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Effect of Solid State Fungal Fermentation on the Chemical Composition of Adansonia digitata Seed

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Abstract: The seed of *Adansonia digitata* was fermented with the aim of producing additional plant protein food and feed. The seed was subjected to natural fermentation for 120 hours under laboratory condition. Nine moulds and two yeasts were isolated and characterized macroscopically and microscopically as *Aspergillus niger, Aspergillus flavus, Penicillium citrinum, Penicillium chrysogenum, Mucor racemosus, Mucor hiemalis, Rhizopus stolonifer, Alternaria tenuis, Scopuloriopsis brevicaulis, Saccharomyces cerevisiae and Schizosaccharomyces pombe*. Spores of isolated fungi were used as starter cultures in the fermentation of the seed using solid-state fermentation method for 120 hours. The fermented products were analyzed for proximate and anti-nutrient content using standard methods. The result showed a significant increase ($p<0.05$) in crude protein, total ash and carbohydrate but decreased significantly ($p>0.05$) in crude fat and crude fibre. The anti-nutrients in form of total tannins, saponins, oxalate and phytate content were significantly decreased after fermentation. From the findings in this research, it was concluded that fermented *A. digitata* seed can serve as additional plant protein food source in food and feed formulation for livestock.

Key words: *Adansonia digitata*, anti-nutrients, nutrients, fermentation, fungi.

Introduction

The growing concern for the acute food shortages for the world's expanding population has led to the exploitation of non-conventional food sources as potential alternatives [1]. The solution to the food problem must be sought through a combination of all available sources. Due to the increasing demand for protein and energy to support the ever-increasing world population, efforts are been directed at exploring new and nonconventional sources of food that grow in the arid and semiarid land regions of the world. Food and agricultural scientists are now beginning to screen wild and under-exploited native plants for possible potential sources of food in an attempt to widen the narrow food base [2, 3]. Several reports have also indicated that lots of lesser-known native crop species are high in nutrients and could possibly relieve critical food shortages if given adequate promotion and research attention [4, 5]. However, prior to utilization of such unconventional resources, data indicating the nutrient composition and toxic factors should be available. Toxicological evaluation of possible epidemiological response to the ingestion of novel food sources and the methods of processing that will enhance their utility as food or feed ingredient are all necessary in order to achieve optimal utilization [6]. Competition between man and his livestock for food sources has been recognized as a major cause of the increase in the cost of ingredients used in compounding livestock feed. This has been recognized to account for more than 70% of the total cost of animal production thus seriously reducing the return and marginal profit [7] in the developing countries essentially in Africa and particularly in Nigeria. Several methods have been employed to improve the nutritional quality of legumes, cereals and other form of seeds, essentially fermentation. Fermentation is one of the oldest methods and widely used process of producing and preserving food on local and industrial levels [8]. Fermentation for food production may either be anaerobic or aerobic or both. Fermentation changes the characteristics of the food by the action of the enzymes produced by the fermenting microbes whether bacteria, mould or yeasts. The term solid-state fermentation (SSF) has been variously defined as the cultivation of microorganisms on solid, moist substrates in the absence of free aqueous phase [9], or cultivation of microorganisms in the presence of a liquid phase at maximal solid substrate concentrations or on inert carriers supporting moist substrate [10]. It has several advantages over liquid state or submerged fermentation. *Adansonia digitata*, the baobab tree, is a member of the Bombacaceae family, which consists of around 20 genera and around 180 species [11]. Authors [12] reported that the acceptability and optimal utilization of *A. digitata* seed as a protein source is limited by the presence of inherent anti-nutrients such as protease inhibitors, tannins, phytic acid and amylase inhibitors. Phytochemicals (anti-nutrients) have been reported to be toxic at 5 g per serving [13]. The acceptability and optimal utilization of *A. digitata* seed as a protein source has been reported to be limited by the presence of anti-nutritional factors such as trypsin inhibitors, protease inhibitors, tannins, phytic acid, oxalate, alkaloids, phytate and amylase inhibitors [14, 15, 16]. [17] suggested that though processing techniques may rob a food item of some nutrients, processing systems may also enhance food nutritional quality by reducing or destroying the anti-nutrients present. The aim of this work therefore, is to evaluate the proximate and antinutrient content of *A. digitata* seed fermented with mono-culture fungi under

solid state techniques with a view to determining their nutritive potentials.

Materials and Methods

Collection and authentication of seed

Mature, dried *A. digitata* pods were collected from the premises of University of Ilorin, Ilorin, Kwara State, Nigeria was authenticated at the Department of Plant Biology with voucher number of *Adansonia digitata* (UIH 1048).

Preparation of seed

The pods were cracked manually to release the seeds. The seeds ebbed in pulp were washed with plenty of clean water to remove the pulp before drying to remove the wetness. The seeds were pulverized with an electrical grinder to rough particles sizes of about 2 mm in diameter, thereafter they were stored in airtight container for further use.

Isolation of organisms from naturally fermented *A. digitata* seed

The pulverized seeds were subjected to natural fermentation as follows. Precisely 250 g of the pulverized seeds were mixed with 250 ml of sterile distilled water in plastic fermentors of two litre capacities. The mixtures were stirred properly until a uniform mash was obtained, covered and allowed to ferment at room temperature (28±2 ^{o}C) in the laboratory for seven days [18, 19]. Fungi were isolated from the naturally fermented seeds through serial dilution and pour plate method using Potato- Dextrose agar into which 10 % Streptomycin has been added to inhibit bacteria growth. Culturing was done in duplicates.

Identification of the Isolates

The fungi isolated from the fermenting mixture were sub cultured until pure isolates were obtained. Morphological and microscopical analyses for the identification of the isolates were carried out and result obtained compared with literature to identify the organisms as described by [20]. Pure cultures of the fungal isolates were preserved on agar slant at 4 ^{o}C for further use.

Fungal spore preparation and monoculture fermentation of seed

Fungal spore suspension of actively growing mid log phase culture of the fungal isolates were prepared according to the method described by [21]. An agar slant of four days old pure culture of each of the organisms was used. Sterile distilled water (10 ml) was added to the slant and shook well to wash the spores. The spore suspension was counted using the Neubauer counting chamber. A spore suspension of about $5x10^4$ spore/ml was used in each case for inoculation. Twenty grams (20 g) of the seed samples were measured separately into 250 ml Erlenmeyer flasks, plugged with cotton wool, wrapped with aluminium foil and sterilized in the autoclave at 121 ^{o}C for 15minutes. The sterile samples were mixed with 20ml of sterile distilled water and stirred properly until uniform mashes were obtained in each case. Two millilitre (2 ml) from each of the monoculture suspension was used as fermentation starter to inoculate each of the samples in the fermentors. The mixtures were allowed to ferment for 120 hours at room or ambient temperature (28±2^{o}C) [18, 19]. Fermented samples were taken daily, dried at 60 ^{o}C in the oven for 4hours to safe moisture content and used for analysis of proximate (moisture content, crude fibre, crude protein, crude fat, ash content, carbohydrate and glucose), phytochemical (saponins, tannins, phytates and oxalates) analysis were done on fermented products after 120 hours.

Determination of proximate content of the seed

The crude protein content of the samples was determined following the Kjeldahl method.

The moisture content, total ash, crude fibre, crude fat (Soxhlet extraction

method) content of the seed were determined following [22]. The total carbohydrate or Nitrogen Free Extract (NFE) was determined by the difference method.The reducing sugar content of the seed wasdetermined quantitatively by the 3,5- Dinitrosalicylic Acid (DNSA) as described by [22]. The water holding capacity of the seed was determined according to the method described by [23].

Determination of the some anti-nutritional factors in the seed

The antinutrient content of the seed was determined quantitatively. Total saponins was determined by the method of [24], oxalates by the method of [25], total soluble tannin by the method described by [26] and the phytate content was determined by the method of [27].

3. Results

Isolation of Fungi

Nine moulds were isolated and identified during fermentation as *Aspergillus niger, Aspergillus flavus, Penicillium chrysogenum, Penicillium citrinum, Rhizopus stolonifer, Mucor racemosus, Mucor hiemalis, Alternaria tenuis, Scopulariopsis brevicaulis, Saccharomyces cervisiae and Schizosaccharomyces pombe* (Table 1).

Proximate content of fermented products

The effect of monoculture fungal fermentation on *A. digitata* seed at ambient temperature for 72 hours is presented in Table 2. Fermentation with each of the fungus has various effects on the proximate composition of the seed. The results obtained are significantly ($p<0.05$) different from the unfermented sample. Crude protein, carbohydrate and total ash were significantly ($p<0.05$) increased after fermentation while the crude fat and crude fibre were significantly ($p<0.05$) decreased. The highest increase in protein (31.29%) was recorded in sample fermented with *Penicillium citrinum* while the lowest (28.80%) was recorded in sample fermented with *Mucor racemosus* (Table 2).

Reducing sugar (glucose) content of fermented seed

The effect of fermentation on the reducing sugar content of monoculture-fermented seed is as presented in Figure 1. The value of reducing sugar increased significantly ($p<0.05$) in all the fermented products compared to the unfermented sample. The highest increase (16.5 mg/g) was recorded in sample fermented with *Shizosaccharomyces pombe* while the value was insignificantly reduced ($p<0.05$) to 2.5mg/g recorded in sample fermented with *Rhizopus stolonifer.*

Effect of monoculture fermentation on some anti-nutrients in the fermented seed.

The effect of monoculture fermentation on saponins, oxalates, tannins and phytates content of *A. digitata* seed is presented in Figures 2 to 5. The values of the phytochemicals significantly ($p<0.05$) reduce after fermentation.

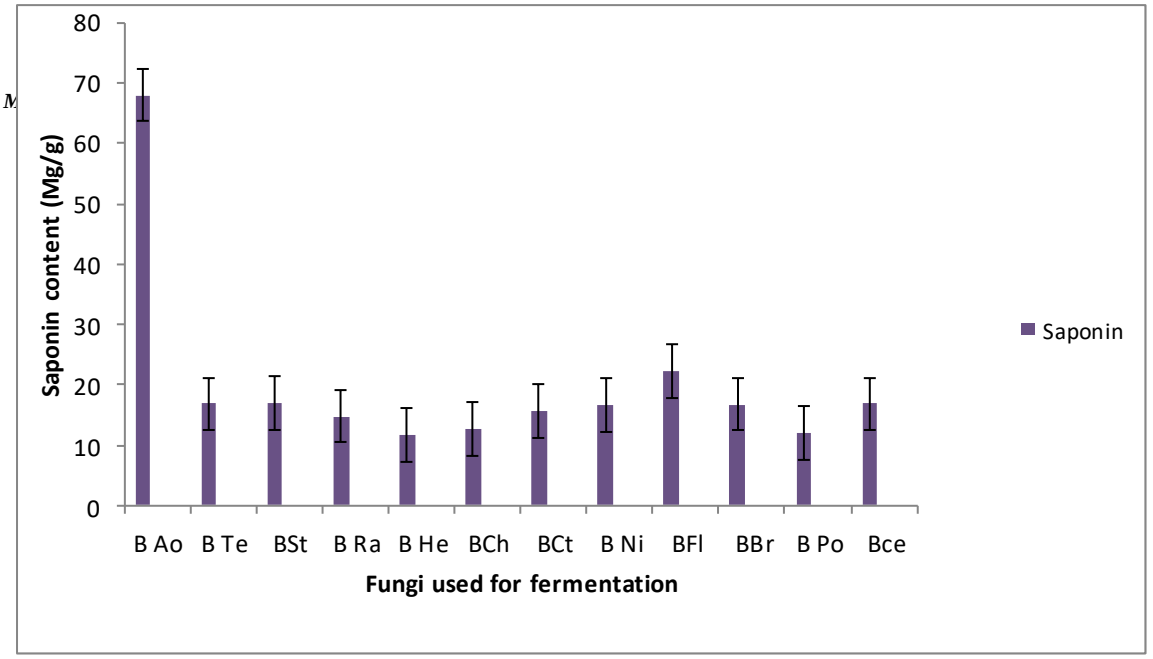
Macroscopy and microscopy description of isolates	Fungal isolates
Filaments were white fast spreading with brown-black spores at the tip	*Aspergillus niger*
Colonies were greenish yellow with rough edges, flat and fast spreading	*Aspergillus flavus*
The filaments were bluish green or pale with broad white margin	*Penicillium chrysogenum*
Filaments were whitish on top but leathery and orange yellow underneath	*Penicillium citrinum*
Colony appeared fluffy white but turned black with age	*Rhizopus stolonifer*
Filaments appeared gray, fluffy white but turn dirty white with age	*Mucor racemosus*
Mycelia were grayish or slightly yellowish turning grayish brown with age	*Mucor hiemalis*
Colony has blackish aerial mycelium; spores were dark, brown borne in chains	*Alternaria tenuis*
Colony has brownish loose hyphae carrying lemon shaped spores	*Scopulariopsis brevicaulis*
Colonies were creamy with rough edges; cells were ovoid or ellipsoidal	*Saccharomyces cervisiae*
Colony was round and smooth at the edge; cells were cylindrical	*Schizosaccharomyces pombe*

Table 1: Fungal isolates from naturally fermented pulverized *A. digitata* seed

Organisms	MC	TA	PRO	FAT	FIB	CHO
BTe	6.98±1.39^{ab}	4.32±0.22^{ab}	31.50±2.06^{c}	11.92±0.64^{a}	4.46±0.7^{ab}	40.84±0.88^{ab}
BSt	5.87±0.00^{a}	3.96±0.00^{a}	29.43±0.00^{ab}	12.57±0.00^{ab}	4.96±0.00^{ab}	43.21±0.00^{bc}
BRa	7.43±1.28^{bc}	4.45±0.40^{ab}	28.80±1.12^{ab}	11.85±0.13^{a}	4.88±0.21^{ab}	42.6±0.24^{bc}
BHe	6.29±0.05^{ab}	4.44±0.05^{ab}	28.92±0.33^{ab}	11.91±0.60^{a}	4.48±0.62^{ab}	43.98±1.55^{bc}
BCh	8.20±3.34^{c}	6.75±2.02^{b}	30.83±0.34^{bc}	11.77±0.46^{a}	3.74±1.90^{a}	38.76±7.40^{a}
BCt	8.27±3.29^{c}	6.61±2.25^{ab}	31.29±2.60^{c}	12.25±0.41^{a}	3.45±1.34^{a}	38.14±7.21^{a}
BNi	7.25±1.89^{bc}	5.52±0.97^{ab}	30.36±2.04^{bc}	13.31±0.89^{ab}	3.71±1.91^{a}	39.87±1.95^{a}
BFl	7.91±3,10^{bc}	3.89±0.74^{a}	30.60±1.68^{bc}	12.59±0.21^{ab}	3.65±1.91^{a}	41.36±3.39^{bc}
BCe	7.50±0.00^{bc}	5.00±0.00^{ab}	31.00±0.00^{c}	13.50±0.00^{ab}	3.50±0.00^{a}	40.20±0.00^{ab}
BPo	8.00±0.00^{c}	5.00±0.00^{ab}	30.00±0.00^{bc}	13.00±0.00^{ab}	3.00±0.00^{a}	40.10±0.00^{ab}
BAo	7.64±2.11^{bc}	4.39±1.61^{ab}	19.86±1.30 ^{a}	18.60±8.46^{b}	8.87±5.31^{b}	40.01±1.35^{ab}

Table 2: Proximate composition of *Adansonia digitata* fermented with mono-culture of fungal isolates.

Data are mean of two replicate ± SEM. Mean within the same row carrying different superscripts are significantly different at ($p<0.05$). (MC= moisture content, TA= total ash, CPRO= crude protein, CFAT= crude fat, CFIB= crude fibre and CHO= total carbohydrate.)
(BSt= baobab fermented with *R.stolonifer*, BTe= baobab fermented with *A. tenuis*, BRa= baobab fermented with *Mucor racemosus*, BHe= baobab fermented with *M. hiemalis*, BCh= baobab fermented with *P. chrysogenum*, BCt= baobab fermented with *P. citrinum*, BNi= baobab fermented with *A. niger*, BFl= baobab fermented with *A. flavus*, BPo= baobab fermented with *S. pombe*, BCe= baobab fermented with *S. cerevisiae* and BRo= unfermented baobab seed)



Data are mean of two replicate ± SEM.

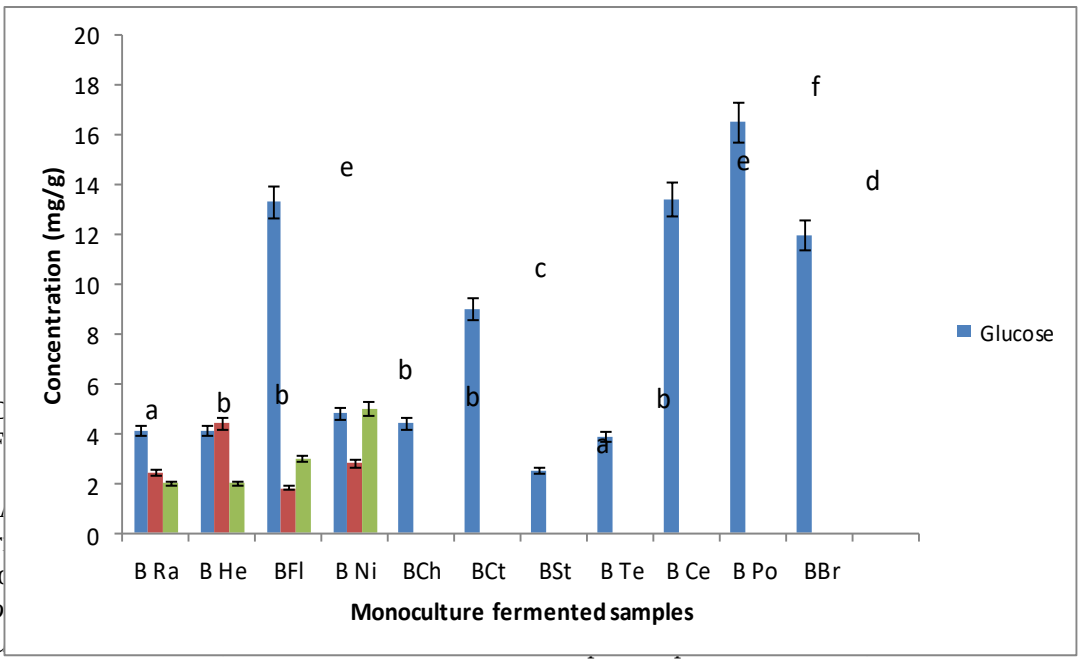
Figure 1: Glucose content of monoculture fungal fermented *Adansonia digitata*

(BAo: unfermented baobab; BTe:Moringa fermented with *Alternaria tenuis*; BSt: baobab fermented with *Rhizopus stolonifer; B*RA: baobab fermented with *Mucor racemosus;* BHi: baobab fermented with *Mucor hiemalis;* BCh: baobab fermented with *Penicillium chrysogenum;* BCt: baobab fermented with *Penicillium citrinum;* BNi: baobab fermented with *Aspergillus niger;* BFl: baobab fermented with *Aspergillus flavus;* BBr: baobab fermented with *Scopuloriopsis brevicaulis;* BPo: baobab fermented with *Schizosaccharomyces pombe;* BCe: baobab fermented with *Saccharomyces cerevisiae*) Data are mean of two replicate ± SEM.

Organisms	MC	TA	PRO	FAT	FIB	CHO
BTe	6.98±1.39^{ab}	4.32±0.22^{ab}	31.50±2.06^{c}	11.92±0.64^{a}	4.46±0.7^{ab}	40.84±0.88^{ab}
BSt	5.87±0.00^{a}	3.96±0.00^{a}	29.43±0.00^{a} b	12.57±0.00^{a} b	4.96±0.00^{ab}	43.21±0.00^{bc}
BRa	7.43±1.28^{bc}	4.45±0.40^{ab}	28.80±1.12^{a} b	11.85±0.13^{a}	4.88±0.21^{ab}	42.6±0.24^{bc}
BHe	6.29±0.05^{ab}	4.44±0.05^{ab}	28.92±0.33^{a} b	11.91±0.60^{a}	4.48±0.62^{ab}	43.98±1.55^{bc}
BCh	8.20±3.34^{c}	6.75±2.02^{b}	30.83±0.34^{b} c	11.77±0.46^{a}	3.74±1.90^{a}	38.76±7.40^{a}
BCt	8.27±3.29^{c}	6.61±2.25^{ab}	31.29±2.60^{c}	12.25±0.41^{a}	3.45±1.34^{a}	38.14±7.21^{a}
BNi	7.25±1.89^{bc}	5.52±0.97^{ab}	30.36±2.04^{b} c	13.31±0.89^{a} b	3.71±1.91^{a}	39.87±1.95^{a}
BFl	7.91±3,10^{bc}	3.89±0.74^{a}	30.60±1.68^{b} c	12.59±0.21^{a} b	3.65±1.91^{a}	41.36±3.39^{bc}
BCe	7.50±0.00^{bc}	5.00±0.00^{ab}	31.00±0.00^{c}	13.50±0.00^{a} b	3.50±0.00^{a}	40.20±0.00^{ab}
BPo	8.00±0.00^{c}	5.00±0.00^{ab}	30.00±0.00^{b} c	13.00±0.00^{a} b	3.00±0.00^{a}	40.10±0.00^{ab}
BAo	7.64±2.11^{bc}	4.39±1.61^{ab}	19.86±1.30 ^{a}	18.60±8.46^{b}	8.87±5.31^{b}	40.01±1.35^{ab}

Table 2: Proximate composition of *Adansonia digitata* fermented with mono-culture of fungal isolates.

Data are mean of two replicate ± SEM. Mean within the same row carrying different superscripts are significantly different at ($p<0.05$). (MC= moisture content, TA= total ash, CPRO= crude protein, CFAT= crude fat, CFIB= crude fibre and CHO= total carbohydrate.)
(BSt= baobab fermented with *R.stolonifer*, BTe= baobab fermented with *A. tenuis*, BRa= baobab fermented with *Mucor racemosus*, BHe= baobab fermented with *M. hiemalis*, BCh= baobab fermented with *P. chrysogenum*, BCt= baobab fermented with *P. citrinum*, BNi= baobab fermented with *A. niger*, BFl= baobab fermented with *A. flavus*, BPo= baobab fermented with *S. pombe*, BCe= baobab fermented with *S. cerevisiae* and BRo= unfermented baobab seed).



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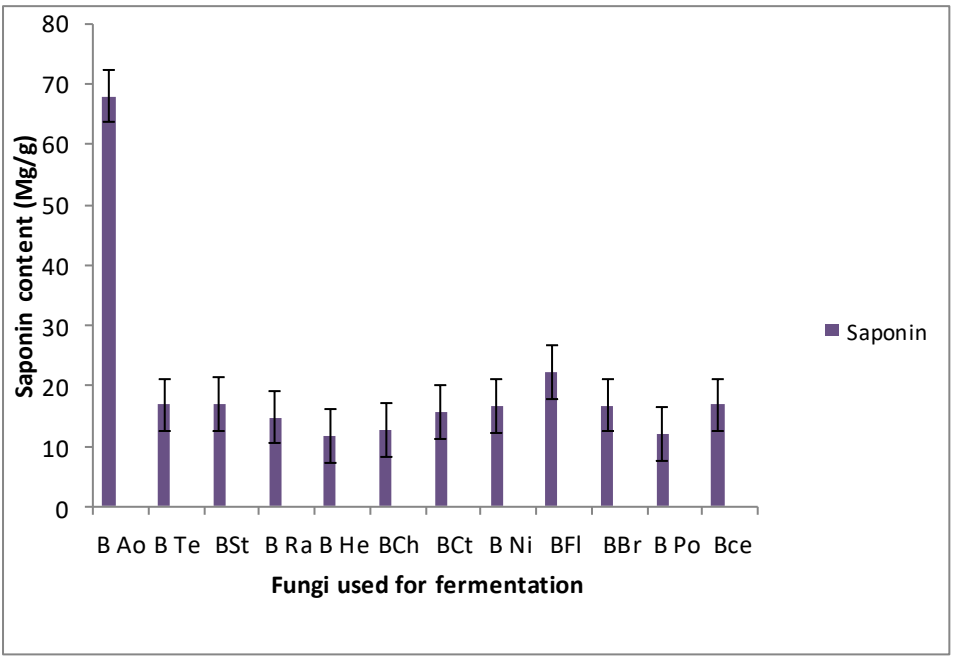
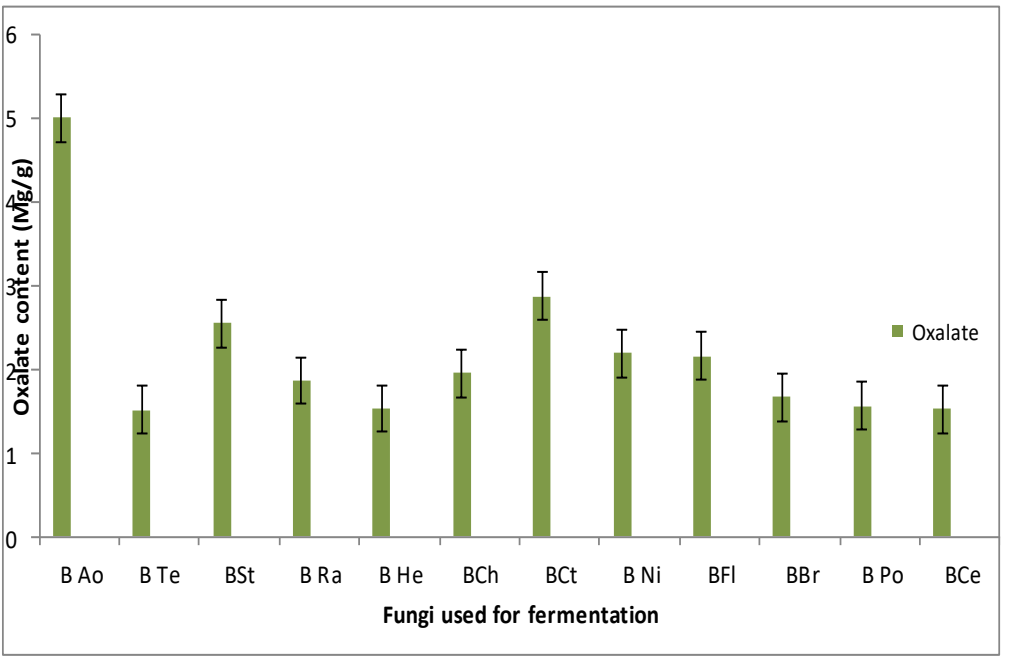
fermented with *Mucor hiemalis;* BCh: baobab fermented with *Penicillium chrysogenum;* BCt: baobab fermented with *Schizosaccharomyces pombe;* BCe: baobab fermented with *Saccharomyces cerevisiae*)

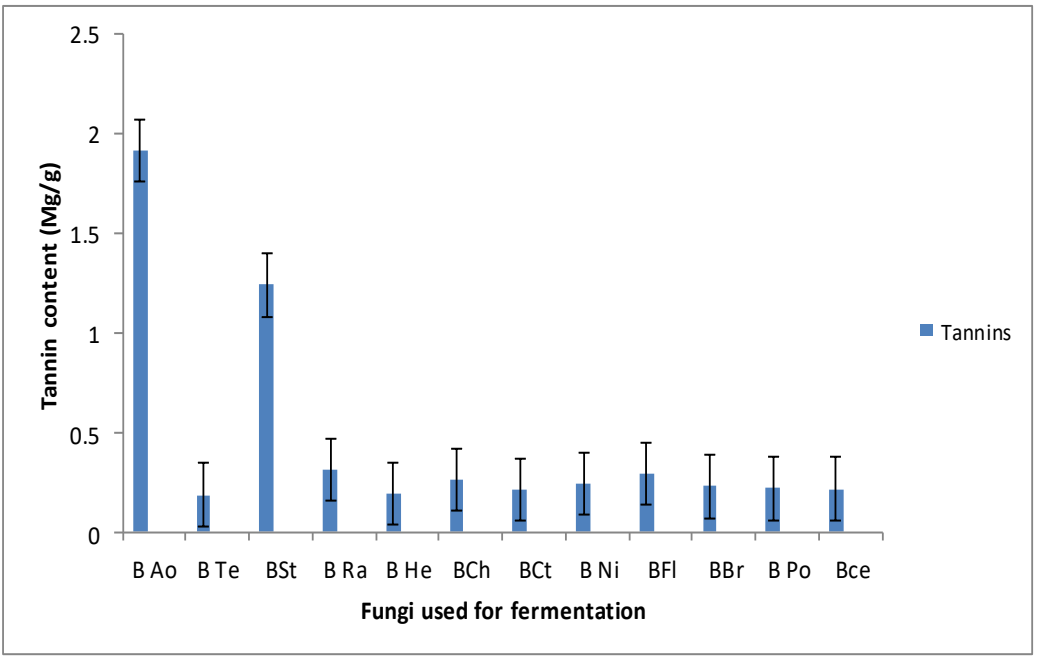


(BAo: unfermented baobab; BTe:Moringa fermented with *Alternaria tenuis*; BSt: baobab fermented with *Rhizopus stolonifer; B*RA: baobab fermented with *Mucor racemosus;* BHi: baobab fermented with *Mucor hiemalis;* BCh: baobab fermented with *Penicillium chrysogenum;* BCt: baobab fermented with *Penicillium citrinum;* BNi: baobab fermented with *Aspergillus niger;* BFl: baobab fermented with *Aspergillus flavus;* BBr: baobab fermented with *Scopuloriopsis brevicaulis;* BPo: baobab fermented with *Schizosaccharomyces pombe;* BCe: baobab fermented with *Saccharomyces cerevisiae*)



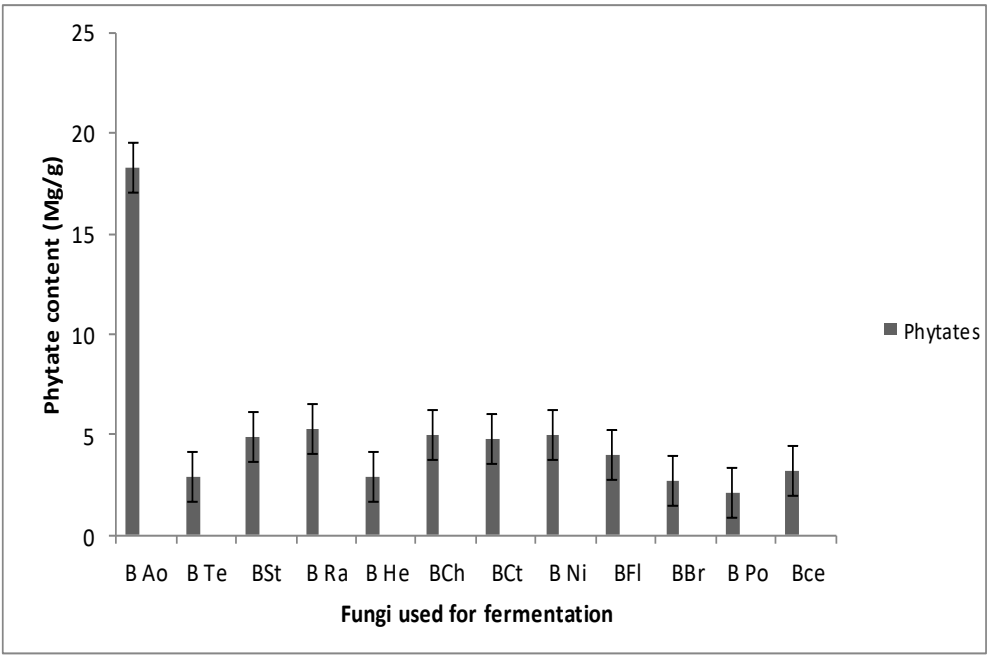
Data are means of two replicates ± SEM.
Figure 3: Tanin content of mono-culture fungal fermented *Adansonia digitata*

(BRO: unfermented baobab; BTe:Moringa fermented with *Alternaria tenuis*; BSt: baobab fermented with *Rhizopus stolonifer; B*RA: baobab fermented with *Mucor racemosus;* BHi: baobab fermented with *Mucor hiemalis;* BCh: baobab fermented with *Penicillium chrysogenum;* BCt: baobab fermented with *Penicillium citrinum;* BNi: baobab fermented with *Aspergillus niger;* BFl: baobab fermented with *Aspergillus flavus;* BBr: baobab fermented with *Scopuloriopsis brevicaulis;* BPo: baobab fermented with *Schizosaccharomyces pombe;* BCe: baobab fermented with *Saccharomyces cerevisiae*)



Data are means of two replicates ± SEM.
Figure 4: Tanin content of mono-culture fungal fermented *Adansonia digitata*

(BAo: unfermented baobab; BTe:Moringa fermented with *Alternaria tenuis*; BSt: baobab fermented with *Rhizopus stolonifer; B*RA: baobab fermented with *Mucor racemosus;* BHi: baobab fermented with *Mucor hiemalis;* BCh: baobab fermented with *Penicillium chrysogenum;* BCt: baobab fermented with *Penicillium citrinum;* BNi: baobab fermented with *Aspergillus niger;* BFl: baobab fermented with *Aspergillus flavus;* BBr: baobab fermented with *Scopuloriopsis brevicaulis;* BPo: baobab fermented with *Schizosaccharomyces pombe;* BCe: baobab fermented with *Saccharomyces cerevisiae*)



Data are means of two replicates ± SEM.

Figure 5: Phytate content of mono-culture fungal fermented *Adansonia digitata*

(BAo: unfermented baobab; BTe:Moringa fermented with *Alternaria tenuis*; BSt: baobab fermented with *Rhizopus stolonifer; B*RA: baobab fermented with *Mucor racemosus;* BHi: baobab fermented with *Mucor hiemalis;* BCh: baobab fermented with *Penicillium chrysogenum;* BCt: baobab fermented with *Penicillium citrinum;* BNi: baobab fermented with *Aspergillus niger;* BFl: baobab fermented with *Aspergillus flavus;* BBr: baobab fermented with *Scopuloriopsis brevicaulis;* BPo: baobab fermented with *Schizosaccharomyces pombe;* BCe: baobab fermented with *Saccharomyces cerevisiae*)

Discussion

The valuable nutrients in the fermented seed such as crude protein, mineral ash and total carbohydrate were increased after fermentation. This improvement can be attributed to the amylolytic and proteolytic activities of the fungi involved during growth in the process of fermentation. These enzymes were involved in breaking down complex organic molecules into simpler ones such as glucose and amino acids. The product of the enzymes is also utilized by the organisms for their own metabolic activities [28]. Moreover the noticeable increase in crude protein in the mono-culture fermented seed could also be attributed to the addition of mycoprotein (single cell protein), non-protein nitrogen amide and nucleic acid synthesized by fungal cells during growth [19]. The improvement observed could be due to the breaking down of the complex organic carbon compound in the seed hence the increase in glucose and decrease in crude fiber and fat content [29]. However the

available carbohydrate and lipid in the fermented seed was still sufficient to meet the daily requirement for animal feed, also they are now in a readily accessible form upon consumption by animals when incorporated into food and feeds items. The increase in carbohydrate content may also be attributed to the reduction in the crude fibre content. During fermentation polysaccharides including cellulose, pectin, lignocellulose and starch are broken down by microorganisms thereby reducing the fibre content of such seed. This result was in contrast to that obtained by earlier author on carbohydrate content of fermented *A. digitata* seed [30, 31] but was similar to that obtained by [19, 32, 33] on effect of fermentation on *Mangifera indica* and pigeon pea seed. The improvement in total ash recorded can be attributed to the breakdown of organic complexes like protein tannin complex or calcium oxalate complex in the seed to release the minerals into biologically available form [34]. The inherent antinutrients content was lowered significantly ($p<0.05$) after fermentation. The decrease in tannin, saponins, oxalates and phytate content of *A. digitata* seed could be due to degradation by microbial enzymes that are secreted by the fermenting fungi during growth and metabolism in the process of [35, 31]. These antinutrients are known to occur in complex compounds (protein-tanin complexes, calcium- oxalate complex, phytate and saponin protein complexes and other forms of complexes) in plants where they occur. The formation of these complexes binds protein and minerals in the seed and renders them biologically not available to plants after consumption. The breaking down of these complexes by various amylolytic, proteolytic and lipolytic enzymes produced by these fungi probably led to the reduction in anti-nutrients. Tannins are known to reduce the availability of proteins, carbohydrates and minerals by forming indigestible complexes with the nutrients. The reduction in tannin level due to fermentation could improve the availability of nutrients in the seed [36, 37, 31]. However, this result is contrary to the report of [30] on tannin content after fermentation of *A. digitata* seed. Fermentation has been reported as a means to improve the nutritional quality and drastically reduced anti-nutritional factors to safe level because the process produces enzymes that break down protein-tannin complexes to release free tannins [36]. Similarly the reduction in phytic acid is attributable to increase in the activities of phytase during fermentation. According to earlier report, the series of enzymatic actions terminating with the formation of inositol and phosphoric acid releases certain metals to increase their availability and caused subsequent decrease in phytate and increase in total ash [31, 38]. Moreover, reduction of phytic acid content of some plant products after processing has been reported [39, 40]. Phytic acid has been reported to form complexes with proteins (protein-phytate complex) [41] and chelates essential dietary minerals such as iron, zinc, calcium and magnesium, thus decreasing their utilization.

Furthermore, saponins has been shown to affect animal nutrition, performance and metabolism through erythrocyte haemolysis, depression of growth rate, bloat (ruminants), inhibition of smooth muscle activity, alter cell wall permeability and therefore produce some toxic effects when ingested, cause enzyme inhibition and reduction in nutrient absorption if it occurs beyond certain level in feed. [42]. Saponin content of *A. digitata* seed was significantly ($p<0.05$) decreased after fermentation. The finding was similar the report of [43, 38].

High occurrence of oxalates in feeds, has been previously shown to bind minerals like calcium and magnesium and interfere with their metabolism, cause muscular weakness and paralysis, gastrointestinal tract irritation, blockage of the renal tubules by calcium oxalate crystals, development of urinary calculi and hypocalcaemia [44]. Oxalates (22 fermented *A. digitata* seeds reduced significantly after fermentation with the isolated fungi. Fermentation and other methods of processing have been reported to decrease the oxalate content of food [45]. [19] however reported an increase in oxalate content of mango kernel cake fermented by *A. niger.*

Conclusion

Monoculture fungal fermentation has desirable effects on the seed of *A. digitata*. Fermented seed could therefore be considered as an alternative, supplement or additional protein source for propounding animal feed. This will tremendously reduce the cost of feeding in animal production and also reduce the competition between man and animal for the available staple food. However only fungi without history of poisoning or production of harmful metabolites should be employed for the fermentation.

References

[1] D. Dhanasekaran, S. Lawanya, S. Saha, N. Thajuddin and A. Paneerselvam. Production of Single Cell protein from Pineapple waste using yeast. *Innovative Romanian Food Biotechnology* 8 2011.

[2] N. Vietmeyer and J. Janick. New Crops. Pages 2 – 8. In: Proceedings of The Third National Symposium of American Society of Horticultural Scientist, Alexandria, USA. 1996.

[3] E. A. Oelke, R. A. Porter, R. A. W. Grombache, and P. B. Addis. Wild Rice – New Interest in an Old Crop. *Cereal Foods World*, 42(4) 1997.

[4] F. N. Madubuike, P.C. Ojimelukwe and P.O. Ajah. Proximate Composition, Energy Content And Physicochemical Properties of Afzelia Africana And Brachystegia Eurycoma Seeds. *Plantsfoods For Human* Nutrition,46. 1994.

[5] S.S. Murray, M. J. Schoeninger, H.T. Bunn, T.R. Pickering and J.A. Marlett. Nutritional Composition of Some Wild Plant Foods and Honey Used By Hadza Foragers of Tanzania. *Journal of Food Composition And Analysis*, 14. 2001.

[6] T. Longvah, Y.G. Deosthale. and P. U. Kumar Nutritional and Short-Term Toxicological Evaluation Of Perilla Seed Oil. *Food Chemistry*, 70. 2000

[7] H. Saina. Guinea fowl production under smallholder farmer management in Guruve District, Zimbabwe. Department of Animal Science, Faculty of Agriculture, University of Zimbabwe, Harare. 2003.

[8] J.K. Chavan and S.S. Kadam. Nutritional improvement of cereals by fermentation. *Crit. Rev. Food Sci. Nutr.* 28. 1989.

[9] A. Pandey. Solid-State Fermentation. *Biochemical Engineering Journal* 13. 2003.

[10] L. P. Ooijkaas, F. Weber, R. M. Buitelaar, J. Tramper and A. Rinzema. Defined media an inert supports: their potential as solid-state fermentation production

system. Trends in Biotechnology 18. 2000.

[11] M. Sidibe and J. T. Williams. Baobab. Adansonia digitata.Book published by the International Centre for Underutilised Crops, Southampton, UK. 2002.

[12] M.A. Osman. Effect of different processing methods on nutrient composition, anti- n 23 factors and in vitro digestibility on *Dolichos lablab* bean (*Lablab purpureus* (*L*) *Sweet*). *Pak. J. Nutr*. 6(4). 2007.

[13] M. Messina and V. Messina. A contributing paper to cancer resource foundation bulletin,U.S.A 1;59(3). 1999.

[14] J. Proll, K.J. Petske, I. E. Ezeagu and C.C. Metges. Low Nutritional Quality of Unconventional Tropical Crop Seeds in Rats. *Journal of Nutrition*, 128, 1998.

[15] M. A. Osman. Chemical and Nutrient Analysis of Baobab (*Adansonia digitata*) Fruit and Seed Protein Solubility. *Plant Foods for Human Nutrition* 59.

Springer Science+Business Media, Inc. 2004a.

[16] M.A. Osman. Changes, in sorghum enzyme inhibitors, phytic acid, tannins, and in vitro protein digestibility occurring during Khamir (local bread) fermentation. *Food Chem*. 88, 2004b.

[17] E. De Caluwe, K. Halamova and P.Van Damme. *Adansonia digitata* L. A review of Traditional Uses, Phytochemistry and Phamacology. AFRIKA FOCUS, 23(1). 2010.

[18] T.E. Lawal, E.A. Iyayi and F. A. Aderemi. Biodegradation of groundnut pod with extracted enzymes from some isolated tropical fungi: growth responses and carcass quality of broilers finisher birds.Proceedings of Annual Conf Anim Sci Ass. of Nig. (ASAN). 2005.

[19] R. M. O. Kayode and A. Sani. Physicochemical and proximate composition of mango (*Mangifera indica*) kernel cake fermented with mono-culture of fungal isolates obtained from naturally decomposed mango kernel. *Life Science Journal*, Vol 5, No 4, 2008.

[20] R. A. Samson and S.E.Van Reen-Hoekstra. Introduction to Food Borne Fungi. 3rd Edition. Albureay Schimmenculture, Netherlands. 299.1988.

[21] A. Sani, F.A. Awe and J.A. Akinyanju. Amylase synthesis in *Aspergillus flavus* and *Aspergillus niger* grown on cassava peel. *J Ind Microbiol*; 10. 1992.

[22] AOAC. (2000). Official method of analysis. 15th Edition. Association of Official Analytical Chemists. Washington D. C. 1990.

[23] Zazueta- Murales, J J., Sapiens, L., Ordorica, C.A., Baez, R., Torres, J.V. and Anzaldua-Murales (2006). Physiochemical and nutritional characterization of mango kernel (*Magnifera indica*) C V, Kent, for food purpose Universidad Autonoma De Sinaloa, Culiacan, Mexico.

[24] Makkar, H. P. S., Siddhuraju, P. and Becker, K. (2007). Plant secondary metabolites. Humana Press Inc., Totowa, NJ, USA.

[25] Iwuoha, C.I. and Kalu, F.A. (1995). Calcium-oxalate and physico-chemicalproperties of cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifilium*) tuber flours as effected by processing. Food Chemistry; 54(1).

[26] Padmaja, G. (1989). Evaluation of Techniques to reduce Assayable

Tannin and Cyanide in Cassava leaves. *Journal of Agric. Food Chemistry*. 37

[27] G. Ma, Y. Jin, J. Piao, F. Kok, B. Guusje and E. Jacobsen. Phytate, Calcium, Iron and Zinc content and their molar ratio in foods commonly consumed in China. *Journal of Agric. Food C* 24 53. 2005.

[28] S. M. Odetokun. Effect of fermentation on some physico – chemical properties, antinutrients and in vitro multienzyme digestibility of selected legumes. Ph.D. Thesis, Federal University of Technology, Akure, Nigeria. 2000

[29] C. E. Chinma, O. Adewuyi and O.J. Abu. Effect of germination on the chemical, functional and pasting properties of flours from brown and yellow varieties of tiger nut (*Cyperus esculentus*). *Food Research International* 42. 2009.

[30] E. O. H. Addy, L. I. Salami, L. C. Igboeli and H.S. Remawa. Effect of processing on nutrient composition and anti-nutritive substances of African locust bean (*Parkia filicoidea*) and baobab seed (*Adansonia digitata*). *Plant Foods for Human Nutrition*, 48. 1995.

[31] N. M. Nnam and P.N. Obiakor. Effect of fermentation on the nutrient and antinutrient composition of baobab *(Adansonia digitata)* seeds and rice *(Oryza sativa)* grains. *Ecology of Food and Nutrition*, 42. 2003.

[32] R. M. O. Kayode, A. Sani and F. L. Kolawole, Physico-chemical analysis and nutrient retention of mixed-culture fungal fermented mango (*Mangifera indica*) kernel cake in cockerels. *African Journal of Biotechnology* Vol. 9(36). 2010.

[33] Adebowale, O.J. and Maliki, K. (2011).Effect of fermentation period on the chemical composition and functional properties of Pigeon pea *(Cajanus cajan)* seed flour. *International Food Research Journal* 18(4). 2011.

[34] A. O. Ojokoh. Effect of fermentation on the chemical composition of mango (*Mangifera indica* R) peels. *Journal of Food Composition and Analysis*, 10. 2007

[35] L.C. Igboeli, E. O. H. Addy and L. I. Salami. Effects of some processing techniques on the antinutrient contents of baobab seeds (*Adansonia digitata*). *Biores. Technol*., 59. 1997.

[36] C. Ikemefuna, J. Obizoba and J.V. Atii. Effects of soaking, sprouting, fermentation and cooking on nutrient composition and some antinutritional factors of sorghum (*Guinesia*) seeds. *Plant foods for Hum. Nutr*., 41. 1991.

[37] I. C. Obizoba and N. A. Amaechi. The effect of processing methods on the chemical composition of baobab *(Adansonia digitata* L.*)* pulp and seed. *Ecology of Food and Nutrition*, 29. 1993.

[38] C. M. Uchegbu, C. Okere, I.P. Ogbuewu, I. C. Ifeanyi C. H. Nwaodu, C. T. Ezeokeke and G. A. Anyanwu. Evaluation of Proximate and Phytochemical Compositions of Fermented Raw and Fermented *Napoleona Imperialis* Seed and Their Feeding Values on Finisher Broilers. Nature and Science. 2010.

[39] J. Liange, B. Han, M. J. Nout and R. J. Hamer. Effect of soaking, germination and fermentation on phytic acid, total and in vitro soluble zinc in brown rice. *Food Chem.* 110. 2008.

[40] M.O. Nuha, A. M. A. Isam and E. B. Elfadil. Chemical composition, antinutrients and extractable minerals of Sicklepod (*Cassia obtusifolia*) leaves as influenced by fermentation and cooking. *International Food Research Journal* 17. 2010

[41] K. E. Akande, U. D. Dc[illegible] H.O. Agu and H. M. Adam 25 Antinutrients Found in Plant Protein Sources: Their Effect on Nutrition. *Pakistan Journal of Nutrition* 9 (8). 2010.

[42] R. Belmar, R. Nava-Montero, C. Sandoval-Castro and J. M. McNab. Jack bean (*Canavalia ensiformis* L. DC) in poultry diets: antinutritional factors and detoxification studies – a review. *World´s Poultry Science Journal*, Vol. 55. 1999.

[43] H. A. Umaru, R. Adamu, D. Dahiru and M. S. Nadro. Levels of anti - nutritional factors in some wild edible fruits of Northern Nigeria. *African Journal of Biotechnology*. 6(16). 2006.

[44] D. B. Oke, B. L. Fetuga and O.O. Tewe. Effect of autoclaving on the anti-nutritional factors of cowpea varieties. *Nigerian Journal of Animal Production* 23. 1996.

[45] A. S. Adeboye and J. M. Babajide. Effect of processing methods on antinutrients in selected leafy Vegetables. *Nigerian Food Journal*. 25(2). 2007.