INCORPORATION OF SPENT GRAINS IN BREAD: SENSORY AND ORGANOLEPTIC PROPERTIES

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Abstract
The recent research efforts focused on utilization of agro-industrial wastes as functional ingredient in the formulation of diets that will not only meet the nutritional needs but also serve as functional food that will help to ameliorate some health challenges. Spent grains – an industrial waste product had been identified to possess some nutritional attributes and would meet the rising demand for low cost healthy foods. This study aimed at evaluating the organoleptic and sensory characteristics of bread in which spent grains were incorporated. Brewer's spent grains (ISG), red and white Sorghum spent grains (RSSG and WSSG) were incorporated as partial replacement (5, 10, and 15 %) for wheat flour, the composite bread were analyzed for colour, loaf shape, volume, crumb structure, crumb texture and taste, by twenty (20) semi-trained panelists who scored the parameters on 7 point hedonic scale. The results were subjected to analysis of variance and then compared to white bread (control). Results indicated that spent grains incorporated breads were reported to have intense darker colour compared to control bread and for all parameters, values obtained were significantly higher ($p < 0.05$) as the percentage incorporation of spent grains is increased. Breads with 5% level of spent grains were found acceptable for consumption by the evaluators. The study concluded that incorporation of spent grains could be an effective way to develop nutritious bread without jeopardizing desirable organoleptic properties and consumers' acceptability.

Keywords: functional food, spent grains, organoleptic properties

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INTRODUCTION

There is a growing interest toward the consumption of food products with added health benefit and not only of food that meet basic nutritional needs (Ng *et al.*, 2017). Cereal food has been identified as the main food staples of most nations however during processing a third of total weight of edible part of cereal foods produced for human consumption is lost or wasted (FAO, 2014). By-products formed during food processing that may not be directly considered as a useful resource by its producer could still be used to produce new and useful product (Chandraskaran *et al*., 2016). Most developing nations, Nigeria inclusive continually generate abundant quantities of Agro-industrial by-products such as industrial spent grains (ISG) generated as 'waste' from brewery process whose nutritional values are often under exploited. Industrial spent grains (ISG) generated as a by-product in brewery can conveniently serve as a starting material in many production spheres, especially where there is need to boost fiber contents (Lairon *et al*., 2005; Stojceska *et al*., 2008).

Consumption of foods high in dietary fiber provides many health benefits. Their frequent intake reduces risk of developing some diseases including coronary heart disease (Liu *et al*., 1999), certain gastrointestinal disorders (Petruzziello *et al.*, 2006), hypertension (Whelton *et al*., 2005), diabetes (Montonen *et al*., 2003), obesity (Lairon *et al*., 2005) and stroke (Murtaugh *et al*., 2003).

White bread is a daily staple in most Nigeria families. Unfortunately, bread is known to have a high glycemic index (in fact it is a reference for high glycemic index foods). This is because most wheat flour used in bread making is highly refined; and therefore most of its fiber had been lost. Several approach such as addition of fiber rich sources as ingredient to wheat bread in order to improve the nutritional

quality of bread have been introduced (Victor *et al*., 1993)

Ogunwale *et al* (2018) had earlier reported that the incorporation of 5 %, 10 %, 15 % spent grains into bread samples was observed to yield a dose dependent increase in fiber, crude protein, ash, available lysine and low glycemic index in these bread samples compared to the control bread. However, the study did not report the organoleptic quality of the bread at each level of spent grain substitutions. The major issue related to incorporating spent grains into food products is the effect on its acceptability, for example, its effect on colour, loaf volume, crumb structure and taste (Tsen 1982; Morad 1984) Therefore, the objectives of this study were to evaluate the sensory quality and organoleptic properties of spent grain incorporated bread, in order to ascertain the consumers' acceptability of the bread.

MATERIALS AND METHODS

Sample and sample preparation

Sorghum (*sorghum bicolor* L. Moench) grains (white and red species) were purchased from Odo Ogbe Market, Ile-Ife, the grains were handpicked to remove foreign particles and the spent grains were produced using the method of Ilori *et al.,* (1990), following the procedure schematically illustrated in **Figure 1**. Distilled water (54ml) was added to the grit and the mixture heated to 72^0C, rested at this temperature for 20 min, then boiled for 10 min and cooled to 64^0C. The uncooked thin mash, which contained the active enzymes, was also brought to 64^0C and mixed with the cooked grit. The mash mixture was allowed to rest at this temperature for 10, 20, 40, 60 or 80 min and then allowed to rest at 72 and 75^0C for 20 and 15 min respectively. The mash was filtered and the spent grain sparged with water (78^0C) three times. The clarified wort was made to 500ml. spent grains obtained were dried at 70^0C for 72 hours.

Samples of Industrial spent grains (ISG) were collected from International Breweries, Omi Asoro, Ilesa, Nigeria. The samples were dried and milled using a locally fabricated mill (Lawood Metals, Osogbo, Nigeria).

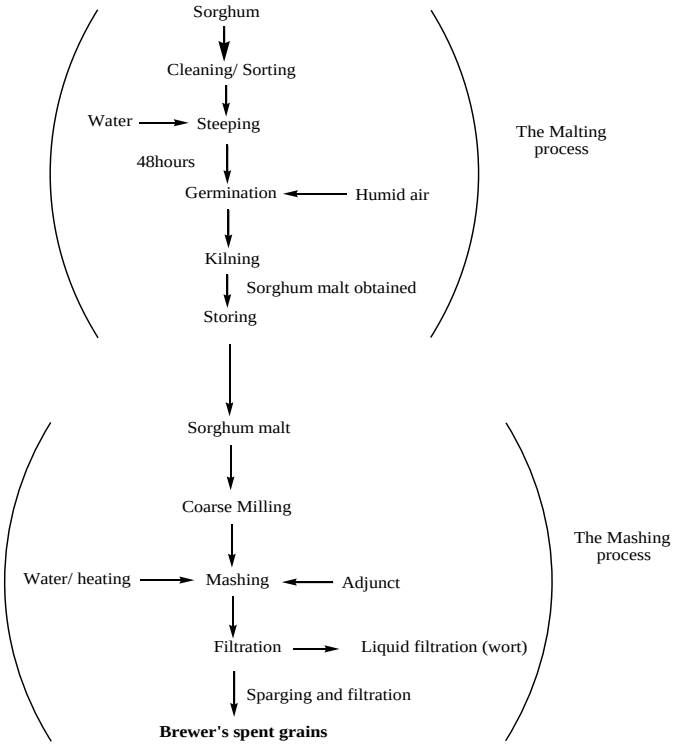

Figure 1 Schematic representation of the process to obtain spent grains from sorghum

The milled samples were sieved using a local sieve (aperture size of 0.6 mm) to remove the coarser fragments. All the samples were milled as one batch, mixed thoroughly and sub-samples randomly taken from different parts of each milled sample, mixed together and stored in the freezer until analyzed.

Baking of composite bread

The bread samples were produced at the bakery section of the Department of Food Science and Technology, Obafemi Awolowo University, Ile–Ife, Nigeria Wheat flour and spent grains (industrial spent grains, red sorghum spent grains and white spent grains) were each blended in the ratios of 95:5, 90:10, 85:15 with each sample weighed in triplicate using a weigh balance and a plastic spoon. The control bread sample was however made of 100 % wheat flour. The bread formulation and ingredients is presented in **Table 1.**

Sensory quality and Organoleptic Analysis

Sensory evaluation was carried out according to the method of Nupo *et al*(2013).Twenty (20) semi trained panelists and regular consumers of white bread were given the prepared bread for assessment.

Table 1 Ingredient formulation for spent grain bread and control

SAMPLES	Spent Grains (g)	Wheat Flour (g)	Sugar (g)	Margarine (g)	Yeast (g)	Salt (g)	Water (ml)
Control	0	1000	80	100	3	2.5	As required
5 % WSSG	50	950	80	100	3	2.5	As required
10 % WSSG	100	900	80	100	3	2.5	As required
15 % WSSG	150	850	80	100	3	2.5	As required
5 % ISG	50	950	80	100	3	2.5	As required
10 % ISG	100	900	80	100	3	2.5	As required
15 % ISG	150	850	80	100	3	2.5	As required
5 % RSSG	50	950	80	100	3	2.5	As required
10 % RSSG	100	900	80	100	3	2.5	As required
15 % RSSG	150	850	80	100	3	2.5	As required

The panelists were asked to score each sample on a 7 point Hedonic scale, 7 meant liked very much, while 1 meant disliked very much. The properties evaluated were shape, colour, taste, crumb texture crumb structure, inner core feel, and preference. Results were then subjected to one way analysis of variance (ANOVA) statistics using Turkey Kreamer version 10.1. The samples certified well for consumption by the taste panels constituted (Report unpublished) were taken for further analysis.

Statistical analysis

Data were reported as mean and standard deviation of triplicate analysis The Duncan's test is used to evaluate the significance of differences between mean values atp < 0.05. The results were analyzed with the 2009 XLStat software.

RESULTS AND DISCUSSION

Result of malting red and white sorghum varieties (Table 2) revealed that 7 Kg each of red and white sorghum grains produced 5.32 and 5.74 Kg malts respectively. This represents malting loss of 24 % and 18 % for red and white sorghum grains respectively.

This is consistent with results of Adewusi and Ilori (1992), where malting loss was reported to range between 10 and 30 %.The mashing of 5.32 Kg of red sorghum malt yielded 2.86 Kg red sorghum spent grains (RSSG), representing 46.24 % mashing loss, while mashing of 5.74Kg white sorghum malt produced 3.58 Kg of white sorghum spent grains, representing 37.63% mashing loss.

Table 2 Malting and mashing yield of Sorghum grains and malt

Sorghum	Grains used	Malt produced	% Malting loss
Red sorghum	7.0 kg	5.32 kg	24 %
White sorghum	7.0 kg	5.74 kg	18 %
Sorghum malt	**Malt used**	**Spent grains produced**	**Mashing loss**
Red sorghum malt	5.32 Kg	2.86 Kg	46.24 %
White sorghum malt	53.76 Kg	3.58 Kg	37.63 %

The sensory and organoleptic properties of spent grains incorporated bread were reported in Table 3. One of the important parameter that determines the quality and consumer acceptance of bread is the colour. The colour of composite breads ranged from 3.55 to 4.50, composite bread with 5% spent grains recorded the values that were not significantly different ($p < 0.05$) from control, where as those supplemented with 15% spent grains recorded significantly low values. As expected the result indicated that the colour of the composite bread becomes darker with increased quantity of incorporated spent grains (Figure 2 A-D). There are several reasons that could be responsible for intense dark colour of the composite bread compared with the control bread. Cereals are known to contain higher content of polyphenolic compounds. Polyphenols are substrate for enzymatic activities of polyphenol oxidase and peroxidase, whose actions could result in the formation of brown colour. This browning process is called enzymatic browning. Spent grains is often coloured and it could impact the flour colour when incorporated. On the other hand, baking process is another factor that could be responsible for colour development, non enzymatic browning (Maillard reaction), which is the reaction induced by heat and involves sugar and protein in the composite flour, the reaction could lead to the formation of brown pigment melanoidins which is responsible for the colouration especially of the bread crust. There is also the possibility of colouration due to cararamelization (Ames, 2009).

The results of the quality attributes of the composite bread were presented in Table 3. The results indicated that there was no significant difference ($p < 0.05$) in crumb taste, finger feel and Inner core taste between all white sorghum spent grains composite bread samples. The loaf size and shape of 5 %, 10 % and 15 % spent grain composite bread decreased as amount of spent grains in them is increased, likewise the attractiveness and fineness of these bread samples. The results obtained were consistent with those of other authors for instance, addition of oat β-glucan into wheat bread have been reported to lead to a higher crumb hardness accompanied by a decreased loaf volume and height (Blzakova *et al*, 2015) on the other hand, the incorporation of oat β-glucan into gluten free bread lead to a higher softness of bread crumb (Skeudi *et al.*, 2010). Texture is a general term in food that is determined by touch, though the use of machine could allow objectivity and guarantee quality of the bakery products. Firmness describes a product which presents moderate resistance to breaking during mastication (Ng *et al*., 2017), and is considered to be the function of freshness. Addition of spent grains increases the firmness and lead to a higher crumb hardness accompanied by decreased loaf volume and size.

Also spent grain incorporated bread have been reported to have lower moisture content compared to control (Ogunwale *et al*., 2018), the low moisture content may be attributed to high fiber content which could tightly bound to large amount of water, the water will not be ready available for dough inflation and gas cell stability as well as extension of gluten during baking process thus the bread crumb could have more shelf life. Bread generally go stale with time due to activities of microorganisms, the lower the moisture content the less their activity.

Other factor observed to affect the texture of the composite bread is the presence of high protein content of the spent grains; this has been reported to interfere with starch by disturbing the uniformity of starch structure during baking (Huttner *et al*., 2010) and hence may result in poor texture of the composite bread compared to control.

For easy comparison of five most preferred composite bread (5 % ISG, 5 % WSSG, 10 % WSSG, 10 % ISG and 5 % RSSG), their quality attributes was extracted from the results in Table 3 and then presented in Table 4. Also the photographs of the samples were shown in Figures 2 A – D.

Table 3. Results of Quality Analysis of Spent Grains Composite Bread and Control

Quality Attributes	Control	5%WSSG	10%WSSG	15%WSSG	5%RSSG	10%RSSG	15%RSSG	5%ISG	10%ISG	15% ISG
Crumb colour	6.30 ± 0.86	4.35 ± 1.93	4.45 ± 1.93	4.15 ± 1.69	3.95 ± 1.47	4.10 ± 1.80	3.55 ± 2.14	4.45 ± 1.47	4.50 ± 1.85	3.90 ± 1.69
Loaf volume	5.95 ± 1.39	5.60 ± 1.43	5.95 ± 1.15	4.8 ± 1.77	5.65 ± 1.50	4.55± 2.01	4.15 ±2.30	5.60 ± 1.10	4.95 ± 1.76	5.35 ±1.79
Loaf shape	6.00 ± 1.69	5.05 ± 1.64	4.85 ± 1.66	4.7 ± 1.56	4.75 ± 1.97	3.85 ± 1.66	3.55 ± 2.21	5.00 ± 1.03	4.30 ± 1.38	4.45 ± 1.91
Crumb structure	5.60 ± 1.73	4.65 ± 1.73	4.10 ± 1.77	4.15 ± 1.69	4.30 ± 1.72	3.20 ± 1.61	2.70 ± 1.70	4.60 ± 1.39	4.00 ± 1.76	4.00 ± 1.62
Crumb texture	5.90 ± 0.97	4.80 ± 1.47	3.95 ± 2.01	3.6 ± 1.50	4.55 ± 1.64	3.40 ± 1.85	2.6 ± 1.70	4.05 ± 1.40	4.10 ± 1.55	3.90 ± 1.59
Crumb taste	5.55 ± 1.73	4.35 ± 1.76	3.90 ± 2.02	3.11 ± 1.60	3.55 ± 1.88	2.90 ± 1.86	3.79 ± 1.90	4.25 ± 1.62	3.95 ± 1.76	3.00 ± 1.53
Finger feel	5.75 ± 1.16	4.35 ± 1.87	4.30 ± 1.92	3.21 ± 1.75	3.95 ± 1.70	3.90 ± 1.59	3.30 ± 2.13	4.70 ± 1.49	4.45 ± 1.91	3.60 ± 1.88
Inner core taste	5.75 ± 1.07	4.00 ± 1.49	3.70 ± 1.89	3.20 ± 1.92	3.50 ± 1.79	3.00 ± 1.69	2.60 ± 1.93	4.75 ± 1.68	3.80 ± 1.61	2.79 ± 1.55
Taste and quality	5.45 ± 1.61	4.10 ± 1.59	3.30 ± 1.79	2.74 ± 1.70	3.45 ± 1.50	2.85 ± 1.79	2.80 ± 2.22	4.45 ±1.85	3.95 ± 1.73	2.47 ± 1.74
Qualities mean ± SD	5.81 ± 0.26	4.58 ± 0.51	4.30 ± 0.74	3.74 ± 0.74	4.18 ± 0.72	3.53 ± 0.60	3.23 ± 0.57	4.65 ± 0.45	4.22 ± 0.36	3.72 ± 0.89

Note: Above values are mean of respondents' ratings on a 7 point hedonic scale ± SD Confidence interval – 95% level of significance-

Quality Attributes	Control	5 % ISG	10 % ISG	5 % WSSG	10 % WSSG	5%RSSG
Loaf volume	5.95 ± 1.39[a]	5.60 ± 1.10[a]	4.15 ± 2.30[b]	5.60 ± 1.43[a]	5.95 ± 1.15[a]	5.65 ± 1.50[a]
Loaf shape	6.00 ± 1.69[a]	5.00 ± 1.03[a]	3.55 ± 2.21[b]	5.05 ± 1.64[a]	4.85 ± 1.66[a]	4.75 ± 1.97[a]
Crumb structure	5.60 ± 1.73[a]	4.60 ± 1.39[a]	2.70 ± 1.70[b]	4.65 ± 1.73[a]	4.10 ± 1.77[a]	4.30 ± 1.72[a]
Crumb texture	5.90 ± 0.97[b]	4.05 ± 1.40[a]	2.6 ± 1.70[ac]	4.80 ± 1.47[a]	3.95 ± 2.01[a]	4.55 ± 1.64[a]
Crumb colour	6.30 ± 0.86[b]	4.45 ± 1.47[a]	3.55 ± 2.14[a]	4.35 ± 1.93[a]	4.45 ± 1.93[a]	3.95 ± 1.47[a]
Crumb taste	5.55 ± 1.73[ab]	4.25 ± 1.62[a]	3.79 ± 1.90[ad]	4.35 ± 1.76[a]	3.90 ± 2.02[a]	3.55 ± 1.88[ac]
Finger feel	5.75 ± 1.16[ab]	4.70 ± 1.49[a]	3.30 ± 2.13 [ac]	4.35 ± 1.87[a]	4.30 ± 1.92[a]	3.95 ± 1.70[ad]
Inner core taste	5.75 ± 1.07[ab]	4.75 ± 1.68[a]	2.60 ± 1.93 [ac]	4.00 ± 1.49[a]	3.70 ± 1.89[a]	3.50 ± 1.79[ad]
Taste and quality	5.45 ± 1.61[b]	4.45 ±1.85[a]	2.80 ± 2.22[a]	4.10 ± 1.59[a]	3.30 ± 1.79[a]	3.45 ± 1.50[a]
Qualities mean ± SD	5.81 ± 0.26[b]	4.65 ± 0.45[ac]	3.23 ± 0.57[ad]	4.58 ± 0.51[a]	4.30 ± 0.74[a]	4.18 ± 0.72[a]

Table 4: Quality attributes of five best composite bread base on Organoleptic Test

Note: Above values are mean of respondents' ratings on a 7 point hedonic scale ± SD Confidence interval – 95% level of significance-

The values were extracted from Table 3

Fig. 2a 5 %, 10 %, 15 % WSSG Composite Bread Samples

Fig. 2b 5 %, 10 %, 15 % ISG Composite Bread Samples

Fig. 2c 5 %, 10 %, 15 % RSSG Composite Bread Samples

Fig. 2d 5 % WSSG, 5 %RSSG, 5 % ISG Composite Bread Samples

Table 5 Correlation between Best 5 Spent Grains Composite Bread Samples and Control

Samples	10 % WSSG	5 % RSSG	5 % WSSG	Control	10 % ISG	5 % ISG
10 % WSSG	1					
5 % RSSG	0.891636	1				
5 % WSSG	0.88135	0.982139	1			
Control	0.568673	0.457154	0.382343	1		
10 % ISG	0.752311	0.466447	0.546856	0.368208	1	
5 % ISG	0.80819	0.665293	0.635558	0.236427	0.5437	1

The correlation analysis of the attributes among the bread samples were presented in Table 5.
The results revealed that there were positive correlations in the attributes between 5 % WSSG and 5 % RSSG, 5 % ISG and 5 % RSSG and between 5 % ISG and 5 % WSSG.
The findings from the consumer's point of view, bread substituted with 5 % spent grains was discovered to have the most acceptable sensory and organoleptical tributes and the order of preference is 5 % WSSG > 5 % ISG > 5 % RSSG, therefore 5% WSSG incorporated bread was the most acceptable to the consumers.

CONCLUSION

From the results of the sensory evaluation of the spent grain bread, samples having 5 % ISG, 5 % WSSG and 10 % WSSG are adjudged the best of all spent grains incorporated bread samples analyzed in this study. It became evident that incorporation of spent grains into wheat bread at moderate level does not significantly affect sensory and organoleptic qualities while it helps enhanced the nutritional quality of the bread. For commercial production of spent grain bread, it is better to ascertain the level of incorporation that will be acceptable to consumers of different ethnic backgrounds.
Further research should be tailored towards production of spent grains incorporated biscuits, meat pie, rolls, doughnut, chin- chin, cheese balls, etc. This could help provide varieties of foods with functional properties.

Conflict of Interest: There is no conflict of interest

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Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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