala* from different ratios of yam flour and Distiller's Spent Grain (DSG) blends.

Amino acids	100yam: 0DSG	95yam: 5DSG	90yam: 10DSG	85yam: 15DSG	80yam: 20DSG	75yam: 25DSG	70yam: 30DSG	65yam: 35DSG
Methionine	0.10	0.09	0.14	0.20	0.18	0.20	0.23	0.25
Aspartic acid	0.67	0.78	0.82	0.87	0.94	1.04	1.06	1.13
Glutamic acid	0.87	1.27	1.42	1.58	0.19	2.20	2.37	2.56
Serine	0.35	0.45	0.48	0.56	0.63	0.70	0.77	0.81
Glycine	0.24	0.32	0.35	0.41	0.46	0.51	0.55	0.59
Histidine	0.15	0.19	0.24	0.26	0.31	0.33	0.37	0.39
Arginine	0.41	0.49	0.59	0.67	0.71	0.75	0.76	0.80
Threonine	0.22	0.27	0.31	0.36	0.41	0.46	0.49	0.53
Alanine	0.28	0.41	0.50	0.60	0.71	0.81	0.89	0.99
Proline	0.27	0.39	0.51	0.64	0.76	0.88	0.97	1.09
Tyrosine	0.20	0.19	0.26	0.35	0.36	0.41	0.44	0.44
Valine	0.26	0.31	0.37	0.42	0.50	0.56	0.59	0.64
Isoleucine	0.22	0.27	0.31	0.34	0.40	0.45	0.47	0.51
Leucine	0.42	0.59	0.74	0.87	1.07	1.26	1.38	1.49
Phenylalanine	0.32	0.39	0.45	0.51	0.58	0.66	0.70	0.74
Lysine	0.16	0.21	0.24	0.26	0.30	0.29	0.30	0.35
Tryptophan	0.09	0.10	0.08	0.11	0.12	0.12	0.14	0.14
TAa	5.19	6.70	7.82	9.00	8.61	11.61	12.48	13.45
TIaA with histidine	1.93	2.42	2.88	3.33	3.86	4.31	4.67	5.04
TIaA without histidine	1.78	2.22	2.64	3.06	3.55	3.98	4.30	4.65
TCDAa	0.60	0.67	0.85	1.02	1.07	1.16	1.20	1.25
TDAA	2.67	3.61	4.09	4.66	3.69	6.14	6.61	7.17

TAa: Total amino acids; d ations from triplicate greater than the corresponding LSD in the same column is significant; TIaA: Total indispensable amino acids; TCDAa: Total conditionally dispensable amino acids; TDAA: Total dispensable amino acids.

that the inclusion of DSG in the blends increased the amount of the limiting amino acids. This was in agreement with the observation made by FAO⁷.

FAO/WHO/UNN³⁰ reported that the total indispensable amino acids requirements (g/100 g protein) for school children aged 10-12 years are 24.1 (with histidine) and 22.2 (without histidine). For adults, the figures are 12.7 and 11.1 g/100 g. Based on this information, *amala* from this investigation with total indispensable amino acid content (g/100 g protein) range from 26.97 to 31.50 (with histidine) and 24.80-28.95 (without histidine) might be able to improve the total essential amino acids level of the target group when consumed.

Dietary fibre: Dietary fibre (DF) describes a number of different substances, such as cellulose, pectin, lignin and guar, all of which are naturally found only in plants and are resistant to digestion in, and absorption by, the human small intestine³¹. The TDF content of the *amala* products ranged from 8.41% to 12.17% with the IDF contributing the highest amount and the SDF contributing the least (Table 3). The IDF content of the *amala* products ranged from 7.56% to 11.54% with a mean of 9.17%. The content of SDF ranged between 0.62% and 0.85% with a mean of 0.75%. *Amala* from 100% yam has both the lowest IDF and the highest SDF. *Amala* from 65% yam:35% DSG has the highest IDF and the lowest SDF contents (Table 3).

It was observed that cooking the blends to *amala* increased both the IDF and TDF (except for the 85% yam:15% DSG blend). The SDF was reduced compared with their respective flour blends (Table 3). This was similar to the observation made by Fornal *et*

*al.*³² on the reduction of food dietary fibre after processing. Food can only be used as a source of dietary fibre where the product contains at least 3 g/100 g fibre or considered high in dietary fibre where the product contains at least 6 g/100 g fibre³³. Intake of dietary fibre could therefore be increased by the consumption of *amala* from all the flour blends. A high intake of dietary fibre is positively related to different physiological and metabolic effects²⁷. Thus, consumption of the *amala* from this investigation might be able to reduce cardiovascular diseases and other physiological and metabolic effects in the body.

Sensory properties: An increase in the level of substitution of DSG for yam flour reduced the acceptance of all the sensory characteristics studied (Table 4). There were no significant differences ($p \leq 0.05$) between the *amala* from 100% yam flour and 95% yam flour:5% DSG blend in terms of taste, hand-feel, colour and overall acceptability; the odour was the exception (Table 4). The significant difference in odour might be attributed to the characteristic smell of DSG in the blends. *Amala* from 100% yam flour and 95% yam:5% DSG blends were the preferred samples; 75% yam:25% DSG blend was the least liked in terms of taste, hand-feel, color, odor and overall acceptability. All the samples of *amala* were as sticky as the control product (*amala* from 100% *D. rotundata* flour) except those from 75% yam:25% DSG, 70% yam:30% DSG and 65% yam:35% DSG blends. This might be due to the low amylose content of the blends³³.

There were no significant differences ($p \leq 0.05$) in appearance among all the *amala* products compared with the control, as all the products were as attractive as the control. The *amala* from 100% yam flour, 95% yam:5% DSG and 90% yam:10% DSG blends was lighter than the control, *amala* from 85% yam:15% DSG, 80% yam:20% DSG and 75% yam:25% DSG blends were as brown as the control. The 65% yam:35% DSG blend was darker than the control. The products from 95% yam:5% DSG, 90% yam:10% DSG, 85% yam:15% DSG and 80% yam:20% DSG were as soft as the control; those from 75% yam:25% DSG, 70% yam:30% DSG and 65% yam:35% DSG blends were slightly softer than the control sample in terms of hand-feel. This might be as a result of the increase in DSG supplementation.

However, *amala* made from 95% yam flour:5% DSG, 90% yam flour:10% DSG, as well as that of 85% yam:15% DSG were well accepted and compared favorably with whole yam flour *amala*.

Conclusions

The consumption of the *amala* from this investigation by the target group (children and adults) might improve their level of total essential amino acids and as a result reduce the incidence of PEM and serve as well as a good source of TDF. Thus, *amala* with higher nutritional values can be made with composite flours from DSG, but the

Table 3. Dietary fibre content of different ratios of yam flour and distiller's spent grain (DSG) and *amala*.

Codes	Flour blends			Amala products		
	IDF	SDF	TDF	IDF	SDF	TDF
TDSG	23.53	0.67	24.20	-	-	-
100yam:0DSG	5.10	0.92	6.02	7.56	0.85	8.41
95yam:5DSG	5.47	0.91	6.37	7.58	0.84	8.42
90yam:10DSG	6.38	0.87	7.25	7.72	0.83	8.55
85yam:15DSG	8.27	0.85	9.13	8.20	0.77	8.97
80yam:20DSG	8.67	0.78	9.45	8.87	0.73	9.60
75yam:25DSG	9.59	0.76	10.34	10.85	0.69	11.55
70yam:30DSG	10.05	0.75	10.80	11.03	0.65	11.68
65yam:35DSG	11.01	0.72	11.73	11.54	0.62	12.17
Mean	9.79	0.80	10.59	9.17	0.75	9.92
Minimum	5.10	0.67	6.02	7.56	0.62	8.41
Maximum	23.53	0.92	24.20	11.54	0.85	12.17

TDSG (DSG) Treated Distiller's grain, IDF Insoluble dietary fibre; SDF Soluble dietary fibre; TDF Total dietary fibre.

Table 4. Sensory evaluation of *amala* from different ratios of yam flour and distiller's spent grain (DSG).

Samples	Taste	Hand-feel	Colour	Odour	Overall Accep.
100yam:0DSG	3.30±1.57 ^b	2.90±1.20 ^c	2.70±1.64 ^c	3.10±1.29 ^c	3.40±1.78 ^c
95yam:5DSG	3.20±1.14 ^b	3.20±1.93 ^c	3.20±1.32 ^c	3.20±1.40 ^{cd}	3.50±1.84 ^c
90yam:10DSG	4.10±2.51 ^b	4.30±1.57 ^{cde}	3.50±1.43 ^{bc}	4.20±2.35 ^{bcd}	4.50±2.64 ^{bc}
85yam:15DSG	3.70±2.00 ^b	3.40±1.35 ^{de}	3.40±1.43 ^{bc}	4.10±1.97 ^{bcd}	3.90±2.13 ^{bc}
80yam:20DSG	3.90±1.66 ^b	4.90±1.97 ^{bcd}	4.00±2.05 ^{abc}	4.30±1.70 ^{bcd}	4.40±1.78 ^{bc}
75yam:25DSG	4.40±2.07 ^{ab}	5.00±1.89 ^{bc}	4.80±2.04 ^{ab}	4.90±1.79 ^{abc}	5.30±2.21 ^{ab}
70yam:30DSG	4.90±2.23 ^{ab}	6.00±1.83 ^{ab}	4.90±1.91 ^{ab}	5.80±2.10 ^{ab}	4.90±1.79 ^{abc}
65yam:35DSG	6.00±1.89 ^a	6.70±2.00 ^a	5.20±2.15 ^a	6.30±2.41 ^a	6.60±1.78 ^a
Mean	4.19	4.55	3.96	4.49	4.56
Minimum	3.20	2.90	2.70	3.10	3.40
Maximum	6.00	6.70	5.20	6.30	6.60
CV (%)	45.98	38.24	44.78	42.65	44.15
P level	*	*	*	*	*

Mean values in the same column with different letters are significantly different at $p \leq 0.05$. Values are means ± standard deviations. * $P < 0.05$.

maximum levels of DSG substitution which was found acceptable during the preference tests were 5%, 10% and 15%.

Acknowledgements

This research was supported and carried out in the International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria. We acknowledge Dr. K. Dashiell, United State Department of Agriculture-Agricultural Research Service (USDA-ARS), North Dakota, United States America for supplying DSG.

References

- ¹Ige, M. T. and Akintunde, F. O. 1981. Studies of the local techniques of yam flour production. *J. Fd. Technol.* **16**:301–311.
- ²NRCRI 1983. National Root Crops Research Institute, Umudike. Annual Report, NRCRI, Umudike, Umuahia, Nigeria.
- ³Orkwor, G. C. 1998. The importance of yams. In Orkwor, G. C., Asiedu, R. and Ekanayake, I. J. (eds). *Food Yams: Advances in Research*. IITA, Ibadan, Nigeria and NRCRI, Umudike, Umuahia, Abia State, Nigeria, pp. 1-11.
- ⁴Hahn, S. K., Osiru, D. S. O., Akoroda, M. O. and Otoo, J. A. 1987. Yam production and its future prospects. *Outlook on Agriculture* **16**(3):105-110.
- ⁵Omueti, O. and Morton, I. D. 1996. Development by extrusion of soybean snack sticks, a nutritionally improved soya-maize product based on the Nigeria snack (*kokoro*). *Int. J. Food Sci. Nutri.* **47**:5-13.
- ⁶Achi, O. K. 1999. Quality attributes of fermented yam flour supplemented with processed soy flour. *Plant Foods in Hum. Nutr.* **54**:151–158.
- ⁷FAO 1992. Maize in Human Nutrition. FAO Food and Nutrition Series **25**. FAO, Rome, Italy.
- ⁸Onis, M. D., Monteiro, C. and Clugston, G. 1993. The worldwide magnitude of protein-energy malnutrition: An overview from the WHO Global Database on Child Growth. *Bulletin of the World Health Organization* **71**(6):703-712.
- ⁹Gupta, Y. P. and Kapon, A. C. 1980. Chemical evaluation of protein quality of various grain legumes. *Indian J. Agric. Sci.* **50**:393–398.
- ¹⁰Akingbala, J. O., Oguntimein, T. B. and Sobande, A. O. 1996. Physico-chemical properties and acceptability of yam flour replaced by soy flour. *Plant Foods in Hum. Nutr.* **48**:73-80.
- ¹¹Rasco, B. A., Dong, F. M., Hashisaka, A. E., Gazzaz, S. S., Downey, S. E. and San-Buenaventura, M. L. 1987a. Chemical composition of distiller's dried grains with solubles (DDGS) from soft white wheat, hard red wheat and corn. *J. Food Sci.* **52**:236-237.
- ¹²Rasco, B. A., Downey, S. E. and Dong, F. M. 1987b. Consumer acceptability of baked goods containing distiller's dried grains with solubles from soft white winter wheat. *Cereal Chem.* **64**:139-143.
- ¹³Wu, Y. V., Sexson, K. R. and Lagoda, A. A. 1985. Protein rich alcohol fermentation residues from corn dry milled fractions. *Cereal Chem.* **62**:470-473.
- ¹⁴Rasco, B. A. and McBurney, W. J. 1989. Human food product produced from dried distiller's spent cereal grains and solubles. <http://www.freepatentsonline.com/4828846.html>
- ¹⁵Kaiser, R. M. 2006. Utilizing the Growing Supply of Distiller's Grains. University of Wisconsin – Extension, USA. Dairy Agent, pp. 1-6. <http://dysci.wisc.edu/uwex/brochures/brochures/ADDProceedings02.pdf>
- ¹⁶Tsen, C. C., Eyestone, W. and Weber, J. 1982. Evaluation of the quality of biscuits supplemented with distillers dried grain flours. *J. Food. Sci.* **47**:684-685.
- ¹⁷Emin, B. O., Halil, V., Incilay, G. and Ozen, O. 2009. Utilization of brewer's spent grains in the production of frankfurters. *Int. J. Food Sc. Tech.* **44**(6):1093-1099.
- ¹⁸Udensi, E. A., Oselebe, H. O. and Iweala, O. O. 2008. The Investigation of chemical composition and functional properties of water yam (*D. alata*): Effect of varietal differences. *Pak. J. Nutri.* **7**(2):342-344.
- ¹⁹Adelakun, O. E., Adejuyitan, J. A., Olajide, J. O. and Alabi, B. K. 2004. Effect of soybean substitution on some physical, compositional and sensory properties of *kokoro* (a local maize snack). *Eur. Food Res. Technol.* **220**:79-82.
- ²⁰AOAC. 1990. Official Methods of Analysis of the Association of Official Analytical Chemists. 15th edn. Arlington. Virginia, USA.
- ²¹Foss Analytical Manual AB. 2003. Manual for Kjeltac System 2300 Distilling and Titration Unit. Kjeldahl method of protein determination.
- ²²Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. *Anal. Chem.* **28**:350-356.
- ²³Prosky, L., Asp, N. G., Schweizer, T. E., Devries, J. W. and Furda, I. 1988. Determination of insoluble, soluble and total dietary fiber in foods and food products: Interlaboratory study. *J. Assoc. of Anal. Chem.* **71**:1017-1024.
- ²⁴Cohen, S. A., Meys, A. and Tarvin, T. L. 1988. The Pico-Tag Method: A Manual of Advanced Techniques for Amino Acid Analysis. Waters Chromatography Division. Milford, MA, USA.
- ²⁵Iwe, M. O. 2002. Hand book of Sensory Methods and Analysis. pp.1-73.
- ²⁶SAS 2003. SAS Institute Inc. SAS® 9.1 Qualification Tools User's Guide. SAS Institute Inc, Cary, NC, USA.
- ²⁷Baah, F. D., Maziya-Dixon, B., Asiedu, R., Oduro, I. and Ellis, W. O. 2009. Nutritional and biochemical composition of *D. alata* (*Dioscorea* spp.) tubers. *J. Food Agric. Environ.* **7**(2):373-378.
- ²⁸Alozie, Y., Akpanabiatu, M. I., Eyong, E. U., Umoh, B. I. and Alizie, G. 2009. Amino acid composition of *D. dumentorum* Varieties. *Pak. J. Nutri.* **8**(2):103-105.
- ²⁹Finnin, B. and Peters, S. 1996. Amino acids and body building. *From Muscle and Fitness Magazine*.
- ³⁰FAO/WHO/UNN. 2007. Protein and Amino acids Requirements in Human Nutrition. World Health Organization, Press, Geneva.
- ³¹Bauer, W. and Turler-Inderbitzin, S. 2008. Nestle professional Nutrition Magazine-Dietary fibre and its various health benefits. *Nutri. Pro. Food* **6**.
- ³²Fornal, L., Soral-Smietana, M., Smietana Z. and Szpendowski, J. 1987. Chemical characteristics and physicochemical properties of the extruded mixtures of cereal starches. *Starch/Staerke* **39**:75-78.
- ³³IFST 2007. Information Statement of the Institute of Food Science and Technology on Dietary Fibre. Public Affairs and Technical & Legislative Committees, London, pp. 1-10.