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Production and evaluation of specialty bread from sprouted mixed-grains

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Specialty bread was made from sprouted mixed-grains using adaptable technology. The grains were sprouted at atmospheric conditions (30°C, 75% RH) over a period of 6, 12, 18 and 24 h. Paste obtained from the sprouts was mixed at different ratio together with other ingredients to obtain five bread samples. Nutritional, functional and sensory properties of the resulting loaves were carried out using standard analytical methods. Conventional bread served as a control. Sprouting improved ($p<0.05$) the nutritional and functional properties of mixed-grain bread. Dietary fiber was 5.36 and 20.91 g/100 g^{-1}, acidity 1.23 and 5.73% and protein energy 29.13 and 108.72 KJg^{-1} for control and 24 h sprouted mixed-grain bread, respectively. The developed bread may qualify as a health food judging from the data generated in this research. The breads were equally acceptable to the panel judges. Twenty-four hour sprouting is considered best for production of mixed-grain bread.

Key words: Bread, consumer, mixed grains, sprouting.

INTRODUCTION

People all over the world depend on bread for their regular and convenient source of energy and other nutrients. In fact, bread has become a food staple in many countries of the world including Nigeria. Judging from the culinary role of bread, it is necessary that bread is not only safe but nutrient-dense. Unfortunately conventional bread in Nigeria and some other parts of the world is low in important nutrients such as dietary fiber and protein (Jideani and Onwubali, 2009; Edema et al., 2005). A high proportion of bread is baked with refined (white) flour and using a technology that does not permit full generation of metabolites in the dough (AOAC, 1990; Ostman et al., 2005). Ancient breads were prepared with coarse milled flour and using a sour-dough process (Ostman et al., 2005). Increased incidence of some diseases including diabetes, cancer, celiac disease, intestinal dysbiosis, constipation, heart-burn, decreased pancreatic function and sensitized intestinal tract have been associated with diets consisting of refined foods such as white bread. There is enough evidence that these diseases result directly or indirectly from the consumption of wheat (gluten) in bread (Moroni et al., 2009; Dewettinck et al., 2008; Crockett et al., 2011; http://www.foodforlife.com). Some people avoid bread in order to remain healthy, while some uninformed individuals continue to suffer diverse ailments associated with bread meal without knowing the root cause of their ill-health.

Over the years, man has searched for healthy bread and has come up with many types of bread namely white bread, brown bread, whole-meal bread, whole- germ bread, granary bread and composite-flour breads.

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Table 1. Sprouting scheme for selected grains.

Total time of sprouting (h)	Steps involved in sprouting
6	No sprouting, just soaked for 6 h and grind
12	6 h soaking + 30 min initial air-rest + 5 h soaking + 30 min final air-rest
18	6 h soaking + 1 h initial air-rest + 5 h soaking + 5 h soaking + 1 h final air-rest
24	6 h soaking + 1½ h initial air-rest + 5 h soaking + 5 h soaking + 5 h soaking + 1½ h final air-rest

One of the latest bread products is the sprouted grain bread that is fondly called *Ezekiel* bread (Brenna and Cleary, 2005). *Ezekiel* bread is made from mixtures of sprouted grains and legumes (Brenna and Cleary, 2005) and is claimed to be richer in protein and vitamins than the conventional white bread (Kent, 1984). As reported by Shipard (2005), bread from sprouted mixed grains could contain all the nine essential amino acids and is low in fat, has no trans-fat or cholesterol and is relatively low in sodium. Shipard (2005) claimed that sprouting of grains will take care of the anti-nutritional factors and also circumvent the use of additives and chemicals to achieve improved nutrient content. This according to him is because during germination and sprouting of grains and seeds, many enzyme inhibitors are effectively neutralized, whilst at the same time, the activity of beneficial plant digestive enzymes is greatly enhanced. The digestible energy, bio-available vitamins, minerals, amino acids, proteins and phytochemicals necessary for a germinating plant to grow are also essential for human health (Moroni et al., 2009; http://www.foodforlife.com). The objectives of this present research are to: (a) investigate the potential of sprouting locally available grains/legume for use in preparation of specialty bread (b) to determine the functional and nutritional content of the sprouted mixed-grain bread and (c) to determine the consumer acceptability of the sprouted mixed-grain bread.

MATERIALS AND METHODS

All the consumables excluding chemicals were bought from a local market in Owerri, Imo State, Nigeria. The grain samples were identified at the Crop Science Laboratory, Federal University of Technology, Owerri, Nigeria. The grains included wheat (*Triticum aestivum*), maize (*Zea mays*), sorghum (*Sorghum vulgare*), millet (*Eleusine caracana*), lentil (*Digitaria excelis staph)*, soybean (*Glycine max*) and sesame seed (Sesamum *indiacum L).* They were chosen from locally available cereals/legumes with full consideration to ease of sprouting. Chemicals were obtained from Food Science and Technology Laboratory, Federal University of Technology, Owerri, Nigeria.

Sprout production

The method of Eneje and Orji (2002) with slight modifications was used for the sprouting of the grains. The grains were sprouted under ambient conditions (30°C, 75% RH) for 6, 12, 18 and 24 h before milling. The period of sprouting was decided following a trial sprouting experiment with the various grains. Half a kilogram of each grain (maize, sorghum, millet, wheat, sesame seed, lentil and soybean) was used for each sprouting period. The scheme for the sprouting experiment is illustrated in Table 1. The grains were sorted and washed with ethanol/water (70/30 v/v) to remove stones and dirt before sprouting. Then, the seeds were first soaked in water (50/50 w/w) for 30 min to help bring out the seeds out of quiescence (Glennie et al., 1983). Soaking was followed by draining and rinsing at regular intervals until the seeds sprouted. The sprouted grains were milled using a manual attrition milling machine (corona corn mill, manufactured by YCIA, S.A. Colombia). Samples of the sprouted grains are shown in Plate 1a.

Product formulation

The combinations of the sprouted grain dough were based on nutrient composition of the grains. The quantity of other ingredients namely honey (20 ml), salt (0.01), eggwhite (22 ml), yeast (0.3 g) and water (10 ml) per 100 g of the dough remained constant. Production panel judges (PPJ) were used for the trial testing of samples to select the best four formulations as shown in Table 2.

Production of sprouted mixed-grain bread

The production of sprouted mixed-grain bread was according to the Biblical Ezekiel, chapter four verse nine, cited from Brenna and Cleary (2005). One hundred grams of paste was weighed out from the four batches of mixed paste generated from the sprouting scheme, and was mixed with the other ingredients. Yeast was dissolved in 10 ml of water (40°C) and 20 ml of honey, and was allowed for 10 min at 45°C for yeast reaction to take place. After 10 min, the dissolved yeast, honey, salt and egg were mixed with the paste and stirred continuously for 5 min. The paste was allowed to ferment for another 10 min at 45°C and to proof before it was placed in an aluminium baking pan and was baked at 250 to 300°C for 45 min. A stove heated sand-box was used as the baking oven. The pictorial view of the whole process is shown in Plate 1a to d.

Analysis of bread samples

Nutritional composition

The determination of proximate composition (moisture, carbohydrate, crude protein, fat and ash content) of the bread samples was carried out according to the method of Association of Official Analytical Chemists (1990). Energy was calculated using Atwater formula (FAO, 1973) using values of 9, 4, and 3.8 kcalg^{-1} for fat, protein and carbohydrate, respectively. pH and acidity of the samples were determined using the method described by AOAC

Plate 1. A to d: Pictorial view of Ezekiel bread process methods.

(1995). The total dietary fiber was determined according to the method of the AOAC (1995) with slight modifications. One gram of each sample (dry basis) was put into a beaker, and 10 ml of distilled water was added and the mixture was stirred. The beaker with the sample was then put into a water bath containing boiling water and was gelatinized over a hot plate while stirring continuously. When the sample had gelatinized, the pH of the gelatinized sample was adjusted to 6.0. Termamyl was added and incubated at 100°C for 30 min. This was followed by protease incubation and lastly by amyloglucosidase enzyme incubation at 60°C for 30 min. At the end of amyloglucosidase incubation, the sample was precipitated with four volumes of ethanol and acetone. The sample was then dried in a drying oven at 100°C. Total dietary fiber was calculated as:

$$\text{Total dietary fiber} = \frac{\text{Weight of residue after drying}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of functional properties

Water absorption capacity (WAC) and foaming capacity (FC) were determined by a combination of the AOAC (1990) methods. For WAC, 2 g of each dough sample was dispersed in 20 ml of distilled water, stirred using a magnetic stirrer at 1000 rpm and centrifuged at 4600 rpm for 30 min. The supernatant was carefully decanted. The WAC of the protein was expressed as percentage of water bound. For FC determination, 5 g of dough samples was dispersed in 20 ml of distilled water, homogenized using a metabolic shaker for 30 min and centrifuged (Hettich Universal Bayern, Germany) at 3000 rpm for 15 min at 30°C. The supernatant obtained was mixed for 5 min using a magnetic stirrer at 1200 rpm, poured into a 100 ml measuring cylinder and its volume was immediately noted. Foaming capacity (FC) was then expressed using the equation:

$$FC = \frac{\text{Vol. of foam after blending - Vol. of foam befiire blending}}{\text{Vol. of foam before blending}} \times \frac{100}{1}$$

Sensory evaluation

Sensory evaluation of the bread samples was carried out using 20-member panel selected randomly from the university community. The panelists were instructed to rate the samples in terms of aroma, texture, taste, crust colour, crumb colour and overall acceptability based on 9-point hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely). The panelists worked under controlled condition to avoid biased results.

Experimental design and statistical analysis

This research is a two factor experiment in a randomized complete block design (RCBD) with 4 sprouting periods and 5 grain proportions as sources of variation. Therefore, the experimental design is thus, 4 x 5 factorial designs.

Table 2. Formulations for preparation of sprouted mixed-grain bread.

Product code	Grains (g 100 g^{-1})							Total weight
	Maize	Soybean	Lentil	Sesame	Sorghum	Millet	Wheat	
PD1	0	0	0	0	0	0	100	100
PD2	20	10	10	10	10	20	20	100
PD3	5	10	5	10	5	5	60	100
PD4	10	10	10	10	10	10	40	100
PD5	Control (unsprouted commercial white wheat bread)							

RESULTS

Nutritional composition of sprouted mixed-grain bread

The effect of sprouting on proximate composition of mixed grain bread is shown in Table 3. There was a steady increase in protein content, protein energy and dietary fiber content of bread samples as sprouting period increased while fat, energy value and carbohydrate content decreased. Protein increased from 6.42 to 16.55 gg^{-1}, protein energy from 43.76 to 94.03 KJg^{-1}, and total dietary fiber from 8.33 to 21.65 g 100 g^{-1} for unsprouted and 24 h sprouted mixed-grain bread, respectively. There were variations in proximate composition of the bread samples as a result of the grain proportion (Table 4). Expectedly, samples with low wheat inclusion had low carbohydrate content. Generally, control sample had more carbohydrate content but low protein energy and dietary fiber than the specialty bread. Bread samples made from sprouted wheat grain (PD1) had the lowest fat content of 6.01 g/100 g, while the commercial loaf had 9.53 g/100 g. Higher ($p = 0.05$) moisture content (14.15 to 17.01 g/100 g) occurred in sprouted mixed-grain bread samples when compared with the commercial loaf (9.49 g/100 g). Interaction of sprouting period and formulation showed that 24 h sprouting and uniform (even) distribution (except for wheat) of the grains gives bread better parameters (Table 5). This explains why sample PD4 had better nutritional parameters than others.

pH and acidity of bread samples

The effects of sprouting period and grain proportions on pH and acidity of sprouted specialty bread are shown in Table 6. The average acidity of bread increased ($P < 0.05$) from 3.59 to 4.67% as a result of sprouting, while the values for pH decreased from 5.44 to 5.13.

Functional properties of mixed grain bread

Water binding capacity (WBC) decreased with sprouting period, while foaming capacity increased (Table 3). Commercial bread sample had higher water absorption capacity (WAC) when compared with the specialty breads, but their foaming capacity measured up with the specialty bread samples.

Product acceptability

The result of one-way analysis of variance apparently showed that sprouting up to 24 h produced bread with better sensory qualities (Table 7). Bread samples with closer distribution of the grain exhibited better sensory parameters than others. It was observed that mixed-grain bread (PD4^{24}) sprouted for 24 h with grain proportions of maize 10 g; soybean 10 g; lentil 10 g; sesame 10 g; sorghum 10 g; millet 10 g and wheat 40 g compared more favourably with the commercial bread in all the sensory parameters tested.

DISCUSSION

The increase in protein content following grain sprouting could be as a result of solubilization of nitrogen part of protein/amino acids, making them more available for digestion. Increase in dietary fiber contents as observed in this work could be an indication of the hydrolysis of the complex starch molecules during sprouting and the decrease in fat content could be as a result of hydrolysis of triacylglycerols to glycerol and constituent fatty acids, and part of the lipids contained inside the germ of the grains being used for germination. The observed decrease in carbohydrate content and energy value of specialty bread is in agreement with previous report of Akpapunam and Dedeh (1995) that at 24 h sprouting, the growth process and metabolic activities suspended at maturation, dehydration and storage of the grain resumed under favourable conditions. These observations also tally with the report of Chavan and Kadam (1989) who stated that the desirable nutritional changes (such as increase in protein and dietary fiber content) that occur during sprouting are mainly due to the breakdown of complex compounds into simpler form. Okun et al. (1980) found that in sprouted wheat at 30°C the free amino acids did not change significantly for two days of sprouting but significant increases in free amino acids were noticed at 40°C for 24 to 48 h of sprouting. Protein synthesis has

Table 3. Effect of sprouting period on nutrient and functional properties of mixed grain bread[a]

SP	Proximate (g 100 g^{-1}DM)					TDF	Energy (KJg^{-1} DM)		PEP	Functional properties	
	Carb	Protein	Fat	Ash	Moisture	(g 100 g^{-1})	Total	Protein		WBC (g g^{-1})	FC (g g^{-1})
6 h	60.17±13.01	6.42±1.25	9.01±2.22	20.50±4.22	13.48±4.41	8.33±4.31	1452.04	43.76	0.0303	4.99 ±0.55	2.81±1.08
12 h	44.51±10.71	14.10±2.21	8.18±1.28	20.82±1.22	16.57 ±5.21	15.07±4.65	1323.50	68.30	0.0532	4.49± 0.51	2.96±1.07
18 h	39.04±12.00	15.51±2.05	7.16±2.27	21.62±1.32	15.01 ±4.30	18.16±5.52	1210.49	82.77	0.0721	3.19± 0.52	4.81±0.9
24 h	37.17±13.14	16.55±1.15	2.85±3.21	15.78±2.21	17.87 ±5.47	21.65±7.09	1148.62	94.03	0.0879	2.43± 0.99	4.91±0.6
Control	67.67±7.21	5.44±0.5	9.55±0.22	11.13±0.51	9.49±1.51	5.36±0.4	1452.79	24.93	0.0012	4.11± 0.05	4.19±0.11
LSD	1.03	0.09	0.35	0.21	1.04	0.57	121.12	1.96	0.024	1.21	1.32

[a]SP = sprouting period; Carb = carbohydrate; TDF = total dietary fiber; Control, commercial white bread; WBC, water binding capacity; FC, foaming capacity; PEP, proportion of total energy derived from protein; LSD, least significant difference; DM, dry matter.

Table 4. Effect of grain formulation on nutrient and functional properties of mixed-grain bread[a].

Products	Proximate (g 100 g^{-1} DM)					TDF	Energy (KJg^{-1}DM)		PEP	Functional properties	
	Carb	Protein	Fat	Ash	Moisture	(g 100 g^{-1})	Total	Protein		WBC (g g^{-1})	FC (g g^{-1})
PD1	41.99±1.9	14.67±1.5	6.01±3.1	20.48±2.1	17.01±1.5	16.69±3.7	1226.03	81.33	0.0683	3.46 ± 1.14	4.70± 0.97
PD2	38.76±1.2	15.66±1.1	7.33±4.1	18.93±1.4	16.16±1.5	18.58±4.5	1229.91	84.30	0.0724	3.29 ± 1.51	4.63± 1.49
PD3	40.37±9.5	15.07±1.3	6.83±4.7	18.72±3.1	16.06±1.5	19.53±1.5	1208.65	81.33	0.0695	3.22± 1.56	4.13± 1.99
PD4	39.93±3.5	16.17±1.4	6.22±4.5	18.47±3.5	16.15±1.5	18.36±3.5	1214.67	87.29	0.0753	2.76± 1.05	3.49± 1.48
Control	67.67±7.2	5.44±0.5	9.55±0.2	11.13±0.5	9.49±1.5	5.36±0.4	1539.98	29.13	0.0189	4.11 ± 0.05	4.19± 0.01
LSD	1.03	0.09	0.35	0.21	1.04	0.57	135.28	18.63	0.022	1.21	1.71

*SP = Sprouting period; Carb= carbohydrate; TDF = total dietary fiber; WBC, water binding capacity; FC, foaming capacity; PEP, proportion of total energy derived from protein; LSD, least significant difference; DM, dry matter; Control, commercial white bread. Decoding of product code is as shown in Table 2.

been proven to be one of the essential processes associated with sprouting (Adeyemo et al., 1992; Wang and Fields, 1978). An increase in proteolytic activity during sprouting is desirable for nutritional improvement of cereals because it leads to hydrolysis of prolamins and liberates amino acids such as glutamic, and conversion of storage proteins into albumins and globulins, and also proline are converted to limiting amino acids such as lysine. Cuddeford (1989) stated that crude fibre, a major constituent of cell walls, increases both in percentage and real terms, with the synthesis of structural carbohydrates such as cellulose and hemicelluloses. The decrease in ash content only on the 24 h sprouting might be as a result of leaching out of minerals into the soaking medium (Shipard, 2005; Cuddeford, 1989) otherwise ash content increased with sprouting. Shipard (2005) claims that when seeds are sprouted, minerals chelate or merge with protein in a way that increases their function, and sprouts are considered a significant source (plant) of digestive enzymes. Solubilization of protein, increase in dietary fiber and decrease in fat and carbohydrate content of *Ezekiel* bread may explain the increased digestibility of the bread as reported by Brenna and Cleary (2005) and Dewettinck et al. (2008). According to Akpapunam and Dedeh (1995), improvements in amino acid composition, B-group vitamins, sugars, protein and starch digestibility and decrease in phytates and protease inhibitors are the metabolic effects of sprouting process. The result of the proximate

Table 5. Interaction of sprouting and formulation on nutrient and functional properties of mixed-grain bread[a].

SP (h)	PDT	Proximate (g 100 g^{-1} DM)					TDF (g 100 g^{-1})	Energy (KJg^{-1} DM)		PEP	Functional properties	
		Carb	Protein	Fat	Ash	Moisture		Total	Protein		WBC (gg^{-1})	FC (gg^{-1})
6	PD1	60.24	9.05	9.85	20.44	12.04	7.15	1478.73	42.77	0.0289	4.91	3.67
6	PD2	55.21	10.18	9.91	21.32	11.22	8.33	1419.98	50.10	0.0353	4.83	2.66
6	PD3	56.88	9.45	9.45	19.45	13.52	7.45	1416.99	46.61	0.0329	4.87	2.51
6	PD4	50.14	10.11	11.77	20.03	14.01	10.05	1408.25	50.17	0.0356	4.71	3.51
Mean		55.62^{a}	9.70	10.25^{a}	20.31^{a}	12.70	8.25	1430.99^{a}	47.41	0.0332	4.83^{a}	2.59
12	PD1	43.63	13.06	9.71	21.17	18.98	12.58	1268.46	72.02	0.0568	4.76	3.55
12	PD2	38.64	15.17	11.90	18.69	13.92	13.65	1337.43	79.57	0.0595	4.92	2.98
12	PD3	37.53	13.43	9.40	19.90	15.65	19.14	1170.61	81.40	0.0695	4.90	1.92
12	PD4	36.35	14.75	12.19	20.33	17.78	14.94	1301.02	79.38	0.0610	3.80	1.85
Mean		39.04^{b}	14.10	$10.8^{a}0$	$20.0^{a}2$	16.58^{a}	15.08	1269.38	78.09	0.0617	4.60^{a}	2.58
18	PD1	39.82	14.44	5.80	22.46	16.88	16.38	1112.24	90.68	0.0815	3.05	4.50
18	PD2	38.60	14.78	7.64	20.68	11.93	18.07	1159.22	89.06	0.0768	3.01	5.90
18	PD3	36.89	16.88	10.52	21.89	16.08	20.79	1155.82	102.04	0.0883	2.98	5.80
18	PD4	35.27	15.95	4.68	21.48	15.17	17.41	1085.15	102.97	0.0949	2.80	3.92
Mean		37.65	15.51	7.16	21.63^{a}	15.02	18.16	1128.11	96.19	0.0854	2.96	5.03^{a}
24	PD1	40.11	16.51	2.46	17.82	19.05	21.10	1044.71	110.66	0.1059	2.58	5.76
24	PD2	37.02	15.03	2.56	17.42	17.60	17.41	1003.02	118.47	0.1181	1.96	5.01
24	PD3	37.22	17.88	2.59	14.36	16.88	21.10	1166.44	89.13	0.0764	1.80	4.69
24	PD4	34.51	17.79	1.79	13.52	17.98	24.01	1064.28	116.63	0.1096	1.70	4.72
Mean		37.22	16.80^{a}	2.35	15.78	17.88^{a}	20.91^{a}	1069.61	108.72^{a}	0.1025^{a}	2.01	5.05^{a}
Commercial		67.67	5.44	9.55	11.13	9.49	5.36	1539.98	29.13	0.0189	4.10	4.19

[a]SP = Sprouting period; ; Carb carbohydrate; TDF = total dietary fiber; WBC, water binding capacity; FC, foaming capacity; PEP, proportion of total energy derived from protein; Control, commercial white bread. Decoding of product code is as shown on Table 2.

composition of the bread samples implies that the commercial bread will offer more calories but fewer nutrients. High dietary fibre is considered an advantage since dietary fibre reduces bowel problems including constipation, which is basic to numerous diseases such as appendicitis, diabetes, large bowel cancer, obesity and gallstone (Moroni et al., 2009; Dewettinck et al., 2008; Onyeka, 2007). The dietary status of the conventional bread as observed in this research is alarming, and calls for the attention of health stakeholders. This is particularly important as bread has become one of the staple foods in Nigeria and for the fact that low intake of dietary fiber is associated with a number of ailments (Moroni et al., 2009; Onyeka, 2007; Montonen et al., 2003; FAO/WHO, 1997). Since sprouted grain bread had low fat content, an increase in the fat content of the dough through the use of grains rich in oil may be considered. The commercial bread had high fat content because the manufactures normally use shortening as part of the major ingredients. The high residual moisture in the specialty bread could explain the short shelf-life (≤24 h) noticed in the present specialty bread samples. According to Kuye and Sanni (1999), high residual moisture content is a

Table 6. Interaction of sprouting and formulation on pH and acidity of mixed grain bread.

Products	Period of sprouting in hours							
	6 h		12 h		18 h		24 h	
	pH	Acidity	pH	Acidity	pH	Acidity	pH	Acidity
PD1	5.18	4.01	5.01	4.64	5.33	5.18	4.95	5.43
PD2	5.15	4.12	5.15	4.72	4.97	5.19	4.62	5.46
PD3	5.00	4.24	4.99	4.84	4.89	5.29	4.74	5.54
PD4	5.04	4.41	4.84	4.91	4.71	5.30	4.56	5.73
Control	6.85	1.21	6.85	1.21	6.85	1.21	6.85	1.21
Mean	5.44	3.59	5.37	4.06	5.35	4.43	5.14	4.67

LSD (p<0.05); pH = 0.21; acidity = 0.33. Decoding of product code is as shown in Table 2.

Table 7. Comparative sensory evaluation scores (1 to 9 scale) for mixed-grain specialty bread and white wheat bread (control)[a].

Parameter	Bread samples				
	Control	PD1[24]	PD2[24]	PD3[24]	PD4[24]
Aroma	$8.50^{a}\pm0.60$	$7.20^{ab}\pm0.02$	$6.45^{b}\pm0.75$	$6.80^{b}\pm0.89$	$7.55^{ab}\pm0.60$
Texture	$8.50^{a}\pm0.68$	$6.80^{b}\pm0.83$	$6.70^{b}\pm0.57$	$6.85^{b}\pm0.81$	$7.45^{ab}\pm0.60$
Taste	$8.45^{a}\pm0.51$	$6.75^{b}\pm0.78$	$6.45^{b}\pm0.68$	$6.90^{ab}\pm0.78$	$7.45^{ab}\pm0.60$
Crust colour	$8.00^{a}\pm0.50$	$6.40^{b}\pm0.59$	$6.85^{ab}\pm0.81$	$6.95^{ab}\pm0.68$	$7.20^{ab}\pm0.69$
Crum colour	$8.00^{a}\pm0.50$	$6.90^{ab}\pm0.91$	$7.05^{ab}\pm0.82$	$7.25^{ab}\pm0.71$	$8.50^{a}\pm0.51$
Acceptability	$8.00^{a}\pm0.50$	$6.00^{c}\pm0.72$	$6.70^{b}\pm0.82$	$7.15^{ba}\pm0.47$	$7.40^{ab}\pm0.50$

[a]Mean scores with the same letter in a row do not differ significantly (p $\leq$0.05) from each other. Only bread from 24 h sprouted grains were used for sensory evaluation because production panel judges (PPJ) scored them higher than others; Control, commercial white bread. Decoding of product code is as shown in Table 2.

disadvantage in that microbial proliferation is enhanced and storage life is reduced. However, moisture content alone cannot be responsible for the relatively short shelf-life of the samples. The activities of the inherent enzymes could also be part of the reason.

The results for pH and acidity obtained in this research are in agreement with the finding of Chavan and Kadam (1989) who stated that increase in sprouting period decreases pH of bread. Unsprouted (low acid) wheat is among a small number of foods that contain measurable amounts of oxalate and when oxalates become too concentrated in body fluids, they crystallize, complex with calcium, and cause health problems (Chandrasheka and Sadyanaranyana, 2006).

Thus, commercial bread from unsprouted wheat which has low acidity (1.21%) and high pH (6.85) may not be good for excellent body health. As reported by Dewettinck et al. (2008), sprouted grains become more alkaline in the process of sprouting, changing it from an acid forming food, pre soaked, to an alkaline forming food source, post soaked. Increase in acidity (organic acid) is an advantage because such foods are alkaline forming which help the body use less energy in its never ending battle to maintain acid-base (pH) balance (Brenna and Cleary, 2005; Ostman et al., 2005). Moreover, foods high in organic acids tend to offer good glycemic response and control of satiety (Ostman et al., 2005; Yoom et al., 1983).

The decrease in WBC following sprouting is because of the disappearance of starch due to hydrolysis. The increased foaming capacity in the specialty bread samples may be attributed to the increased protein content especially albumin and globulins during grain sprouting (Okaka and Potter, 1979; Chavan and Kadam, 1989; Fennema's Food Chemistry, 2008). The foaming capacity observed in the commercial breads could be because the breads were prepared using chemical emulsifiers. The functional properties of the specialty bread samples might have been enhanced by the egg (22 ml) and honey (20 ml) added during processing.

In the findings of Brenna and Cleary (2005), an increase in sprouting period, from 12 to 48 h, improved the colour, taste, aroma and texture of bread. A complementary role of each grain might have impacted positively on the sensory attributes of the bread samples. This is similar to the observation of Olaoye et al. (1983) that maize, sorghum, soybean and wheat grains impacted acceptable sensory properties on bread.

Conclusions

This study has indicated that specialty bread could be prepared from a mixture of sprouted grains. Inclusion of grains other than wheat helped to improve the nutritional value of bread. Functional, nutritional as well as acceptability of the specialty bread was achieved through sprouting of the grains. The combination of cereals and legumes guaranteed proper balance of amino acids to provide a complete protein. However, long-term study is required to extend and explore the beneficial metabolic effects of using mixed grains for bread production. The acceptability of the product by about 82% of the judges shows that the product would be easily accepted by consumers. Therefore, this bread could be utilized to improve the nutritional status of people, especially the aged since the product has low sugar content and a claim of high digestibility (Dewettinck et al., 2008). It would be particularly good in developing countries where consumption of white bread is significant. And the technology used in this research will not be difficult even at local (village) set-up. Grain sprouting is a viable option towards improving nutritional value of locally made bread.

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