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Functional and Nutritional Properties of Spent Grain Enhanced Cookies

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ABSTRACT

The generation of large tonnages of spent grains as byproduct has become major disposal problem in brewing industry. This necessitate sourcing utilization alternatives to complement present use as animal feeds. The incorporation of this brewery spent grain, BSG, into cookie formulations to 15% maximum levels and its effects on the nutritional and functional properties of cookies was investigated. About 6.14% dried and 610 μm milled BSG were added to cookie formulation mix at 0, 3, 6, 9, 12 and 15% levels. Other recipes added include: wheat flour, salt, sodium carbonate, water, non-fatty milk and additives. The trace metal content of the blended products were also compared with local and imported cookies. The results obtained indicated free fatty acid, moisture content, extracted fat and sensory evaluation of the final cookies were limited to 6% optimum inclusion while the spread ratio analysis suggested 3% BSG usage. The undesirable flavor of BSG as additives influenced the taste of the cookies to a great extent and did not change the nutritional status of the samples from 6% BSG inclusion. The trace metals statistical analysis of the BSG supplemented cookies compared well with both locally baked and imported cookies ($p \leq 0.05$). However, addition of brewery spent grains significantly increased the nutritional properties of the cookies up to 6% level of BSG addition.

Key words: Brewery spent grains, physico-chemical composition, cookies, organoleptic evaluation, nutritional evaluation

INTRODUCTION

The brewing industry produces large quantities of by-product solid wastes which include spent grains, surplus yeast, malt sprout and cullet along with desired products and there is increasing demands to ensure total utilization of such waste products to address economic and environmental concerns. Brewery Spent Grain (BSG) is the residue after separation of wort during brewing process and its composition vary with barley variety, time of harvest, characteristic of hops and other adjuncts added as well as brewing technological method. Due to high fibre and protein content, including essential amino acids present in BSG, it became widely used as animal feed (Wang *et al*., 2001; Salama *et al*., 1995). The grain had also been discovered as good substrates, leading to increase nutritional value, for the cultivation of mushrooms specie (Mussato *et al*., 2006;

Santos *et al.*, 2003; Sabbioni *et al.*, 1995). There is also growing interest in the use of BSG in some formulated foods in preventing the increase production of lipids, important vitamin B, in addition to cholesterol and protein enrichment (Ajanaku *et al.*, 2010; Vitali *et al.*, 2009; Stojceska *et al.*, 2008; Hassona, 1993; Windell *et al.*, 1974). There have been advances on the importance of diets and use of supplements in food and this has positioned an increasing role of dietary fibre in controlling chronic disorders like bowel cancer, cardiovascular diseases and constipation which have been well documented (Kamaljit *et al.*, 2010; Wolever *et al.*, 1993; Trowell *et al.*, 1976). There were also observations that protein deficiency has become a major dietary problem facing the world today, especially the underdeveloped and developing countries; which have made researchers (Enweremadu *et al.*, 2008; Bi-Yu *et al.*, 1998; Ahn, 1979), to focus on alternative uses of brewery by-products and waste minimization approach for brewing processes. In the light of the above findings, this present study was undertaken to determine the effect of using BSG as dietary feed in cookie formulation at different blend levels as well as evaluate the nutritional quality of the obtained cookies.

MATERIALS AND METHODS

Raw materials and pre-treatment: Fresh sample of Brewery Spent Grains was obtained from Nigeria Breweries Plc, New Ife Road, Ibadan, Nigeria. It was a barley spent grain and the pH of the spent grain was 6.1 when it was received. The fresh BSG sample was oven-dried at 40°C to ensure preservation. The dried sample was grounded using a 3-axis vertical laboratory milling machine and then sieved through 610 μm aperture sieve to ensure similar particle sizes with the wheat flour used for the experiment. The dried sample was packed in sealed polyethylene bags and stored until used. The ingredients used for cookies formation (fine sucrose, granulated sucrose, non-fat milk, salt, sodium bicarbonate, shortening fat and baking powder) and the golden penny wheat flour were obtained from Flour Mills Plc, Lagos State, Nigeria.

Cookies preparation: Blends of the golden penny wheat flour and brewery spent grains containing 0, 3, 6, 9, 12 and 15% BSG, on a weight/weight replacement basis, were prepared. The 0% was used as the control. The choice of these levels was based on previous work reported on histopathological effect on use of spent grains as supplements (Ajanaku *et al.*, 2010). The compounded samples were then packed in polyethylene bags, sealed and stored in a freezer (0-5°C) until required. Cookies were prepared according to the procedure described by McWatters *et al.* (2003) with slight modifications. The basic ingredients used were 80 g of flour blend, 25.6 g of fine sucrose, 8 g of granulated sucrose, 0.8 g of non-fat milk, 1.0 g of salt, 0.8 g of sodium bicarbonate, 32 g of shortening fat, 15 g of beaten whole egg and 0.4 g of baking powder. The whole ingredients were weighed and mixed thoroughly using a dual shaft Ross mixer. The eggs were added and the resulting dough was thoroughly kneaded in an Ultra Turrax T50 mixer for 10 min. The dough was cut out to a diameter of 25 and 10 mm uniform thickness. The dough pieces were then baked on greased pans at 160°C in an electric oven for 35 min. A total of five cookies were prepared per cake formulation. The prepared cookies were cooled to room temperature and packed in polyethylene bags for further analysis.

Chemical analysis of cookies: The BSG cookies were analysed for moisture, crude protein, ash (Quasem *et al.*, 2009), Neutral Detergent Fibre (NDF) (Van Soest and Wine, 1967), Acid Detergent

Fibre (ADF), cellulose, hemicelluloses, lignin and crude fibre (Van Soest, 1967). The amino acid content of BSG was evaluated using autoanalytic apparatus according to the method described by Yu (1994). All reagents used were of analytical grade (BDH Chemicals).

Petroleum ether was used to extract fat from the cookies by soxhlet extraction and the quantity of fat obtained was weighed. The fat was diluted with 50 cm^3 of benzyalcohol (C_7H_8O) and resulting solution titrated against 0.1 M KOH solution. The percentage free fatty acid was determined using the formula:

$$\frac{1.41\times(\text{Titre value}-\text{Blank})}{\text{Weight of the fat extract}}\times 100 = (\%)\,\text{FFA}$$

Some trace metals, including, Manganese (Mn); Iron (Fe); Copper (Cu) and Zinc (Zn) were examined using an atomic absorption spectrophotometer (Perkin Elmer 300 spectrophotometer) by wet digestion in line with the procedure of American Association of Cereal Chemists (AACC, 2000). The results obtained were compared with the trace metals values obtained for local and imported cookies.

Physical analysis and organoleptic evaluation of cookies: Physical parameters of the BSG supplemented cookies were evaluated in terms of Width (W) Thickness (T) and cookie spread ratio (W/T) in accordance with American Association of Cereal Chemists (AACC, 2000) standard method. Width and thickness measurements of prepared cookies were taken using a vernier caliper in three replicates and the mean values recorded. Weights were determined using a Mettler digital top loading balance. The sensory/organoleptic characteristics of the cookies were screened by a ten-member panel that is well aware of the purpose of investigation. The panel members individually evaluated appearance, flavour, colour and taste of the baked cookies by giving scores ranging between 1 to 10, 10 being the most desirable. The sensory assessment was on a 7-point Hedonic scale for taste, appearance, texture, colour and acceptability. The coded cookie samples were randomized and presented to the judges on white plates in the sensory evaluation laboratory, Flour Mills Plc, Lagos State, Nigeria. The data obtained were subjected to analysis of variance while the overall sensory scores were calculated as the average of the appearance, flavour, colour and taste scores for each bake using the method of Koksel and Ozboy (1999).

RESULTS AND DISCUSSION

The proximate analysis of the brewery spent grain samples is presented in Table 1. There has been numerous correlations on the effect of moisture content and water activity which suggest that the level of water activity of flour baked product should be minimal in order to prolong the shelve life of the products (Egan *et al.*, 1981). The water activity also depends on the food compositions and the type of foodstuff. The moisture content of the spent grains used for the blending is appreciably low and did not affect the final moisture in the product; hence lasting shelf life. The moisture content of the blended cookies ranged from 1.64% for control to 1.86% for 15% blend (Table 2). Cookies are flat round cakes which are commonly called biscuits in some regions. They are produced from wheat flour but could be made from cassava flour and other composites (Ubbor and Akobundu, 2009). Cookies are very low moisture content products. The majority of the moisture lies in a thin lamella of material near the center while the surface and the outer periphery of the product are nearly dry. Biscuits differs from other products like bread and cake because of

Table 1: Results of proximate analysis of brewery spent grains

Variables (%)	Mean values (n = 4)
Crude protein	23.19±2.10
Crude fibre	12.85±1.60
Crude fat	2.79±0.011
Moisture content	6.14±0.241
Ash	16.98±2.01
Carbohydrate	51.39±4.30
Total nitrogen	3.72±0.01
Total phosphorus	0.78±0.055
NDF	64.04±2.10
ADF	24.64±3.20
Lignin	8.26±1.00
Cellulose	15.46±3.20

Table 2: Total percentage of free fatty acid, moisture and ash content in BSG blended cookies

Samples (%)	Extracted fat (g)	FFA (%)	Moisture content (%)	Ash content (%)
0	2.150	0.310	1.64	4.52
3	2.120	0.330	1.68	4.59
6	2.118	0.340	1.64	3.24
9	2.250	0.370	1.84	2.91
12	2.290	0.370	1.76	1.66
15	2.310	0.370	1.86	2.51

having low moisture content which is comparatively free from microbial spoilage thereby enhancing long shelf life of the product (Sharif *et al*., 2009). The typical initial moisture content of cookies dough ranges from about 15-35%, comprising both water added at the dough mixing stage and water naturally occurring in the ingredients while thermal processing reduces the final moisture content to 1-5% in the final product.

There were high crude protein and crude fibre values observed in the BSG samples (23.19 and 12.85%, respectively; Table 1). This may be due to the variety of barley, malting process, the adjunct used, processing procedure or to protein rest and washing operations of the grains as suggested previously (Dawodu and Ajanaku, 2008). This suggest that incorporation of the spent grains in flour for cookies formation will enrich crude protein and dietary fibre value of the cookies as well. Dietary fiber is seen as the edible parts of plants which are resistant to both digestion and absorption in the human small intestine and have partial fermentation process in the large intestine. These type of plant food materials may be a non-starchy polysaccharides such as celluloses, hemi-celluloses, gums, pectins as well as resistant starches (DeVries, 2001). There is also the WHO recommendation for dietary fiber intake which is about 25 g day^{-1} (WHO, 2003).

The total percentage of the Free Fatty Acid (FFA) in each formulation is presented in Table 2. It was observed that as the level of substitution of BSG increased, fats extracted from the cookies increased from 2.120 to 2.310 g in 15% BSG supplement. Fat is a source of energy which is needed in cookies production, thus using BSG to supplement in flour for cookies would enhance its nutritional value. Maximum percentage free fatty acid of cookies should not be above 1.0% since too much of Free Fatty Acid (FFA) causes accumulation of fat and rancidity of fat in the body. There was observation that the percentage FFA (Table 2), for all the supplements are less than 1.0% which illustrate that the cookies produced corresponds to consumer's requirements

Table 3: Amino acid content of wheat flours in contrast with Brewery Spent Grains (0.61 mm and 1.5 mm)

Amino acid (g 100 g^{-1})	Golden penny flour	BSG (fine)	BSG (coarse)	Standard value for flour
Lysine	4.6	2.9	2.6	6.80
Histidine	2.0	2.4	2.3	2.77
Arginine	2.5	4.2	3.5	6.13
Aspartic	5.2	6.4	5.2	7.87
Threonine	3.2	3.7	3.1	5.03
Serine	4.7	4.3	4.0	5.08
Glutamic	33.5	21.4	20.7	11.34
Proline	5.0	10.3	13.3	11.25
Glycine	4.7	3.3	1.3	5.84
Alanine	4.5	6.3	6.1	6.34
Valine	5.0	5.2	5.6	6.30
Methione	0.4	1.9	2.4	2.48
Isoleucine	3.8	3.9	4.0	5.61
Leucine	7.6	10.7	10.9	9.65
Phenyalanine	5.2	5.4	6.0	6.26
Cystine	1.3	1.1	1.3	1.25
Total	93.2	93.4	92.3	100.00

Table 4: Physical and sensory evaluation of BSG blended cookies

Parameter	0%	3%	6%	9%	12%	15%
Width (cm)	4.55±0.61	4.68±0.52	4.72±0.66	4.80±0.23	4.81±0.49	4.85±0.22
Thickness (cm)	1.67±0.11	1.72±0.22	1.82±0.31	1.84±0.31	1.80±0.36	1.85±0.24
Spread Ratio	2.72a	2.72a	2.59b	2.61b	2.67a	2.62a
Appearance (10)	8	7	7	5	4	4
Taste (10)	8	8	7	4	3	3
Colour (10)	8	7	6	5	5	5
Flavor (10)	8	7	7	6	6	5
Overall Acceptability (%)	80	72.5	67.5	50	45	42.5

Values with different letter show significant difference at $p \leq 0.05$

(Banu *et al.*, 1985). In Table 3, the result of the amino acid content of BSG compared with wheat flour was indicated. The overall result showed that fine grain size (0.61 mm) of BSG has the same total amino content with the golden penny flour employed for the blending. This invariably justify the surface area principle that is needed for quality blending of the materials.

The physical and sensory evaluation values of the BSG supplemented cookies are presented in Table 4. The spread ratio of BSG supplemented cookies decreased significantly ($p \leq 0.05$) with increasing incorporation levels. The sensory evaluation of blended cookies signifies that supplements with 3% BSG had higher overall sensory scores than those supplemented with 6 to 15% BSG. The 6% value (67.5%) can still be tolerated by virtue of acceptability by the panelist, hence 3-6% BSG acceptance level based on organoleptic evaluation is suitable. However, above 6% addition level their sensory evaluation scores decreased significantly ($p \leq 0.05$). Brewery spent grain addition affected changes in colour; the intensity of which increased with increasing addition of BSG. These changes were from golden yellow (control) to yellow (3% BSG); brown (6% BSG); dark brown colouration (9-15% BSG). Summarily, the lightness of the cookies decreased as the percentage of BSG addition increased (Fig. 1, 2). The thickness and the width of cookies increased with increase level of BSG blending. The spread ratio decreased in all blends in comparison with the control and this is in accordance with the findings of Kamaljit *et al.* (2010) who

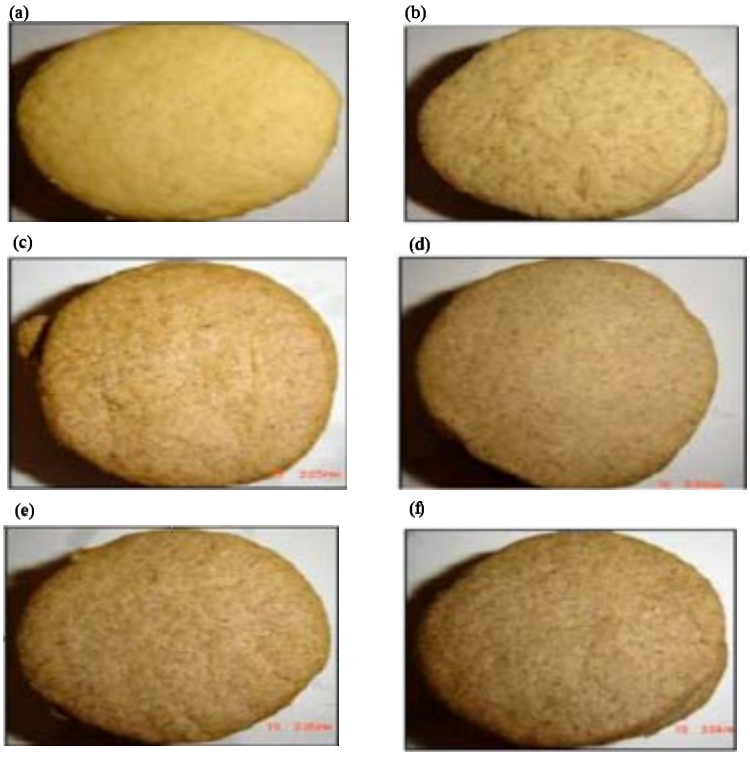

Fig. 1: Sample of BSG blended baked cookies (Magnification x100); (a) Control cookies, (b) 3% BSG blended cookies, (c) 6% BSG blended cookies, (d) 9% BSG blended cookies, (e) 12% BSG blended cookies and (f) 15% blended cookies

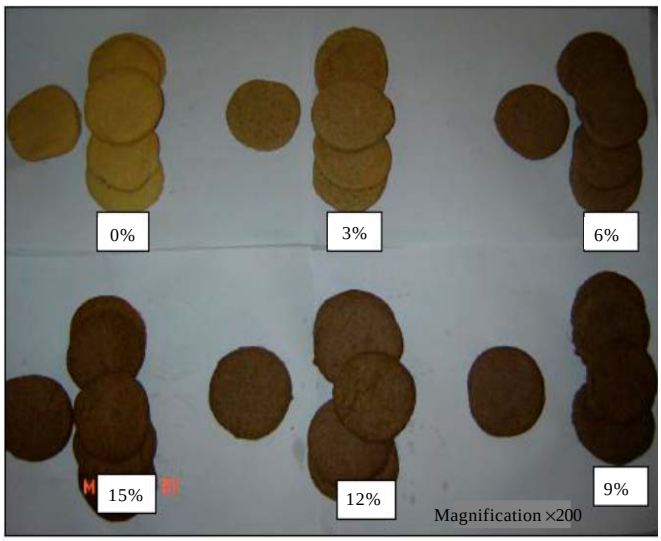

Fig. 2: BSG blended baked cookies showing products from 0 to 15% BSG (Magnification x200)

Table 5: Some trace metals in local and imported cookies in contrast with BSG blends cookies

Samples	Mn (%)	Fe (%)	Cu (%)	Zn (%)
Local				
Al-Bilah malted	0.09	0.15	0.02	0.08
Number one	0.06	0.15	0.01	0.06
Okin biscuit	0.04	0.09	0.01	0.05
Titan chocogem	0.05	0.09	0.01	0.04
Honey crunch	0.08	0.15	0.02	0.07
Milk spread	0.07	0.15	0.01	0.06
Imported				
Chocolate cream	0.08	0.15	0.01	0.08
Custard cream	0.03	0.15	0.01	0.04
Glucose biscuit	0.04	0.09	0.01	0.05
Cream cracker	0.04	0.09	0.01	0.04
BSG supplemented				
Control (0%)	0.04	0.09	0.01	0.05
Blend 1 (3%)	0.08	0.17	0.03	0.06
Blend 2 (6%)	0.09	0.15	0.04	0.04
Blend 3 (9%)	0.04	0.12	0.04	0.03
Blend 4 (12%)	0.08	0.16	0.04	0.05
Blend 5 (15%)	0.08	0.18	0.04	0.03

used pea flour as additives in assessment of cookies quality. An acceptable limit of 3% inclusion is then suggested to enhance quality product. Some trace metals (Mn, Cu, Fe and Zn) present in the local and imported cookies were compared with BSG supplemented cookies and the results presented in Table 5. The content of iron concentration was 0.18 in 15% BSG supplement in comparison with control (0% BSG) of 0.09%. This implies that BSG supplements in cookies increase the iron content of the product and would invariably contribute to the Packed Cell Volume (PCV) of the body since iron content has direct relationship with PCV and the heamoglobin content of the body system. There is also reduction of Zinc content in the BSG blended cookies as the concentration of the blend increases (0.05% for control to 0.03% for blend 5).

CONCLUSION

Cookies supplementation using Brewery Spent Grains has been carried out with a view of improving the dietary nutrition especially in developing countries. Cookies supplemented with 3 and 6% BSG could be seen to possess better cookies properties compared with those supplemented with 9 to 15% BSG. The overall sensory evaluation indicated 3-6% supplementation as the optimum value rated on a par with the control. The trace metals analysis in the BSG supplements further compared favourably with that of locally baked and imported cookies.

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