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Quality assessment of weaning food produced from fermented cereal-legume blends using starters

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Abstract

Infant weaning food was produced from sorghum - cowpea blends fermented with four combinations of starter organisms (*Lactobacillus plantarum* and *Saccharomyces cerevisiae* (AB1), *Lactobacillus plantarum* and *Pediococcus acidilactici* (AB2), *Pediococcus acidilactici* and *Saccharomyces cerevisiae* (AB3), and *Lactobacillus plantarum*, *Pediococcus acidilactici* and *Saccharomyces cerevisiae* (AB4)) for 72 h and sampled 12 hourly for pH, titrable acidity, proximate analysis, antinutritional factors and sensory quality attributes. There was a steady drop in pH with corresponding increase in titratable acidity throughout the fermentation period in all the combinations. The weaning food produced using the combination of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* (AB1) had the highest (26.50%) protein content and the least antinutrient content while Sample AB4 showed the highest value of antinutrients. Porridges made from the formulated blends were rated above average in terms of over-all acceptability. However, samples fermented with the three combinations (AB4) had the highest preference rating. On the whole, fermentation of sorghum-cowpea formulated weaning blends with combinations of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* (AB1) had the highest nutritional contents and the least antinutrients and may be recommended for good quality weaning food.

Introduction

Two major problem exist in the World, starvation (or under-nutrition where there is insufficient food or insufficient economic means to provide the necessary food) and obesity (from over consumption of food in the wealthy, developed world) (Steinkraus, 1994). In Nigeria, the usual first weaning food is called pap, akamu, ogi, or koko and is made from maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum* spp.) (King and Ashworth, 1987). After the successful introduction of cereal gruel, other staple foods in the family menu are given to the child. These foods include yam (*Dioscorea* spp.), rice (*Oryza sativa*), gari (fermented cassava grits), and cocoyam (*Xanthosoma sagittifolium*), which may be eaten with sauce or soup (Naismith, 1973). Like other cereal products, Sorghum products have poor nutritional value. This is due to their deficiency in lysine, threonine and typtophan and to the presence of anti-nutritional factors (Salunkhe *et al*., 1977) such as tannins and phytates that interact with proteins, vitamins and minerals, thus restricting their bio-availability (Harland and Oberleas, 1986; Bhise *et al*., 1988).

Since cereals form the primary basis for most of the traditional weaning foods in West Africa there is therefore the need to supplement it with a very high protein crop to be suitable as weaning foods. Hence, the need for formulation of cereal-legume blends in the production of porridges for children of weaning age. The potential of fermented foods for reducing or alleviating food related factors of malnutrition, particularly among weaning age children is important considering the beneficial properties inherent in these types of food (Lorri, 1993). There is therefore the need to replace the present uncontrolled fermentation process existing in the developing countries with a pure culture fermentation so as to obtain a consistent product quality. Also since cereal grains will continue to be the major basic diets of infants and adults in developing countries, efforts should be geared towards improving the nutritional status of the food products (Sanni *et al*., 1998). The objective of this study is to see how the development of starter fermented sorghum – cowpea blends could bring about improvement in the nutritional quality and general acceptability of the weaning food.

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Materials and Methods

Sample collection

Brown Sorghum (*Sorghum bicolor*) and brown cowpea (*Vigna unguiculata*) (Ife brown) were purchased from Institute of Agricultural Research and Training (I. A. R and T), Moor Plantation, Ibadan, South Western Nigeria. They were transported to the laboratory in cleaned polyethylene bags for further use.

Organisms and culture methods

Pure cultures of *Lactobacillus plantarum* and *Pediococcus acidilactici* were obtained from the Industrial and Biotechnology laboratory of the Department of Microbiology, University of Ibadan, Ibadan. The young cultures of *L. plantarum* and *P. acidilactici* were routinely maintained on de man Rogosa and Sharpe (MRS) broth pH 5.5 at 30± 2^0C. The yeast (Saccharomyces cerevisiae) was isolated from "Ogi" and routinely maintained on Malt Extract Agar (MEA) at 30± 2^0C.

Processing of cereal and legume samples

The cereal grains (*Sorghum bicolor*) was freed from dirt and extraneous materials by manual sorting and washed thoroughly with sterile distilled water. It was then oven-dried at 50^0C for 8 h, dry milled and sieved to obtain a fine particle size 0.5 mm.They were packed in clean polyethylene bags and stored at 4^0C until further use. The legume sample, Ife brown (*Vigna unguiculata*) was freed from dirt and extraneous materials by manual separation, washed thoroughly in sterile distilled water, followed by dehulling and oven drying at 55^0C for 48 h, dry milling and sieving to obtain fine flour. They were packed into clean polyethylene bags and stored at 4^0C until use.

Formulation of composite blends and fermentation

The sorghum and cowpea flour blends were mixed in ratio 70:30 w/w (Malleshi *et al*., 1989). Each formulated composite blends in the fermenting vessel was made into slurry (30% w/v) (Livingstone *et al*., 1993). One litre of each slurry was inoculated asceptically with 1 ml of the inoculum starter organisms containing 2.0 x 109 cfu/ml of *L. plantarum*, and *Pediococcus acidilactici* and 2.8 x 108 cfu/ml of Sacharomyces cerevisiae. The inoculation was accompanied by stirring using a sterile glass rod. Fermentation was allowed for 72 h and sampling carried out 12 hourly.

pH and titratable acidity

Twenty grams of the fermenting samples were collected 12 hourly for 72 h into sterile bottles and mixed with 100 ml of distilled water. The mixture was allowed to stand for 15 min, shaken at 5 min interval and filtered with whatman No. 4 filter paper, the pH of the filtrate was measured using the pin electrode of pH meter. In determining titratable acidity, 10 ml aliquots (triplicates) were pipetted from the filtrate obtained for pH above, into conical flask and then titrated against 0.1M NaOH to phenolphthalein end point The percentage titratable acidity was calculated by multiplying the titre value by 0.09 (Vasconcelos *et al*., 1990).

Proximate analysis

Estimation of crude protein, crude fibre, ether extract, ash and carbohydrate content was by the method of A. O. A. C. (1990).

Antinutritional factors determination

Estimation of tannin, polyphenol and phytic acid contents were determined by employing the procedures of A.O.A.C. (1990).

Sensory evaluation of fermented samples

Sensory characteristics of the starter-developed fermented weaning foods were assessed by 10 untrained panelists of nursing mothers from a location in Ibadan, Oyo state. The penalists where in good health and are familiar with the taste, flavour and other attributes of weaning food. The cooked porridges were prepared and served in sensory evaluation cups. The samples were assessed for colour, taste, flavour, aroma, texture and over all acceptability. The judges were instructed to sip water before and after assessing each product. The samples were assessed using a 7 point hedonic scale ranging between 7 (like extremely) to 1 (dislike extremely).

Statistical analysis

All the data readings were done in triplicates and subjected to statistical analysis using analysis of variance (ANOVA) and Duncan's multiple test range using the SARS software.

Results

There is a decrease in pH values with increase in fermentation period (Table 1). The highest pH value (4.6) was obtained in sample fermented with *Pediococcus acidilactici* and *Saccharomyces cerevisiae* (AB3) while sample fermented with *Lactobacillus plantarum* and *Saccharomyces*

Table 1. The pH and Total Titratable Acidity of starter fermented sorghum-cowpea blends at different fermentation periods

Sample code		Fermentation period (hrs)						
		0	12	24	36	48	60	72
AB1								
	pH	5.5	4.5	4.0	3.9	3.80	3.70	3.60
	TTA(%)	0.40	0.72	0.80	0.90	1.05	1.08	1.15
AB2								
	pH	5.4	4.4	4.1	4.0	3.90	3.90	3.80
	TTA(%)	0.42	0.78	0.82	0.88	0.90	0.90	1.03
AB3								
	pH	5.6	4.6	4.4	4.3	4.2	4.20	3.90
	TTA(%)	0.39	0.54	0.61	0.72	0.83	0.90	0.96
AB4								
	pH	5.5	4.3	4.0	3.9	3.7	3.6	3.60
	TTA(%)	0.40	0.75	0.82	0.98	1.09	1.10	1.13

Sample interpretation
AB1 - *L. plantarum* and *S. cerevisiae*
AB2 - *L. plantarum* and *P. acidilactici*
AB3 - *P. acidilactici* and *S. cerevisiae*
AB4 - *P. acidilactici*, *L. plantarum* and *S. cerevisiae*

Table 2. Effect of fermentation time on crude protein content of starter-produced sorghum-cowpea blends

Sample code	% Crude protein						
	Fermentation period (hrs)						
	0	12	24	36	48	60	72
AB 1	24.62 ± 0.10^{b}	24.70 ± 0.10^{b}	25.20 ± 0.10^{b}	25.50 ± 0.10^{b}	25.70 ± 0.10^{b}	26.10 ± 0.10^{a}	26.50 ± 0.20^{a}
AB 2	24.90 ± 0.10^{a}	25.20 ± 0.10^{a}	25.50 ± 0.10^{a}	25.70 ± 0.10^{a}	25.90 ± 0.10^{a}	26.20 ± 0.10^{a}	26.40 ± 0.10^{a}
AB 3	24.50 ± 0.10^{b}	24.6 ± 0.10^{b}	25.00 ± 0.00^{c}	25.20 ± 0.10^{b}	25.40 ± 0.10^{c}	25.6 ± 0.10^{c}	25.70 ± 0.10^{c}
AB 4	24.80 ± 0.10^{a}	25.10 ± 0.10^{a}	25.40 ± 0.10^{a}	25.70 ± 0.10^{a}	25.80 ± 0.10^{ab}	25.90 ± 0.10^{b}	26.10 ± 0.10^{b}

Values are means of three replicates ± SD. Means within the same column with different superscript are significantly different ($p<0.05$). Sample code as in table 1

Table 3. Effect of fermentation time on tannin content of starter-produced sorghum-cowpea blends

Sample code	% Tannin (mg/kg)						
	Fermentation period (hrs)						
	0	12	24	36	48	60	72
AB 1	15.50 ± 0.10^{ab}	15.00 ± 0.00^{b}	13.50 ± 0.10^{c}	10.50 ± 0.10^{d}	10.00 ± 0.00^{d}	10.00 ± 0.00^{d}	9.50 ± 0.10^{d}
AB 2	15.00 ± 0.10^{c}	15.00 ± 0.00^{b}	14.00 ± 0.10^{b}	13.00 ± 0.10^{c}	12.00 ± 0.10^{c}	11.50 ± 0.10^{c}	11.50 ± 0.00^{c}
AB 3	15.40 ± 0.10^{b}	15.40 ± 0.10^{a}	14.50 ± 0.10^{a}	14.00 ± 0.00^{a}	13.50 ± 0.10^{a}	13.50 ± 0.10^{a}	13.00 ± 0.00^{a}
AB 4	15.60 ± 0.10^{a}	15.50 ± 0.10^{a}	14.40 ± 0.10^{a}	13.50 ± 0.10^{b}	13.00 ± 0.00^{b}	12.50 ± 0.10^{b}	12.50 ± 0.00^{b}

Values are means of three replicates ± SD. Means within the same column with different superscript are significantly different ($p<0.05$). Sample code as in Table 1

Table 4. Effect of fermentation time on polyphenol content of starter-produced sorghum-cowpea blends

Sample code	% Polyphenol (mg/kg)						
	Fermentation period (hrs)						
	0	12	24	36	48	60	72
AB 1	22.10 ± 0.00^{b}	22.00 ± 0.10^{a}	21.00 ± 0.10^{b}	20.00 ± 0.00^{b}	19.00 ± 0.00^{d}	19.00 ± 0.00^{b}	19.00 ± 0.00^{b}
AB 2	22.00 ± 0.10^{b}	22.00 ± 0.10^{a}	21.43 ± 0.13^{a}	20.50 ± 0.10^{a}	20.00 ± 0.00^{b}	19.50 ± 0.10^{ab}	19.00 ± 0.00^{b}
AB 3	22.10 ± 0.10^{b}	22.00 ± 0.00^{a}	21.43 ± 0.15^{a}	20.50 ± 0.10^{a}	20.50 ± 0.10^{a}	19.70 ± 0.10^{a}	19.40 ± 0.10^{a}
AB 4	22.30 ± 0.10^{a}	21.00 ± 0.00^{b}	21.40 ± 0.10^{a}	20.00 ± 0.10^{b}	19.50 ± 0.10^{c}	19.00 ± 0.00^{b}	19.00 ± 0.00^{b}

Values are means of three replicates ± SD. Means within the same column with different superscript are significantly different ($p<0.05$). Sample code as in Table 1

cerevisae (AB1) and that fermented with *Lactobacillus plantarum*, *Pediococcus acidilactici* and *Saccharomyces cerevisiae* (AB4) gave the least pH value (3.6) at 72 h of fermentation. The total titratable acidity (TTA) of all the samples increased with fermentation period. Sample fermented with mixed cultures of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* (AB1) had the highest titratable acidity (1.15%) by 72 h fermentation period while sample fermented with mixed cultures of *Pediococcus acidilactici* and *Saccharomyces cerevisiae* (AB3) had the least titratable acidity (0.96%) as shown in Table 1.

Nutritional quality of starter fermented blends

The analysis of the proximate composition of all the starter fermented formulated sorghum-cowpea blends indicates that the protein content rose with increase in fermentation time while the moisture content, ether extract, ash content, crude fibre and total carbohydrate content decreased with fermentation time. The highest moisture content (76.50%) was observed in samples AB2 and AB4 while the lowest moisture content of 75.60% was observed in sample AB3 at 72 h fermentation time. Statistical analysis using Duncan's Multiple Range Test shows that there are significant differences in the moisture content among the starter developed samples.

The result of the analysis of the crude protein content on Table 2 shows an increase in quantity with respect to increase in fermentation period while no significant difference was observed in samples AB1 and AB3, and AB2 and AB4 until after 48hr. The results also shows that the crude fat content remains constant after 48 h fermentation period with no significant difference among the starter combined formulated blends. For all combinations, the unfermented blends had the highest Ash content with no observable difference after 24 h of fermentation. However, statistical analysis shows little or no significant difference among the starter produced blends with time while there was a significant difference within the combinations. The crude fibre contents of all the starter-produced weaning blends decreased with increased fermentation time but with no significant difference ($p<0.05$) from both among and within the blends.

Anti nutritional analysis of starter-produced blends

Results of the analysis of the anti-nutritional factors of the starter produced blends shows a decrease in tannin, polyphenol and phytic acid contents in all the blends with increase in fermentation period. The highest tannin content was observed in blend AB3 throughout the fermentation period while the highest value of 15.60 mg/kg was observed in unfermented blend AB4 and the least value (9.50 mg/kg) was recorded in blend AB1 at 72hr fermentation time. The tannin contents were significantly different among

Table 5. Effect of fermentation time on phytate content of starter-produced sorghum-cowpea blends

Sample code	% Phytate (mg/kg)						
	Fermentation period (hrs)						
	0	12	24	36	48	60	72
AB 1	18.30 ± 0.10^{b}	17.50 ± 0.10^{b}	15.40 ± 0.10^{b}	13.00 ± 0.10^{d}	11.80 ± 0.10^{c}	10.20 ± 0.10^{c}	8.80 ± 0.10^{c}
AB 2	17.90 ± 0.10^{c}	17.33 ± 0.06^{b}	15.47 ± 0.15^{b}	13.20 ± 0.10^{c}	12.60 ± 0.10^{a}	10.40 ± 0.10^{b}	9.00 ± 0.00^{b}
AB 3	18.00 ± 0.10^{c}	17.40 ± 0.10^{b}	15.50 ± 0.10^{b}	14.20 ± 0.10^{a}	12.50 ± 0.10^{ab}	11.00 ± 0.10^{a}	9.50 ± 0.10^{a}
AB 4	18.50 ± 0.10^{a}	17.80 ± 0.10^{a}	15.80 ± 0.10^{a}	13.90 ± 0.10^{b}	12.40 ± 0.10^{b}	11.00 ± 0.10^{a}	9.00 ± 0.10^{b}

Values are means of three replicates ± SD. Means within the same colum with different superscript are significantly different ($p<0.05$). Sample code as in table 1

Table 6. Organoleptic characteristics and acceptability of fermented starter-produced sorghum-cowpea blends

Sample code	Parameter	Fermentation periods (hrs)							Overall acceptability
		0	12	24	36	48	60	72	
	Colour								
AB 1		1.70^{b}	3.30^{a}	4.30^{a}	4.80^{a}	4.40^{a}	3.80^{b}	5.20^{a}	5.60^{a}
AB 2		1.90^{a}	3.00^{a}	4.20^{a}	4.50^{a}	4.90^{a}	4.00^{ab}	5.40^{a}	5.00^{a}
AB 3		3.30^{ab}	3.10^{a}	4.90^{a}	4.00^{a}	5.10^{a}	4.60^{ab}	4.50^{a}	6.20^{a}
AB 4		3.90^{a}	3.90^{a}	5.30^{a}	4.90^{a}	5.30^{a}	5.30^{a}	4.50^{a}	5.80^{a}
	Taste								
AB 1		1.80^{a}	2.60^{a}	3.90^{a}	4.90^{a}	4.50^{a}	4.00^{a}	4.30^{a}	6.50^{a}
AB 2		1.10^{a}	3.10^{a}	4.10^{a}	4.20^{a}	5.80^{a}	3.90^{a}	4.60^{a}	5.80^{b}
AB 3		1.80^{a}	3.10^{a}	4.70^{a}	4.50^{a}	4.70^{a}	4.40^{a}	4.50^{a}	6.00^{ab}
AB 4		1.70^{a}	3.40^{a}	4.10^{a}	4.90^{a}	4.70^{a}	5.10^{a}	5.60^{a}	6.00^{ab}
	Flavour								
AB 1		1.80^{a}	3.00^{a}	3.80^{a}	5.50^{a}	4.20^{a}	5.70^{a}	5.70^{a}	5.70^{a}
AB 2		2.00^{a}	2.90^{a}	4.60^{a}	4.70^{b}	5.00^{a}	4.70^{a}	4.30^{b}	5.40^{a}
AB 3		1.20^{a}	2.80^{a}	4.40^{a}	4.50^{ab}	5.10^{a}	4.70^{a}	5.30^{a}	5.50^{a}
AB 4		1.80^{a}	4.00^{a}	5.00^{a}	4.90^{a}	5.00^{a}	4.80^{a}	5.10^{ab}	5.60^{a}
	Aroma								
AB 1		2.60^{a}	2.80^{a}	4.60^{a}	4.90^{a}	5.10^{a}	4.10^{a}	5.40^{a}	5.80^{a}
AB 2		1.90^{a}	3.80^{ab}	4.00^{a}	4.00^{a}	5.50^{a}	5.20^{ab}	4.30^{b}	5.70^{a}
AB 3		2.00^{a}	4.50^{a}	5.50^{a}	4.70^{a}	5.20^{a}	5.30^{ab}	3.90^{b}	5.50^{a}
AB 4		2.10^{a}	4.70^{a}	5.20^{a}	4.80^{a}	5.20^{a}	5.60^{a}	3.80^{b}	5.80^{a}
	Texture								
AB 1		1.60^{a}	3.30^{a}	3.70^{ab}	3.40^{b}	3.40^{b}	4.40^{a}	5.00^{b}	5.10^{b}
AB 2		1.20^{a}	1.80^{a}	2.70^{b}	4.00^{b}	4.80^{ab}	5.50^{a}	6.30^{a}	5.90^{a}
AB 3		1.60^{a}	3.10^{ab}	4.30^{a}	4.90^{a}	5.20^{a}	5.30^{a}	6.20^{a}	5.80^{ab}
AB 4		1.30^{a}	3.10^{ab}	4.40^{a}	5.00^{a}	5.50^{a}	5.50^{a}	6.30^{a}	5.80^{ab}

Values are mean scores of 10 judges. Means within the same column with different superscripts are significantly different ($p<0.05$). Sample code as in Table 1

the blends at all fermentation time (Table 3). From Table 4, the highest polyphenol content (22.30 mg/kg) was recorded in unfermented blend AB4 while the least value (19.00 mg/kg) was observed in blend AB1 at 48hr fermentation time. For the first 12h of fermentation, samples AB1, AB2 and AB3 were not significantly different from each other while sample AB4 was significantly different from others. In all, 48hr blends for all combination of starters were significantly different from each other. The highest phytate content (18.50 mg/kg) was recorded in unfermented blend AB4 and the least value (8.80 mg/kg) recorded in blend AB1 by 72hr fermentation time. Statistical analysis shows that for the first 24hrs of fermentation there was no significant difference in the phytase content of samples AB2 and AB3 and in all, 36 h and 48 h blends for all combination of starters were significantly different from each other (Table 5).

Sensory evaluation of fermented starter-produced sorghum-cowpea weaning blends

The results of evaluation of the sensory characteristics are shown on Table 6. Sample AB2 was rated highest (5.40) in terms of colour by all the assessors by 72 h of fermentation and the least colour preference (1.70) in the unfermented sample AB1. However overall acceptability of colour shows that sample AB3 is preferred while there was little or no significant difference in the preference for colours among the blends. Sample AB2 also had the highest rating (5.80) by the 48hr fermentation time, in terms of taste and the least rating in the unfermented sample AB2. Statistically, both fermentation time and starter combination has no effect on taste while overall acceptability indicate that sample AB2 i.e. sample fermented with mixed cultures of *Lactobacillus plantarum* and *Pediococcus acidilactici* is significantly different from others.

Discussion

The pH of the samples decreased as the fermentation progressed from 12 hours to 72 hours. This decrease in pH is attributed to the production of organic acids in the fermenting slurries. A similar result within a short period of fermentation was observed by Sanni *et al*. (1999). Fermented cereal gruels with a pH of less than 4.0 had earlier been produced within 12-24 hrs using micro organisms singly or in mixed cultures (Lorri, 1993; Sanni *et al*., 1994). Report also shows that such a short fermentation period is desirable to obtain a product of good and consistent quality (Sanni *et al*., 1999).

Titratable acidity increased with time over the entire fermentation period in all the sample combinations. A similar increase in acid production had been observed by Sefa-Dedeh *et al*. (2001) during the production of weaning food from maize-cowpea blends. The increase in acidity is of great significance as it was reported to reduce the incidence of diarrhea in infants consuming fermented maize porridge (Mensah *et al*., 1990).

The moisture content decreased with increase in fermentation time for all the samples while the protein content of the fermented blends increased with time. The total carbohydrate referred to as Nitrogen free extract decreased, thus resulting in a high energy protein balanced food. The use of cowpea as a fortifying agent has been reported to improve the protein content of cereal diet (Afoakwa, 1996; Sefa-Dedeh *et al*., 2000; 2001). The observed increase in protein content of the blends may be due to the increased growth and microbial proliferation in the form of single cell protein of the starter culture (Oboh, 2006). It may also be due to the structural proteins that are an integral part of the microbial cell (Tortora *et al*., 2002). The highest crude protein value was obtained in sample AB1 ie. blend fermented with the mixed culture of *Lactobacillus plantarum* and

Sacharomyces cerevisiae. This is in agreement with the report by Onilude et al., (2004) that fermentation of blends with mixture of *L. plantarum* and *S. cerevisiae* increased the protein value of weaning food. Sanni and fellow workers (1999) also reported an increase in the protein content of cereal-soyabean blends fermented with mixed culture of *Lactobacillus plantarum* and *Saccharomyces cerevisiae*. Reports had also shown that protein quality is synergististically improved in cereal-legume blends due to the contribution of lysine by cowpea and methionine by cereal (Bressani, 1993).

In contrast to the above observation, the crude fibre, ash content, ether extract and total carbohydrate of the weaning blends decreased with increase in fermentation time. This observation is in contrast with that of Sefa-Dedeh and Kluvitse (1995), who observed an increase in ash content of fermented maize cowpea blends. The decrease in ash content observed in this study could be due to general activities of the fermenting microorganisms who by enzymatic activity could breakdown most of these components into their absorbable forms. Also, the decrease in fat content could be attributed to its utilization by fermenting micro-organisms. Micro organisms might oxidize the fat to yield considerable amount of energy for their activities. This decrease is similar to the work carried out by Sanni and Ogbonna (1991) in fermenting African cotton seed. Furthermore, this study also shows that the different combinations of starter organisms used for the fermentation affect the proximate composition of the blends.

Study of the antinutritional contents of the blends, showed that fermentation with the different combinations of starter organisms reduced the polyphenol, tannins and phytic acid content with increase in fermentation period. This is in accordance with the work of Khetarpaul and Chauhan (1989), who reported a decrease in polyphenol content in the lactic acid fermentation of millet. Onilude *et al*. (2004) also observed reduction in both polyphenol and tanin content of cereal- soyabean blends as a result of malting and toasting. The reduction in tannin content may be as a result of enzymatic activity of the organisms whose hydrolyzing ability is enhanced by fermentation. This reduction is in accordance with the observation made by Chavan and Kadam (1989) who reported that fermentation reduces tannin content of cereals. Lactic acid fermentation was also found to decrease tannin content in maize (Lopez *et al*., 1993).

The reduction in the phytic acid content of formulated blends may be due to hydrolysis of phytate by the enzyme phytase into lower inositol phosphates which are believed to be activated during the germination and fermentation process (Irving, 1980). This result is similar to that of Usha and Chandra (1997) who observed that fermentation of finger millet (*Eleusine coracane*) with starter from previously fermented finger millet achieved a desirable goal of reduced phytate and tannin when compared to uncontrolled fermentation. It has previously been reported that lactic acid fermentation can reduce phytate levels in bread fermentation (Lopez *et al*., 1983). Similarly, Khetarpaul and Chauhan (1990) have reported that mixed cultures of yeasts and *lactobacilli* may reduce the phytate content of bread. So also the combination of *Lactobacillus* and *Leuconostoc* strains with the yeast strains has showed a high phytate reduction in fermented Soughdough bread (Chaoui *et al*., 2003). The result of this study showed that mixed cultures of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* (AB1), gave better reductions of the antinutritional factors.

Sensory evaluation anlaysis indicates that there are significant difference in the colour, aroma and texture among the sample with respect to the fermentation periods but taste and flavour are not significantly different from each other. This is in contrast with the findings of Sanni *et al*. (1999) who reported that there was little or no significant difference in colour aroma and texture of porridges prepared from the fermentation of Cereal-soybean blends with mixed cultures of *Lactobacillus plantarum* and *Saccharomyces cerevisiae*.

Penalist observed that blend formulated with *Lactobacillus plantarum* and *Saccharomyces cerevisiae* (AB1) were more acceptable in terms of taste, flavour and aroma except for colour and texture. Although statistical analysis of the overall acceptability showed that there are significant difference in taste and texture among the samples but colour, flavor and aroma are not significantly different from each other. This agrees with that reported by Mbata *et al*. (2006) who observed overall acceptability to be rated above average in fermented Maize-bambara nut blends. None of the panelists developed any side effect like diarrhoea and emesis after consuming the preparations.

Conclusion

In conclusion, this research shows that, the use of cowpea as a fortifying agent as well as mixed starter cultures of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* has improved the protein content and organoleptic characteristics of the weaning blends. It has also been able to reduce the

antinutrients such as polyphenol, tannins and phytic acid. This may be recommended as desirable for solving the problem of protein deficiency among infant in developing countries. Further research is needed to determine the minerals and vitamin content of the blends.

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