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Effect of Fermentation on the Functional and Chemical Properties of African Star Apple Seed Flour

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ABSTRACT

African star apple seeds were fermented and processed into flour at different periods of 24, 48 and 72 h respectively with an unfermented African star apple seed flour as the control. The functional properties, pasting properties, antioxidant activity, antinutritional and proximate composition of the flours were determined. The functional properties of the flour samples showed that bulk density ranged from 0.56g/ml-074 g/ml. There was a significant decrease in bulk density with increase in fermentation time. There was also a significant increase in water absorption capacity and oil absorption capacity with increase in fermentation time which ranged from 180-237% and 130-170% respectively. However, swelling index and dispersibility ranged from 2.00-3.00% and 30-43.33% respectively. The pasting properties of African star apple seed flour ranged between 29.75-111.42 RVU for peak viscosity, 23.83-83.33 RVU for trough viscosity, 42.00-109.58 RVU for final viscosity which shows a significant increase with increasing fermentation time. Antioxidant activity which includes DPPH, FRAP, ABTS ranged from 19.75– 40.61%, 0.37– 0.40 mg$FeSO_4$/g, 30.07 - 40.51mgTE/g respectively while Phytochemical properties revealed that total tannin content were negligible, total flavonoids content, total phenolic content ranged from 0.04– 0.11mgCE/g and 0.05–0.18 mg CE/g respectively. The proximate composition showed reduction in ash and fibre contents while there were increase in protein and fat contents with fermentation periods. Fermentation of African star apple for 48 h showed increase in antioxidant and protein contents while fermentation for 72 h improved the functional and pasting properties of the seed flour.

Keywords: African star apple, Functional properties, Pasting properties, Fermentation, Antinutrient

INTRODUCTION

The African star apple (*Chrysophyllum albidum*) is an indigenous fruit tree widely distributed across West Africa and belongs to the Sapotaceae family. In Nigeria, the fruit is commonly referred to as Agbalumo among the Yoruba people and Udara among the Igbo, Efik, and Ibibio ethnic groups (Ogunleye et al., 2020). The fruit possesses a firm outer skin that changes in colour from green to orange as ripening progresses. The edible pulp is soft, juicy, and characterized by a sweet-tart flavour with an orange to reddish-orange appearance. Traditionally, fruit maturity is identified when ripe fruits naturally fall from the tree, indicating readiness for consumption. Due to its high content of vitamin C, iron, and other essential nutrients, *C. albidum* is highly valued as a dietary resource in Nigeria. In addition to its nutritional significance, various parts of the plant are utilized in traditional medicine. For example, the bark is often prepared as a decoction for the management of malaria and yellow fever, while the leaves are employed in treating gastrointestinal disorders, diarrhea, and certain skin infections. These medicinal applications are largely attributed to the abundance of antioxidant compounds present in the plant (Darko et al., 2021).

Although the pulp is extensively consumed, the seeds are frequently discarded after processing and consumption, contributing to environmental waste accumulation. Nevertheless, these seeds constitute a valuable agricultural resource due to their appreciable levels of carbohydrates, proteins, dietary fibre, lipids, minerals, and several biologically active compounds. Consequently, African star apple seeds have attracted increasing attention as a potential raw material for diverse industrial applications. The seeds can be processed into flour for incorporation into functional foods, serve as a source of starch extraction, be utilized in the production of biodegradable materials, or be formulated into nutrient-rich animal feed for livestock, poultry, and aquaculture. In addition, seed residues may be converted into biogas through anaerobic digestion, thereby contributing to sustainable energy generation.

The effective utilization of African star apple seeds supports waste reduction strategies and promotes resource efficiency by transforming underutilized agricultural residues into value-added products (Kumar et al., 2024). Furthermore, phytochemical constituents present in the seeds have been reported to possess antioxidant, antimicrobial, anti-inflammatory, and antimutagenic properties, suggesting potential health-promoting benefits. Despite growing interest in the economic and nutritional importance of *C. albidum*, limited information is available regarding the biochemical and functional modifications that occur in its seeds during processing. Fermentation, a widely used bioprocessing technique, has the potential to alter the nutritional composition, functional characteristics, and bioactive profile of seed flour. Therefore, the present study investigates the influence of fermentation on the chemical composition and functional properties of African star apple seed flour.

MATERIALS AND METHODS

The raw materials African star apple seed was sourced from Ipata market, Ilorin, Kwara State. Nigeria.

Preparation of African Star Apple Seed Flour

African star apple seed was produced using the method of Makinde et al. (2019) with slight modification. The fruits were sorted and the seeds were removed from the fruit pulp. The seeds were dehulled manually to remove the kernel which were divided into four portions in which portion one was unfermented and served as the control, and the other three were steeped and fermented in water for 24, 48 and 72 h. The water was drained from the kernels, oven dried at 60 °C for 18 h, milled and sieved through a 3 mm sieve and packaged for analysis.

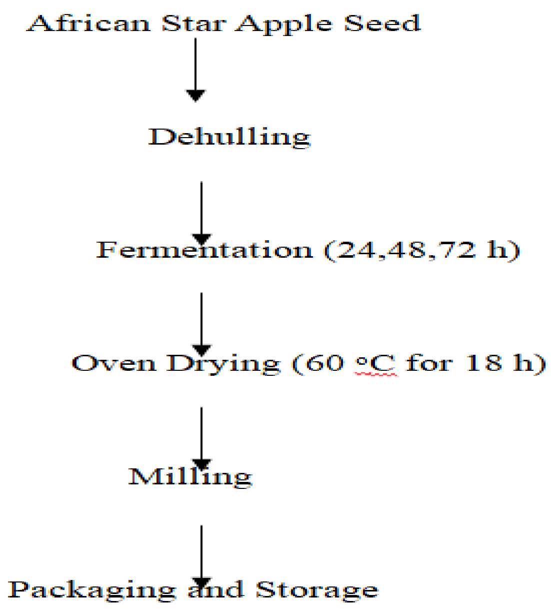

Fig. 1: Production of fermented African star apple seed flour (Makinde et al., 2019).

Analyses

The bulk density (BD) was determined by the method of (Akubor et al., 2013), swelling index and water/oil absorption capacity was done using methods described by (Ocloo et al., 2010). Dispersibility was done using method described by Palamthodi et al. (2021). The pasting properties were determined using the Rapid Visco

Analyzer. Extraction of antioxidants and antinutrients was carried out on samples of seed flour following the method of (Olawoye and Gbadamosi, 2017). with minor modifications. Proximate composition was analyzed using AOAC (2015).

Statistical Analysis

Mean values of triplicate determination were reported with their standard deviations. Analysis of Variance (ANOVA) with the aid of SPSS statistical tool (Version 17) was used to calculate significant difference in the treatment means, and the mean separations were achieved by Duncan's Multiple Range Test ($p<0.05$).

RESULTS AND DISCUSSION

Effect of Fermentation on the Functional Properties of African Star Apple Seed Flour.

The effect of fermentation on the functional properties of African star apple seed flour is presented in Table 1. The bulk density ranged from 0.55 to 0.73 g/cm³. The control sample (SF1) exhibited the highest bulk density of 0.73 g/cm³, while the 72 h fermented flour sample (SF4) had the lowest value of 0.55 g/cm³. No significant differences ($p>0.05$) were observed between the control and the fermented flour samples (SF2, SF3, and SF4). Overall, bulk density decreased with an increasing fermentation period. The bulk density values obtained in this study were higher than the range of 0.31–0.72 g/cm³ reported by Chawla et al. (2020) for fermented watermelon seed flour. Low bulk density in flours is advantageous for the formulation of complementary, infant, and weaning foods (Adeyanju et al., 2021).

The water absorption capacity ranged between 181% and 236%. The unfermented control seed flour (SF1) had the lowest value (181%), while the highest value (236%) was recorded for the 72-hour fermented sample (SF4). The WAC of the seed flours increased gradually and significantly across all samples as the fermentation period progressed. The values obtained from this study were higher than those reported for native and fermented sorghum flours (164% to 183%) by Sobowale et al. (2024). This trend suggests that fermentation enhances water absorption, likely due to the exposure of hydrophilic sites during the process. A high WAC is a vital quality that is associated with the flour's capacity to form a viscoelastic dough, providing the flexibility required for stretching and molding.

The Oil Absorption Capacity (OAC) of the seed flours ranged from 131.50 to 168.50 %, with statistically significant differences ($p < 0.05$) observed between the control and the fermented samples. The OAC demonstrated a progressive increase corresponding to prolong fermentation periods. The unfermented control sample (SF1) exhibited the lowest value (131.50%), whereas the sample fermented for 72 h (SF4) recorded the peak value of 168.50%. Increase in OAC during fermentation can be attributed to the enzymatic degradation of proteins, which uncoils their tertiary structure and exposes the hydrophobic amino acid residues (Kakar et al., 2022). Flours with superior oil-binding capacity hold promise as functional extenders or texturizers in meat-analogue formulations.

The swelling index of the African star apple seed flour varied significantly from 1.99 ml/g to 3.10 ml/g. Varying the fermentation periods (24, 48, and 72 hours) exerted a significant impact ($p < 0.05$) on the swelling behavior of the resulting flours (Table 1). The unfermented control sample displayed the highest swelling index (3.10), which decreased progressively as fermentation time increased, reaching a minimum value of 1.99 in the 72 h fermented sample (SF4). These values were in contrast to the findings reported by Omowaye-Taiwo et al. (2015) for fermented *Cucumeropsis mannii* (white melon) seed flour. According to Menon et al. (2015), swelling indices reflect the non-covalent bonding network within starch granules and the ratio of amylose to amylopectin.

The percentage dispersibility of the flours were between 29.50% and 43.34%. Sample SF3 (fermented for 48 h) yielded the highest dispersibility value (43.34%), while the unfermented control (SF1) exhibited the lowest (29.50%). Statistical analysis revealed significant differences ($p<0.05$) between the untreated and fermented flours, with the dispersibility of SF3 being significantly higher than that of SF1, SF2 and SF4. Notably, dispersibility increased progressively with fermentation from untreated SF to 48 h (SF3) before undergoing a subsequent decline to 33.32% at 72 h in SF4. This trend aligns partially with Sobowale et al. (2024), who observed that *acha* flour fermented for 72 hours exhibited optimal dispersibility compared to its native counterpart. Dispersibility evaluates the effectiveness of a flour matrix to rehydrate in an aqueous medium thereby affecting the overall reconstitution capacity (Neeharika and Suneetha, 2023). Dispersibility values are useful in developing uniform and smooth dough consistencies during commercial mixing stages (Kushwaha and Said, 2020).

Table 1: Effect of fermentation on the functional Properties of African Star Apple Seed Flour

Sample	Bulk Density (g/cm^3)	WAC (%)	OAC (%)	Swelling Index	Dispersibility (%)
SF1	$0.73^a \pm 0.01$	$181.00^d \pm 1.36$	$131.50^d \pm 2.12$	$3.01^a \pm 0.06$	$29.50^d \pm 0.71$
SF2	$0.70^a \pm 0.00$	$226.00^c \pm 1.22$	$147.00^c \pm 2.83$	$2.39^b \pm 0.05$	$38.32^b \pm 0.52$
SF3	$0.58^b \pm 0.01$	$231.00^b \pm 1.41$	$159.00^b \pm 1.41$	$2.18^c \pm 0.09$	$43.34^a \pm 0.31$
SF4	$0.55^b \pm 0.00$	$236.00^a \pm 1.53$	$168.50^a \pm 2.12$	$1.99^d \pm 0.05$	$33.32^c \pm 0.41$

Values are means ± standard deviations of duplicate determination. Means on the same column with different superscript are significantly different (P<0.05)

SF1 (Control) - Unfermented African star apple seed flour, SF2 - African star apple seed flour fermented for 24 h, SF3 - African star apple seed flour fermented for 48 h, SF4 - African star apple seed flour fermented for 72 h.

Effect of fermentation on the Pasting Properties of African Star Apple Seed Flour

The pasting properties of African star apple seed flours (SF1–SF4) were evaluated at different fermentation periods. Fermentation significantly influenced the structural and rheological characteristics of the starch granules. Peak viscosity values ranged from 29.74 RVU in SF1 to 111.44 RVU in SF4. A significant time-dependent increase ($p < 0.05$) in peak viscosity was observed as fermentation progressed. This increase may be attributed to structural modifications of the starch granules induced by microbial activity, organic acid production, and enzymatic hydrolysis. The action of enzymes can partially disrupt granule surfaces, reducing granule rigidity and facilitating greater water absorption and swelling capacity (Diaz et al., 2018). As a result, the fermented samples exhibited higher thickening ability than the unfermented control flour. This finding contrasts with the report of Oloyede et al. (2016), who observed a decrease in peak viscosity following the fermentation of *Moringa oleifera* flour.

Trough viscosity, which reflects the ability of a starch paste to withstand heating and mechanical shear during processing, ranged from 23.83 RVU in SF1 to 83.32 RVU in SF4. The values increased significantly ($p < 0.05$) with increasing fermentation time. Higher trough viscosity indicates improved paste stability during cooking and greater resistance to mechanical breakdown. This improvement may be associated with fermentation-induced modifications of the starch matrix, which enhance water retention and maintain granule integrity during thermal processing. However, Oladeji et al. (2017) observed higher trough values (55.08- 98.00 RVU) in fermented maize flour. Breakdown viscosity values ranged from 5.91 RVU to 28.09 RVU, showed significant ($p < 0.05$) variations. The control (SF1) recorded the highest breakdown (28.09 RVU), while the 72 hr sample (SF4) had the lowest (5.91 RVU). Breakdown viscosity acts as an index of starch stability, tracking granule disintegration during hot shearing. Higher breakdown indicates a weak starch matrix, while lower values suggest structural cross-linking properties. Prolonged fermentation minimized breakdown, reinforcing the flour's hot-shear resistance (Kaur and Gill, 2020). Final viscosity ranged between 41.99 RVU in SF1 and 109.57 RVU in SF4, increasing significantly ($p < 0.05$) over time. High final viscosity indicates the capacity of these processed flours to form dense and highly viscous pastes. These values were lower than the sorghum flour range (82.71--129.48 RVU) reported by Iwayemi and Ikujenlola (2025). Final viscosity serves as an important metric to predict and define the textural quality of food formulations. Setback viscosity values ranged from 18.16 RVU in SF1 to 26.41 RVU in SF4. Setback increased gradually up to 48 h (SF3) before dropping significantly at the SF4. This property is governed by amylose interactions forming a crystalline network upon cooling (Ai and Jane, 2024).

Lower setback values imply high retrogradation resistance, while high values link to syneresis during storage. The observed setback values were lower than the 62.17--91.67 RVU recorded for maize (Oladeji et al., 2017). Setback viscosity remains an indicator of the overall retrogradation tendency of starch (Mei et al., 2016). Peak time (cooking time) varied from 4.62 min in SF1 to 6.41 min in SF3 and the value declined in SF4. This implies that intermediate fermentation lengthens cooking time, whereas prolonged processing shortens it. These results align with the pasting times (4.23--4.93 min) found for *Moringa* by Oloyede et al. (2016). Pasting temperature values increased from 84.04 ºC to 89.69 ºC alongside longer fermentation steps. Higher pasting temperatures reflect strong associative forces in granules, increasing the thermal energy required to cook.

Table 2. Effect of fermentation on the pasting properties of African star apple seed flour

Sample	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Pasting Time (min)	Pasting Temp (ºC)
SF1	$29.74^{d}\pm0.98$	$23.82^{d}\pm0.47$	$5.91^{d}\pm0.61$	$41.99^{d}\pm1.22$	$18.16^{d}\pm0.68$	$4.62^{d}\pm0.03$	$84.04^{d}\pm0.07$
SF2	$56.76^{c}\pm1.23$	$49.16^{c}\pm0.62$	$7.56^{b}\pm0.53$	$68.01^{c}\pm1.21$	$18.85^{c}\pm0.82$	$5.66^{c}\pm0.04$	$84.77^{c}\pm0.09$
SF3	$69.75^{b}\pm1.11$	$62.77^{b}\pm1.10$	$7.15^{c}\pm0.69$	$89.16^{b}\pm1.43$	$26.41^{a}\pm0.81$	$6.41^{a}\pm0.04$	$88.92^{b}\pm0.08$
SF4	$111.44^{a}\pm1.02$	$83.32^{a}\pm1.14$	$28.09^{a}\pm0.81$	$109.57^{a}\pm1.62$	$26.24^{b}\pm0.92$	$5.72^{b}\pm0.06$	$89.69^{a}\pm0.06$

Means in the same column with different superscript are significantly different (P<0.05)

SF1- Unfermented African star apple seed flour, SF2- African star apple seed flour fermented for 24h, SF3- African star apple seed flour fermented for 48h, SF4-African star apple seed flour fermented for 72h.

Effect of Fermentation on the Antioxidant Activity of African Star Apple Seed Flour

Table 3 represent the result of antioxidant activity of fermented African apple seed flour at different periods. The DPPH (2,2-diphenyl2-picrylhydrazylhydrazyl) scavenging activity of the seed flour ranged from between 19.75–40.61%. In comparison to the control sample, the fermented flours were found to be greater in DPPH activity. There were significant (p<0.05) differences between fermented and unfermented flours. SF1 had the lowest value 19.75 % while the highest DPPH was observed in SF3 (40.61%). Values of DPPH in the seed flour initially increased with increased fermentation from 24–48h followed by a decrease in DPPH activity which was observed in SF4 (72h). A subsequent decrease seen in 72 h fermentation period may be due to breaking down of phenolic compounds by fermentation. The reports of this study were lower than the findings of Kumari et al (2024) for fermented almond flour with value 55.12-65.01%.

The Ferric Reduced Antioxidant Capacity (FRAP) of the seed flours ranged from 0.37-0.40 mgFeSO4/g. The highest value of 0.40 mgFeSO4 /g was obtained in SF1 while the least value of 0.37 mgFeSO4/g was observed in SF3.It was observed there was no significant (p<0.05) difference between SF1, SF3, SF4. Fermented seed flour SF2 was significantly (p<0.05) different from seed flour SF1, SF3, SF4. The result showed an increasing trend in the Fe3+ reducing abilities with the extension of fermentation (0-48h fermentation period representing seed flour SF1- SF3), then a subsequent decrease in value was observed at 72 h fermentation period (SF4). The FRAP (Ferric reducing antioxidant power) is the ability to reduce FE3+ complex to the ferrous form in the presence of antioxidants in the seed flour extracts.

The ABTS scavenging capacity of seed flour varied between 30.07 – 40.51 mg TE/100g. The low value of 30.07 mg TE/100g was observed in SF1 (Control) while SF3 had the highest value of 40.51 mg TE/ 100g. ABTS method detected no significant (p>0.05) difference among the seed flours of SF1, SF2and SF4. SF3 was significantly different (p<0.05) from the untreated and other fermented seed flours. The ABTS activity recorded in this study was higher than those reported for fermented quinoa seed flour by Sanchez-Garcia et al. (2023) but lower than the value obtained for ABTS of fermented maize flour by Oladeji, (2022). Higher value of ABTS antioxidant activity by fermentation may be as a result of fermentation releasing bound phenolic compounds and also synthesis of antioxidant compounds.

Table 3: Antioxidant activity of unfermented and fermented African star apple seed flour

Sample	DPPH (%)	FRAP (mgFeSO$_4$/g)	ABTS (mgTE/g)
SF1	19.75^{c}± 0.96	0.40^{a}±0.02	30.07^{b} ±1.17
SF2	33.92^{b}±1.07	0.39^{a}±0.01	32.27^{b} ±1.58
SF3	40.61^{a}±1.30	0.37^{b}±0.00	40.51^{a}±1.72
SF4	33.12^{b}±1.18	0.39^{a}±0.01	30.19^{b}±1.24

Means in the same column with different superscript are significantly different (P<0.05)

SF1- Unfermented African star apple seed flour, SF2- African star apple seed flour fermented for 24h, SF3- African star apple seed flour fermented for 48h, SF4-African star apple seed flour fermented for 72h.

Effect of Fermentation on the Phytochemical Properties of African Star Apple Seed Flour

The effect of fermentation on the tannin, flavonoid, phenol levels in African Star Apple Seed flour are shown in Table 4. The tannin levels were found to be very negligible in the flour samples. It was observed that the absence of tannin may be attributed to the hydrolysis of polyphenolic compounds or tannin complexes during fermentation. Feyera et al., (2021) reported that tannin- protein, tannin acid –starch, and tannin-iron complexes are broken down during fermentation to release free nutrients.

The levels of flavonoid content ranged from 0.04-0.11 mgCE/100 g. The maximum flavonoids content of seed flour (0.11 mgCE/g) was observed in fermented seed flour SF3 and least value (0.04 mgCE/g) were found in control (SF1). Oladeji et al., (2022) reported higher value (42.09 -56.66 mgCE/g) of flavonoid for fermented maize flour than the value obtained in the present study. Significant (p<0.05) increase occurred in the flavonoid content of seed flour within 48h fermentation period and subsequently decreased at 72 h. The lowest level of flavonoid 0.04 mg CE/g was observed both in SF1 (24 h) and SF4 (72 h). Phenolic content ranged from 0.05-0.18 mg GAE/g. The highest value of 0.18mgGAE/g is attained in SF1 while the lowest value of 0.05 mgGAE/g was reported in SF4. There was no significant difference (p>0.05) between SF1 and SF2 but a significant difference (p<0.05) was observed between SF1 (Control) and SF4. SF3 was not significantly different from either SF1, SF2 or SF4. The phenol content gradually decreased with increasing fermentation time. Phenolic compounds act as antioxidant by forming stable radical intermediates, preventing further oxidative processes in food products. These findings were in agreement to the report of Sanchez–Garcia et al. (2023) for fermented white quinoa seed flour where the phenol content were observed to decrease during fermentation

Table 4: Phytochemical Properties Of Unfermented and Fermented African Star Apple Seed Flour

Sample	Tannin (mg/CE/g)	Flavonoid (mg/CE/g)	Phenol (mg/GAE/g)
SF1	ND	0.04^{c}±0.00	0.18^{a}±0.00
SF2	ND	0.06^{b}±0.01	0.16^{a}±0.01
SF3	ND	0.11^{a}±0.00	0.11^{ab}±0.00
SF4	ND	0.04^{bc}±0.01	0.05^{b}±0.01

Means in the same column with different superscript are significantly different (P<0.05)

ND- Not detected

SF1- Unfermented African star apple seed flour, SF2- African star apple seed flour fermented for 24h, SF3- African star apple seed flour fermented for 48h, SF4-African star apple seed flour fermented for 72h.

Effect of Fermentation on the Proximate composition of African Star Apple Seed Flour

Table 5 showed the effect of fermentation on the proximate composition of African star apple seed flour. Moisture contents of the flour ranged from 6.32 to 10.53 %. There were significant differences (p<0.05) in the moisture values. Fermented African star apple flour had higher values than the untreated samples. This result corroborates the findings of Achi and Ukwuru (2015) who reported increase in water retention as a result of fermentation due to the hydrolysis of carbohydrates. The untreated flour had higher ash and crude fibre contents which were significantly different (p<0.05) from the fermented flours. The ash and crude fibre contents decreased with fermentation time but there were no significant differences (p>0.05) in the values of samples fermented for 48 h and 72 h. Enujiugha and Agbede (2000) reported low ash contents in fermented African oil bean seed due to leaching of the mineral into the fermentation medium. Likewise, Oboh and Akindahunsi (2003) explained the reduction in fibre contents during fermentation as a result of breakdown of insoluble fibres to sugars by the cellulolytic enzymes from the fermenting microbes. There were no significant differences (p>0.05) in the SF1, SF2 and SF3 in crude fat contents, and in SF1 and SF2 in protein contents. SF4 had the highest fat content 5.04% while SF3 had the highest in protein content (11.86 %). Protein contents increased progressively till 48 h and declined at 72 h. Increase if fat content may be due to moisture loss or synthesis of lipids by microorganism as reported by Nnam (2002). Increase in the protein contents could be attributed to amino acid synthesis by the fermenting microorganism while the decline at 72 h could be due to reduction in microbial population as reported by Mukherjee et al., (2021) and Ijarotimi and Keshinro (2020) for fermented legumes and oil seeds. Carbohydrate content ranged from 68.33% in SF 2 to 70.54 % in SF4. There were no significant differences (p>0.05) in the values for the untreated and fermented samples. Fermentation had insignificant effect on the carbohydrate contents of African star apple seed flour

Table 5: Proximate Composition of Fermented African Star Apple Seed Flour

Sample	Moisture (%)	Ash (%)	Crude Fibre (%)	Crude Fat (%)	Crude Protein (%)	Carbohydrate (%)
SF1	$7.32^{d}\pm0.10$	$1.95^{a}\pm0.02$	$6.26^{a}\pm0.11$	$4.65^{b}\pm0.15$	$10.45^{b}\pm0.15$	$69.37^{ab}\pm0.49$
SF2	$10.53^{a}\pm0.12$	$1.63^{b}\pm0.06$	$4.54^{b}\pm0.06$	$4.77^{b}\pm0.21$	$10.20^{b}\pm0.09$	$68.33^{b}\pm0.33$
SF3	$8.64^{c}\pm0.12$	$1.12^{c}\pm0.08$	$3.45^{c}\pm0.06$	$4.54^{b}\pm0.29$	$11.86^{a}\pm0.09$	$70.39^{a}\pm0.51$
SF4	$10.30^{b}\pm0.15$	$1.18^{c}\pm0.16$	$3.53^{c}\pm0.12$	$5.04^{a}\pm0.05$	$9.41^{c}\pm0.09$	$70.54^{a}\pm0.44$

Means in the same column with different superscript are significantly different (P<0.05)

SF1- Unfermented African star apple seed flour, SF2- African star apple seed flour fermented for 24h, SF3- African star apple seed flour fermented for 48h, SF4-African star apple seed flour fermented for 72h.

CONCLUSION

Sample SF4 (72 h) exhibited the highest water and oil absorption capacities while SF3 had the highest dispersibility, though its swelling index declined with extended fermentation. Regarding pasting behavior, an increase in fermentation time led to a corresponding increase in peak, trough, breakdown, and final viscosities. Fermentation significantly enhanced the antioxidant activity of the seed flour, with fermented samples showing higher DPPH and ABTS radical scavenging activities compared to the unfermented control. However, the Ferric

Reducing Antioxidant Power (FRAP) followed an opposite trend: the unfermented control possessed a higher reducing capacity, indicating that fermentation exerts a reducing effect on FRAP values. In terms of phytochemical composition, the highest flavonoid content was achieved in sample SF3, whereas the total phenol content progressively declined with increasing fermentation time. SF3 (48 h) had the highest protein, antioxidant activity, and flavonoid retention while SF4 (72 h) had the highest pasting and functional properties which could be employed in functional foods.

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