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EFFECTS OF FERMENTATION PERIOD ON THE FUNCTIONAL, ANTI-NUTRIENT AND SENSORY EVALUATION OF OFOR D. MICROCARPUM A PREDOMINANT SOUP THICKER AMONG HOUSEHOLD

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ABSTRACT

This study determined the effect of fermentation periods (24, 48 and 72 h) on the functional properties, anti-nutrient and sensory evaluation of ofor D. microcarpum a predominant soup thicker among households. D. microcarpum seeds was produced into flour after fermentation at different time intervals (24, 48 and 72 h). Samples were analyzed for the functional properties and anti-nutrient composition using standard laboratory methods. The differently fermented D. microcarpum seeds were milled and used to prepare soups. sensory evaluation of the soups where conducted using A 9-point Hedonic scale. Results of the anti-nutrient analysis revealed that increased fermentation time significantly ($p<0.05$) decreased the tannin (0.44-0.10mg/g) and oxalate (0.14-0.08 mg/g) contents of the D. microcarpum seed while phytic acid content (8.78-9.11 mg/g) was not significantly ($p>0.05$) affected. Functional properties showed packed and loosed bulk densities to range between 0.34-0.47 ml/g and 0.46-0.75 ml/g with sample B (D. microcarpum fermented for 24 h) as highest in both cases. Solubility and water absorption capacity ranged from 26.50-34.81% and 2.57-4.89 g/g with sample C D. microcarpum fermented for 48 h and Samples A (unfermented) and B having the highest, respectively. Viscosity of the D. microcarpum seeds decreased as fermentation time increased with values ranging from 68.01-71.72 pa.S Taste and appearance of the D. microcarpum soup prepared from the D. microcarpum flour increased as the fermentation time decreased. Fermentation time had no significant ($p>0.05$) effect on all the sensory parameters studied. This showed that the soups irrespective of the fermentation time of D. microcarpum seeds were acceptable by the panelists. These findings underscore the potential of optimized fermentation practices to enhance the functional, and sensory attributes of D. microcarpum seed, thereby promoting its utilization in household food preparations. The outcome of this study indicated that results for viscosity and sensory evaluation for 24h soaking time showed no significant difference. The study therefore, recommends 24h fermentation period in order to prevent possible microbial spoilage that will affect the health of households negatively.

Keywords: Ofor; Fermentation time, Functional; Antinutrient., Sensory Evaluation

1. INTRODUCTION

Soup thickener are ingredient used by households to give soup a thicker, more substantial texture to elevate the overall mouthfeel and flavor of the soup, making it more satisfying and enjoyable to eat. Thickening agents are compounds that when added to a mixture specifically soups increase its viscosity while leaving other attributes untouched. Food condiments used as thickeners are globally used to provide certain textures, flavor and consistency to meals consumed by households. Households represents collective groups of individuals residing in shared accommodation and functioning as a consuming unit within a specific physical setting (China *et al, ,2020*). There are several types of local soup thickeners utilized by households each with its own unique properties and uses. Popular soup thickeners in Nigeria are cocoyam (Colocasie escculenta) , ukpo (*mucuna flagellipes*) , achi (*Brachystegia eurycoma*) , White yam (*Diioscorea alata*) Akpalata (*Afzelia Africana*) , corn flour, corn starch, ofor *Detarium microcarpum*, among other (Lawal , *et al* 2022). Ofor D. microcarpum, a leguminous tree seed as a soup thicker, represents one of such potential nutritional powerhouses that has received limited attention. *D. microcarpum* is an African tree classified within the Fabaceae family (Dayamba *et al*., 2016; Gaisberger *et al*., 2017), which is commonly referred to as sweet detar. In the cultural context, it is known as 'abu laila' in western Sudan, 'dank' in Senegal, 'tambadala' in Mali, and 'ofor' in southeastern Nigeria (Aviara, 2015). Indigenous to arid regions in central and western Africa, this species can attain heights of up to 15 m, reaching 25 m in areas with substantial rainfall (Padonou *et al*., 2015). 9 D. microcarpum holds significance as a traditional remedy, recognized for its medicinal attributes in treating ailments such as diarrhea, meningitis, tuberculosis, and hemorrhoids (Meda *et al.,* 2017). The edible fruit and leaves of *D. microcarpum* have served as both a condiment and vegetable within various African tribes. Additionally, in certain African nations, the seeds are processed into flour, conventionally employed as an emulsifying and thickening agent due to its elevated carbohydrate content (Aviara, 2015). Analysis of *D. microcarpum* seeds reveals approximately 7.5% oil content and a significant gum composition comprising water-soluble polysaccharides. De-hulled seed flour boasts a composition of 2.9% crude fiber, 3.5% moisture, 3.5% ash, 37.1% crude protein, and 39% carbohydrates (Hassanin *et al*., 2018). Furthermore, the fruit of *D. microcarpum* is a notable source of vitamin C (3.2 mg/100 g) and contains around 4.8 g/100 g of protein. Notably, the fruit comprises up to 64.5 g/100 g of sugar, with sucrose, raffinose, glucose, fructose, and stachyose identified as the primary soluble sugars in alcoholic extracts of dehulled flour. According to Hassanin *et al*. (2018), *D. microcarpum* fruit boasts the highest concentration of antioxidants, flavonoids, and total phenols among 14 types of African fruits.

Despite the nutritional richness of *D. microcarpum*, its consumption and integration into mainstream diets face challenges primarily associated with the presence of anti-nutritional factors. These factors, including phytates and tannins, can limit the bioavailability of essential nutrients, posing a potential impediment to the optimal utilization of the nutritional potential of *D. microcarpum*. In response to these challenges, traditional food processing methods, such as fermentation, have been recognized as effective means to enhance the nutritional quality of various food sources. Many researchers have reported that processing legumes and seeds by fermentation decrease the anti-nutrients, improve nutritional value, digestibility and leads to increased bioavailability of the minerals (Oloyede *et al*.,

2015; Ujong and Emelike, 2023). In developing countries like Nigeria, attention is being drawn to harness low cost but, quality plant proteins to combat protein energy malnutrition and enhance nutrition and food security of the teeming household population. While the application of fermentation to enhance the nutritional quality of staple foods is well-documented, the specific impact of varying fermentation periods on the functional properties, anti-nutrient content, and sensory characteristics of Ofor flour remains an underexplored area of research.

The aim of the study is to determine the effect of fermentation periods on the functional properties, anti-nutrient and sensory evaluation of D. microcarpum flour. This research hypothesizes that fermentation of D. microcarpum would increase the digestibility of the proteins, reduce anti-nutritional factors, and enhance the flavour and colour of the flour. Establishing the optimum fermentation periods for D. microcarpum is essential for its successful incorporation into local diets, with the ultimate goal of fostering increased household consumption hence, the need for this study.

2. MATERIALS AND METHODS

2.1. Materials

Dehulled D. microcarpum seeds were purchased from Mile 3 market in Port Harcourt, Rivers State, Nigeria. Reagents and other supplies were acquired from the Department of Food Science and Technology Laboratory, Rivers State University.

2.2. Processing of D. microcarpum Flour

Unfermented: The dried seeds were sorted, washed and dried in a hot air oven at 70^{o}C overnight and then milled to flour using a hammer mill. The dried D. microcarpum flour was thereafter packaged in an airtight container until required for further analysis.

Fermented: The seeds were sorted, washed and soaked in distilled water to ferment for 24 h, 48 h and 72 h, respectively. After fermentation, the seeds were washed in clean water, dried in a hot air oven at 70^{o}C overnight and then milled to flour using a hammer mill (Amandikwa et al., 2015). The flow chart diagram is shown in figure I

Fig 1. Processing of D. microcarpum flour at different fermentation periods

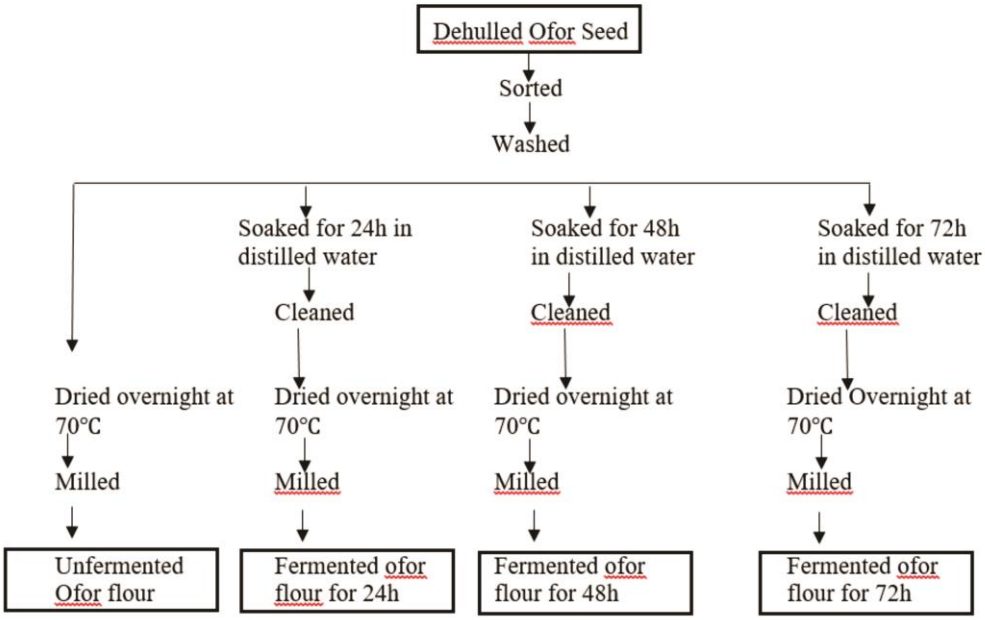

Fig1: Processing of ofor D. microcarpum flour at different fermentation periods source: Amandikwa et al. (2015)

2.3. Anti-nutrient;

Many plants species according to Jyota and Simran, (2023) have been endured by nature with the ability to create variety of chemical compounds that operates as a defensive strategy against insects, bacteria, animal and human that consumed them. As aresult, many of the chemicals may have negative effect on the human body when taken, Anti-nutrients are plant compound found in foods that can interfere with absorption of beneficial nutrients. The major anti nutrient are phytates, tannin, lactins, oxalatea etc. they are extremely bioactive capable of affecting the health human positively or negatively health and they are mostly found in plant- based foods. Awulachew *et al* ,(2022) cited in Jyota and Simran, (2023) noted that, these antinutritional factors are substances that inhibit nutrient intake, digestion, absorption and utilization as well as having negative consequences in human body

2.3.1. Quantification of Phytate Content

To assess the levels of phytate, the method outlined by Russell (1980) was employed. In a 250 ml conical flask, 0.5 g of the sample was combined with 25 ml of 2% concentrated HCl. After a three-hour soaking period, the mixture underwent filtration. To modify the acidity, 25.75 ml of distilled water was introduced to the filtrate (10.5 ml) in a 250 ml beaker. Additionally, 2.5 ml of 0.35 ammonium thiocyanate solution served as an indicator. Standard iron iii chloride ($FeCl_3$), with a concentration of 0.00195g iron/ml, was utilized to titrate the solution until a brownish-yellow color persisted for 5 minutes. The phytic acid content was calculated using the formula:

Phytic acid (g⁄kg) =0.00195 ×volume of FeCl3 consumed ×Dilution factor Sample weight×1000

2.3.2. Quantification of Oxalate Content

To determine oxalate levels, the titration technique as described by Munro (2000) was applied. One gram (1g) of the sample and 75 ml of 3N H_2SO_4 were weighed into a 250 ml conical flask. Two drops of methyl red indicator were added to the filtered solution before pipetting 25 ml into a beaker for filtration using Whatman No. 1 filter paper.

The resulting solution was brought to a boil and then titrated against a 0.05M $KMnO_4$ solution while still hot, until a very light pink color remained for at least 30 seconds. Oxalate concentration was determined by assuming that 2.2mg of oxalate is present in 1 ml of 0.05M $KMnO_4$. The formula used for calculating oxalate content is: Oxalate (mg/100g) = Titre value × 2.2 × Dilution factor.

2.3.3. Determination of Tannin

Tannin content was determined using the method of Jaffe (2003). One gram (1.0g) of dry well blended sample was weighed into a flask and 10ml of distilled water added and agitated. The mixture was left to stand for 30 min at room temperature and thereafter centrifuged at 2500rpm for 15min. One milliliter (1.0 ml) of supernatant was measured into a 10 ml volumetric flask followed by addition of 1 ml of Folin-Ceocalteu reagent. One milliliter (1.0 ml) of saturated Na_2CO_3 solution was also added and the solution diluted to 10 ml with distilled water. This was incubated for 30 min at room temperature and the standard tannic acid prepared. The method was repeated for tannic acid standards 20, 40, 60, 80, 100 and 120mg/l from a stock of 500 ppm (50mg of tannic acid standard dissolved in 100ml of distilled water) excluding centrifugation. The absorbances of the tannic acid concentrations were read off at a wavelength of 725nm. The calibration curve for the tannic acid standards was drawn i.e., absorbance against concentration. The tannic acid concentration of the sample was extrapolated by tracing the absorbance of the sample down the concentration axis.

Tannic acid content (mg/kg) = Concentration galvalume of sample ×DF Sample weight (1000mg) ×100

DF= Dilution factor

2.4. Functional Analysis

2.4.1. Water Absorption Capacity

Water absorption capacity was determined following the method described by Sathe and Salunkhe (1981). One gram of the sample was mixed with 10ml of distilled water, allowed to stand for 30 minutes, and then centrifuged. The water absorption capacity was calculated using the formula: Water Absorption Capacity (WAC) =W2-W1W0

Where W0 is the weight of the dry sample, W1 is the weight of the tube plus the dry sample, and W2 is the weight of the tube plus the sediment.

2.4.2. Bulk Density

Bulk density was determined according to AOAC (2012). A pre-weighed centrifuge tube was filled with the sample, tapped on the bench, and continually filled until it reached a constant volume at 5ml. Bulk density was calculated using the formula:

Bulk density (g/ml) = Weight of sample volume of sample ml

2.4.3. Oil Absorption Capacity

Oil absorption capacity was determined following the method by Sathe and Salunkhe (1981). One gram of the sample was mixed with soy oil, allowed to stand, and then centrifuged. Oil absorption capacity was calculated using the formula:

Oil Absorption Capacity (OAC) =V1-W22.5 ml

Where V1 is the initial volume of oil used, and V2 is the volume of supernatant oil.

2.4.4. Solubility: Solubility of D. microcarpum flour was determined following the method by Robertson et al. (2000). Two grams of the sample were mixed with 20ml of distilled water, heated in a water bath, and centrifuged. Solubility was calculated using the formula:

% Solubility = Weight of supernatant ×100Weight of sample incubated

2.4.5. Viscosity

Five grams of the sample were mixed with 500ml of distilled water, stirred continuously while heating until thickened, and viscosity was measured using a viscometer with readings taken at low-3 and high-6.

2.5. Sensory Analysis

Simple Hedonic test, as outlined by Iwe (2010) was used to determine the consumer acceptability of the soup prepared from the differently processed ofor flour. Twenty (20) students from the Food Science and Technology and Home Science and Management Departments were recruited to serve as panelists; all of them had experience with ofor soup. The extremes of liking and disliking were measured using a 9-point Hedonic scale. Appearance, taste, aroma, thickness, and overall acceptance were some of the attributes considered.

2.6. Statistical Analysis

The data obtained was subjected to analysis of variance (ANOVA) using (SPSS) version 20.0 software 2007. All analysis was done in duplicate. The measure of central tendencies and dispersions was determined and Duncan Multiple Range Test (DMRT) was used to separate the mean.

RESULTS

Anti-nutrient Composition of Fermented and Unfermented D. microcarpum Seeds

Table 1 shows the anti-nutrient composition of D. microcarpum seeds at different fermentation periods. Oxalate content ranged from 0.08-0.14 mg/g with sample D (D. microcarpum seeds fermented at 72 h) recording the lowest value (0.08 mg/g) while Sample A (unfermented D. microcarpum seeds) which is the control had the highest (0.14 mg/g). Tannin and phytic acid content ranged from 0.44-00 mg/g and 8.78-9.11 mg/g, respectively with the lowest values recorded in sample B D. microcarpum seed fermented at 24 h) while the highest was recorded in sample A (unfermented seeds).

Table 1. Anti-nutrient composition (mg/g) of unfermented and fermented D. microcarpum seeds

Samples	Oxalate	Tannin	Phytic acid
A	$0.14^{a}\pm0.00$	$0.44^{a}\pm0.00$	$9.11^{a}\pm0.01$
B	$0.12^{a}\pm0.02$	$0.24^{c}\pm0.02$	$8.78^{a}\pm0.46$
C	$0.11^{ab}\pm0.00$	$0.13^{b}\pm0.01$	$9.10^{a}\pm0.00$
D	$0.08^{b}\pm0.00$	$0.10^{c}\pm0.01$	$9.10^{a}\pm0.00$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEYS:

A= Unfermented ofor seed; B= Fermented ofor seed (24 h);

C= Fermented ofor seed (48 h) D= Fermented ofor seed (72 h)

Functional Properties of Fermented and Unfermented Ofor Seeds

Table 2 shows the functional properties of ofor seeds at different fermentation periods. Water absorption capacity ranged from 2.57-4.89 g/g with the lowest value (2.57 g/g) recorded in sample D (ofor seed fermented at 72 h) while the highest was recorded in sample A (unfermented seed). Bulk density ranged from 0.46-0.75 ml/g with the highest value recorded in sample B (fermented seed for 24 h) while the lowest value was found in

sample D. Solubility of the ofor seeds ranged from 26.50-34.81% with the lowest value recorded in sample A (unfermented seeds) while the highest value was found in sample D. Viscosity ranged from 68.00 cP in sample B to 71.72 cP in sample A.

Table 2. Functional properties of fermented and unfermented Ofor seeds

Samples	Water Absorption capacity (g/g)	Bulk density (ml/g)	Solubility (%)	Viscosity (cP)
A	$4.89^{a}\pm0.73$	$0.60^{b}\pm0.00$	$26.50^{d}\pm0.71$	$71.72^{a}\pm0.05$
B	$4.87^{a}\pm0.32$	$0.58^{a}\pm0.00$	$29.08^{c}\pm0.32$	$68.00^{b}\pm0.28$
C	$4.81^{a}\pm0.87$	$0.56^{c}\pm0.00$	$34.81^{a}\pm0.72$	$68.01^{b}\pm1.20$
D	$2.57^{a}\pm0.16$	$0.46^{d}\pm0.00$	$31.75^{b}\pm0.35$	$68.62^{b}\pm0.67$

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEYS:

A= Unfermented ofor seed; B= Fermented ofor seed (24 h)

C= Fermented ofor seed (48 h); D= Fermented ofor seed (72 h)

Sensory evaluation of Soups Prepared from Fermented and Unfermented D.microcarpum seeds

Table 3 shows the mean sensory scores of soups prepared from fermented and unfermented ofor seeds. Appearance of the soups ranged from 6.50-7.40 with sample D as the most preferred while sample B was least preferred. Taste of the soups ranged from 6.10-6.75 with sample A as the least preferred while sample D was most preferred. Aroma and thickness of the soups ranged from 6.45-6.85 and 6.15-7.10, respectively. Sample B had the highest mean score for aroma while sample B was lowest for thickness. Overall acceptability of the soups ranged from 6.48 in sample B to 7.00 in sample D which was most preferred. Aroma and thickness of the soups ranged from 6.45 – 6.85 and 6.15- 7.10 respectively with sample B having the highest mean score for aroma and lowest in thickness. Overall acceptability of the samples ranged from 6.48 in sample B to 7.00 in sample D.

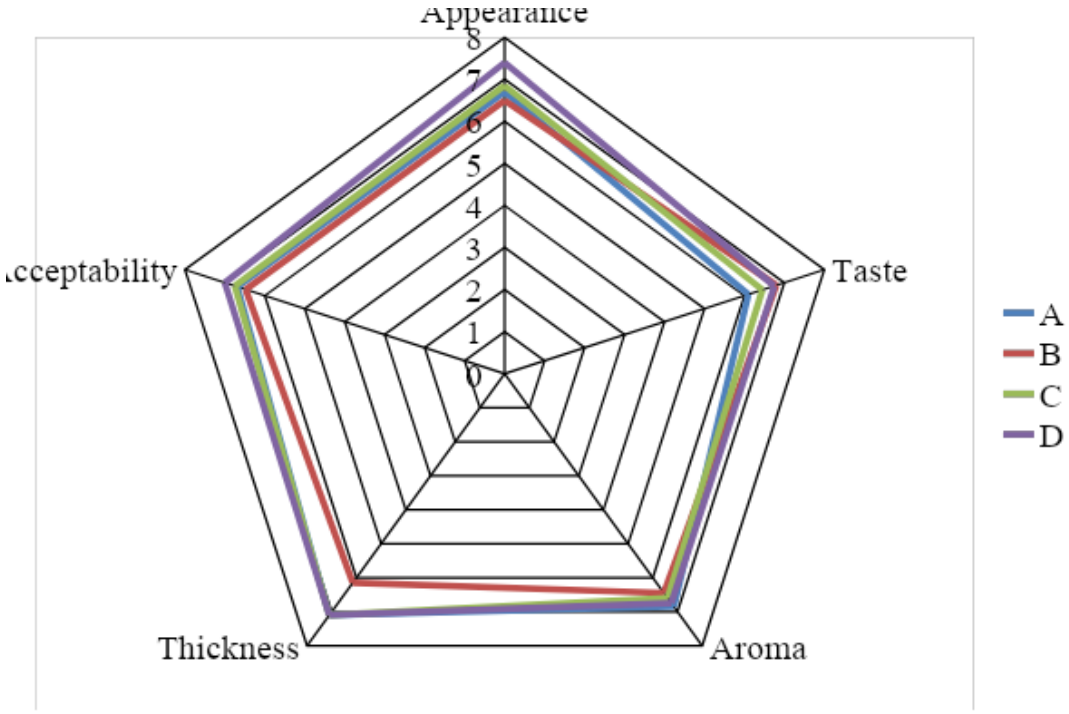

Fig 2. Mean sensory scores of soups prepared from fermented and unfermented D. microcarpum seeds
KEYS:
A= Unfermented ofor seed; B= Fermented ofor seed (24 h)
C= Fermented ofor seed (48 h); D= Fermented ofor seed (72 h)

DISCUSSION

There was a decrease in the oxalate content of the seeds as the fermentation time increase. However, significant ($p<0.05$) effect was observed at 72 h fermentation. This reduction in oxalate content during fermentation can be attributed to enzymatic and microbial activities. Oxalates are known to form insoluble salts with calcium, contributing to the formation of calcium oxalate crystals. Fermentation processes often involve the activation of enzymes and the proliferation of microorganisms that can facilitate the breakdown of oxalates and their subsequent conversion into soluble forms or compounds with reduced bioavailability (Salgado *et al,* l2023). This enzymatic breakdown, along with potential microbial degradation, contributes to the observed decrease in oxalate levels. Ramli *et al*. (2021) also reported a reduction in the oxalate content of *C. ensiformis* as the time for fermentation increased. This was in agreement with Ojha *et al.* (2017) who reported that fermentation significantly reduced the oxalate content of sorghum flour. The implications of reduced oxalate content in D. microcarpum seeds are noteworthy, particularly in the context of nutritional and health considerations. High oxalate levels in foods may pose health concerns, as oxalates are associated with the formation of kidney stones in susceptible individuals (Mitchell et al., 2019). By reducing oxalate content through fermentation, the nutritional quality of ofor seeds may be improved, making them more suitable for consumption, especially for individuals prone to kidney stone formation. Tannin content of the seeds were also observed to decrease significantly ($p<0.05$) as the fermentation time increased. This finding aligns with the study conducted by Anaemene and Fadupin (2022), who

similarly reported a reduction in tannin content of pigeon pea through the process of fermentation. Additionally, Uche (2022) corroborated this trend by documenting a time-dependent reduction in tannin content in *Prosopis Africana* seeds. The decrease in tannin content during fermentation can be attributed to enzymatic activity and microbial action. Tannins are polyphenolic compounds known for their astringent properties and the ability to form complexes with proteins and minerals (Hawashi *et al.* 2019). The fermentation process activates enzymes and encourages the growth of microorganisms, both of which contribute to the breakdown of tannins. Enzymes, particularly tannases, catalyze the hydrolysis of tannins into simpler, less astringent compounds. The possible hydrolizable tannin subdivision is comprised by gallotannins and ellagtannins consisting of gallic acid or ellagic acid. Microbial activity can lead to the degradation or binding of tannins, rendering them less prevalent in the final product (Voidarou *et al.* 2020). Tannins, while possessing antioxidant properties, can also hinder the absorption of essential nutrients, such as iron and protein, and impart undesirable sensory characteristics to foods (Ojo, 2022). Therefore, the reduction in tannin content through fermentation enhances the nutritional quality of D. microcarpum seeds by improving the bioavailability of essential nutrients. Moreover, the decreased tannin levels may positively influence the sensory attributes of the final product. Tannins contribute to bitterness and astringency, and their reduction can lead to an improvement in taste and overall palatability (Remédios *et al.,* 2009). Reduction in tannin content of *Prosopis Africana* seeds as fermentation period increased was also reported by Uche (2022). Phytates are known to be resistant to breakdown by endogenous enzymes and may require specific conditions or additional enzymatic activity for significant degradation (Rizwanuddin *et al.,* 2023). There was also a reduction in the phytate content as the fermentation period increased. The inherent phytase activity in the D. microcarpum seeds may not have been sufficient to drive a significant decrease in phytate levels. Phytates, while contributing to reduced mineral bioavailability, also possess antioxidant properties and have been associated with certain health benefits (Pujol *et al,* 2023). The study suggests that the fermented D. microcarpum product may retain its phytate content, potentially preserving these antioxidant qualities.

There was a decrease in the water absorption capacity of the D. microcarpum seeds as the fermentation time increased. However, this effect was not significant ($p<0.05$). Ramli et al. (2021) also reported a reduction in the water absorption capacity of *C. ensiformis* as the time for fermentation increased. Water absorption capacity is often linked to the hydration and swelling properties of the seed matrix. During fermentation, enzymatic activities and microbial actions contribute to the breakdown of complex structures, potentially affecting the water-binding capacity of the seeds (Awuchi *et al*, 2019; Schopf and Scherf, 2021). Water absorption is a critical parameter in the preparation of various food products, including traditional dishes. Changes in water absorption can influence the texture, consistency, and overall cooking characteristics of the final food product (Awuchi *et al*, 2019).

Bulk densities of the ofor seeds also decreased significantly ($p<0.05$) as the fermentation time increased. This finding aligns with a study conducted by Oloyede *et al*. (2015), which reported a similar decrease in bulk densities of *Moringa oleifera* seeds as fermentation time increased. Enzymatic activities and microbial actions during fermentation can contribute to the

breakdown of structural components in the seeds, leading to a more porous and less dense matrix (Dimidi *et al.,* 2019). Bulk density is a crucial parameter in the handling, storage, and transport of food materials. The reduction in bulk density may enhance the flowability and handling characteristics of the fermented D. microcarpum seeds, making them more amenable to various food processing applications. This is particularly relevant in traditional food preparation methods where the ease of handling and processing can influence the efficiency and practicality of food production.

A significant ($p<0.05$) decrease in the solubility was also observed as the fermentation time increased. The reduction in solubility, a measure of the ability of flour material to dissolve in a given solvent, suggests changes in its molecular structure and interactions (Falade and Okafor, 2015). Enzymatic activities and microbial processes may lead to the breakdown of soluble components or the formation of insoluble compounds, reducing the solubility of the ofor seeds (Dimidi *et al.,* 2019). Solubility plays a crucial role in various processes, including extraction, dissolution, and formulation of products. The reduction in solubility of the ofor seeds may impact the functionality in certain applications, influencing its suitability for specific industrial or culinary purposes.

Viscosity of the D. microcarpum seeds also decreased significantly ($p<0.05$) as the fermentation time increased. This is in agreement with the study of Igbabul *et al.* (2014) who reported decreased viscosity of Mahogany bean with increased fermentation time. This decreased was attributed to the breakdown of complex carbohydrate into simple sugars and compounds. Viscosity plays a crucial role in determining the texture and mouthfeel of food products. The decrease in viscosity may lead to a smoother and more fluid texture, potentially influencing the sensory attributes of foods prepared from fermented D. microcarpum seeds. This alteration in texture can be particularly relevant in the context of traditional dishes, as it may impact the overall acceptability and palatability of the final product.

Sensory results revealed an improvement in the appearance and taste of the soups prepared with fermented D. microcarpum seeds. Increased fermentation time of the seeds also resulted in an improvement in the appearance and taste of the final product. However, this effect was not significant ($p<0.05$). Fermentation involves the activity of microorganisms and enzymes, leading to the breakdown of complex compounds into simpler ones (*Sharma et al.,* 2020). This process can result in the development of savory and umami flavors, contributing to an enhanced taste profile in the soups. The breakdown of pigments and other compounds during fermentation can influence the color of the soups. An improvement in color, which is part of the overall appearance, may contribute to a more visually appealing presentation, influencing the perceived taste. The consistent acceptability of all soups, irrespective of fermentation time, is a positive outcome, indicating that even shorter fermentation durations yield products that meet the sensory expectations of the panelists.

CONCLUSION

The results demonstrated notable changes in several parameters, shedding light on the effects of fermentation on the anti-nutrients, functional, and sensory attributes of D. microcarpum seeds. Increase in the fermentation time resulted in reduction in the oxalate, tannin, and phytate of the of D. microcarpum seeds, which could lead to

improved bioavailability of essential nutrients. The decrease in water absorption capacity, bulk density, solubility, and viscosity could influence the textural and processing characteristics of foods prepared from fermented D. microcarpum seeds, presenting both challenges and opportunities for specific applications. Sensory evaluation indicated an improvement in the appearance and taste of soups prepared from fermented D. microcarpum seeds. While the effect of fermentation period on the sensory attributes where not significant, the overall acceptability of the soups remained consistent across different fermentation durations. This suggests that even shorter fermentation periods yield products that are acceptable to consumers, highlighting the potential for incorporating fermented D. microcarpum seeds into local diets. The study highlights the need for careful consideration of fermentation period as longer fermentation period may encourage microbial growth. The study recommended 24h fermentation period to maximize the nutritional benefits while mitigating potential drawbacks associated with anti-nutrient factors.

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