IMPACT OF SHORT TIME FERMENTATION ON FLOUR FROM TUBER STARCH: *A REVIEW*

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Abstract
Flours derived from tubers contribute significantly to food security at household level and is used in functional food systems innovation. Starches derived from tubers frequently exhibit technological constraints that hamper their broader application such as: pronounced peak viscosity, accelerated retrogradation, and microbiological shelf life relative to conventional cereal flours. Fermentation is used to improve the quality and safety of tuber flours. This methods also have their limitations, like: slow fermentation, product quality variations, making it hard to scale up to industrial conditions. Short time fermentation (STF) has become a faster approach, utilizing lactic acid bacteria (LAB) or baker's yeast acting under mild temperature conditions (25–37 °C). Evidence shows that STF changes the structure of starch granules, reduces peak viscosity, boosts setback viscosity, stabilizes gelatinization and, improves hydration in some cases. It also boosts resistant starch and minerals absorb bioavailability, while cutting antinutrients like phytates and cyanogenic compounds. In bread and puffed snacks, these applications boost softness and volume, and gives a lighter texture. In conclusion, STF offers a clean-label way to boost both the functional performance and nutritional value of tuber flours, showing strong promise for large-scale use in functional foods.

Keywords: Flour, Short-time fermentation, Tuber and Starch.

Introduction

Flours derived from tubers have over the years become indispensable. They contribute significantly to food security at household level and also serves as substrates for industrial expansion in functional food systems innovation (Noort *et al*., 2022). Given their affordability and wide availability, they are staple in traditional diets and are incorporated into processed products. They have found application in many new high-starch raw foods (Buzera, (2024). While offering substantive nutritional and economic advantages, starches derived from tubers frequently exhibit technological constraints that hamper their broader application. These limitations include a pronounced peak viscosity that complicates both mechanical shearing and subsequent thermal treatments. They also exhibit tendencies toward accelerated retrogradation (Almeida Dos, 2019). This heightens staling and diminishes organoleptic and microbiological shelf life, and a structurally weaker gluten-free matrix relative to conventional cereal flours. These limit their straightforward use in aerated systems such as leavened breads, extruded snacks and engineered foods where pronounced geometrical stability is requisite (Šárka *et al.,* 2023).

People have long turned to fermentation to improve both the quality and safety of tuber flours. For generations, people have made sour cassava starch and puba flour, letting microbes work their magic, deepening the flavor, and opening up new ways to enjoy the food (Kasaye *et al.,* 2018). This methods also have their limitations: they often require a slow fermentation: three to seven days powered by wild microbes that change with the dampness in the air, the flour freshness, and even the way the batch is stirred. With no clear standard in place, product quality varies from one batch to the next. Smooth and consistent one day, gritty or uneven the next. This makes it tough to get repeatable results and even harder to scale up to exacting industrial conditions (Paixão E Silva *et al.,* 2021; Soro *et al.,* 2019; Kasaye *et al.,* 2018; Kumoro *et al.,* 2020). Short time fermentation (STF) has become a faster approach, delivering all the flavor and health benefits of fermentation without the long, uncertain waits of the old methods. No more days of watching jars bubble on the counter. Generally characterized as occurring from a few hours to around two days, STF is based on the application of chosen microbial starters, frequently lactic acid bacteria (LAB) or baker's yeast acting under mild temperature conditions (25–37 °C) (Skowron *et al.,* 2022). Under STF, a controlled pH decrease and enzyme activity regulate starch granule structure, hydration capacity, and pasting behavior. These makes the starch/flour develop desirable techno-functional properties within shorter time frame as compared to traditional fermentation. This method results in reduced fermentation times while minimizing contamination risks. The uniqueness of STF is that it does not use chemical modifiers, there by creating a more sustainable and adaptable process for industrial use in clean-label food systems (Zhao *et al.,* 2025). This review explicitly discusses the impact of STF on tuber-derived flours and starches.

Structural changes under STF

Starch subjected to short time fermentation results in structural modification as organic acids and amylolytic enzymes work together, their action creates tiny pore opening, which results from the trimming of some amylopectin chains. These changes usually grow more pronounced, the longer fermentation runs. Often anywhere from 2 hours, when the aroma is still faint, to 36 hours, when it's rich and sharp (Yan *et al.,* 2022). Within about a day and a half, researchers consistently observe three changes: tiny pits and worn spots forming on starch granules; a small yet measurable drop in relative crystallinity, sometimes with a subtle reshuffling of short-range molecular order; and a slow change in apparent amylose content caused by enzymatic debranching (Shao *et al.,* 2025; Zhao et al., 2025). Studies of long, traditional fermentations, like the multi day process for puba starch show that thermal transitions barely shift, a finding confirmed by differential scanning calorimetry (DSC). Still, noticeable shifts in color, texture, and the shape of individual granules appear like a pale yellow deepening to gold showing just how sensitive these physical traits are to the length and conditions of fermentation (Paixão et al., 2021; Wei *et al.,* 2022). These findings highlight how using controlled starter cultures and keeping fermentation to a shorter, well-timed intervals like: 12-hour cycle can ensure starch fermentation systems work reliably every time.

Pasting and thermal behavior

Short time fermentation have influence on the pasting and thermal traits of flours made from tubers. It reshapes starch structure and the way it gels when heated. During fermentation, starch granules break down, hence the peak and breakdown viscosities drop, while final and setback viscosities increases, a shift that points to changes in how the gel forms and sets (Oyeyinka *et al*., 2020). In fermented starches, the onset, peak, and final gelatinization temperatures rise higher than in unfermented controls, as noted by Oyeyinka *et al.,* (2020). In studies of cassava "puba" flour, a traditional naturally fermented product, differential scanning calorimetry showed that over seven days of fermentation, the gelatinization onset, peak, and conclusion temperatures and even the enthalpy stayed unchanged (Paixão., 2021). In studying paste viscosity, researchers found that heaped fermented cassava flour unlike sun-dried flour had lower peak, breakdown, and final viscosities, yet showed a higher trough viscosity and pasting temperature, with paste that stayed stable and smooth in the RVA test, showing no visible breakdown (Nanyonjo *et al.,* 2021).

Hydration and Functional Properties under STF

When tuber flour under goes short time fermentation with *Lactobacillus plantarum*, water holding capacity (WHC) increased markedly compared to non-fermented samples. This increase in WHC results in enhancement of properties attributed to exopolysaccharide (EPS) production and proteolytic activity, which increased the number of hydrophilic groups capable of binding water (Chipurura *et al.,* 2021). Similarly, fermented tuber flour demonstrated lower water holding capacity (WAC) compared to boiled flour, possibly due to interactions involving fat content and reduced availability of hydrophilic groups (Longdom, 2019).

Digestibility under Short-Time Fermentation of Tuber Flours

Studies have reported decreases in readily digestible starch (RDS) and an increases in resistant starch (RS) in fermented tuber, STF can enhance the slowly digestible and resistant fractions by hydrolyzing starch into smaller, less readily digestible components (Padonou *et al.,* 2012). Similarly, fermented tuber flour exhibited increased mineral bioavailability while also significantly reducing antinutrients like phytate, oxalate, and tannins.

Safety and Antinutrients under Short-Time Fermentation of Tuber Flours

The fermenting of tuber flour for 48 hours or less can reduce harmful anti-nutrients like hydrogen cyanide. This produces safer to eat and more nutritious end product with reduced bitter tastes. In a controlled study on cassava flour, researchers found that fermentation wiped out all detectable cyanide, while boiling only lowered it from 3.62 to 0.064 mg per 100 g. After fermentation, tests showed a no - trace value of cyanide (Kasaye *et al.*, 2019). Researchers have showed that, when cassava byproducts went through pre-processing: like sun-drying and solid-state fermentation, the total cyanogenic content dropped by about 40 %, and fermentation alone cut it by 88 %, bringing the leftover amount down from high levels to roughly 54.2 mg/kg dry weight. Fermenting both sweet and bitter cassava tubers sharply reduced HCN levels and wiped out harmful pathogens, leaving cyanide concentrations safely within acceptable limits (Obi *et al.*, 2019).

Product Performance in Bread making and Snacks under Short-Time Fermentation of Tuber Flour

Breads made with 10% fermented cassava flour stayed softer after three days than those with unfermented flour, hinting that STF slows staling and extends shelf life in composite bread systems (Oluwole-Olayede *et al.,* 2019). Likewise, cassava sour starch naturally fermented, then sun-dried showed excellent expansion in gluten-free baking. When tested side by side, sour cassava starch rose higher and spread more evenly than native cassava or maize starch, making it a strong contender for gluten-free breads (Chávez et al., 2018). In snack production, researchers have tested fermented cassava flour in extruded recipes, where the dough puffs and crisps as it leaves the hot machine. When cassava starch, bambara groundnut flour, and corn bran were blended, researchers discovered that careful fermentation boosted key traits for extrusion, hydration, expansion potential, and steady texture, producing crisp, well-formed snacks with a pleasing bite (Ogunmuyiwa *et al.,* 2017).

Table 1.0 Effects of Short-Time Fermentation (STF) on Tuber Flours

Functional properties	Observed Effect(s)	Reference
Structural changes	Granule pitting, reduced crystallinity, changes in amylose content; physical shifts in color/texture	Yan *et al.,* (2022); Shao et al. (2025); Zhao *et al.,* (2025); Paixão et al. (2021); Wei *et al.,* (2022)
Pasting & thermal behavior	↓ Peak & breakdown viscosities; ↑ final & setback viscosities; ↑ gelatinization temperatures; stable pastes in RVA	Oyeyinka *et al.,* (2020); Paixão (2021); Nanyonjo *et al.,* (2021)
Hydration & functional properties	↑ WHC via EPS production and proteolysis; contrasting cases of ↓ WAC due to fat interactions	Chipurura *et al.,* (2021); Longdom, (2019)
Digestibility (RDS/SDS/RS)	↓ RDS, ↑ RS; ↑ mineral bioavailability; ↓ phytate, oxalate, tannins	Padonou *et al.,* (2012)
Safety & antinutrients	Cyanide detoxification: complete elimination in some cases; up to 88% reduction with fermentation; safe HCN levels achieved	Kasaye *et al.,* (2019); Obi *et al.,* (2019)
Product performance (bread & snacks)	Softer breads after 3 days; better loaf volume & crumb with sour cassava starch; fermented blends yield crisp, expanded extruded snacks	Oluwole-Olayede *et al.,* (2019); Chávez *et al.,* (2018); Ogunmuyiwa *et al.,* (2017)

Conclusion

The review shows how short time fermentation enhances tuber flour quality. It improves the technological and nutritional properties of tuber based flours, like their tendency to produce dense, heavy dough. Unlike the slow, multi day fermentations, STF works fast, with tight control and consistent results. It enhances starch pasting, boosts water absorption and enhances digestibility. STF reduces anti-nutritional factors like hydrogen cyanide content which results it the removal of the bitter taste in cassava flour. In bread making and puffed snacks, STF keeps products fresh longer and delivers bigger loaves with a tender crumb and desirable texture. STF delivers functional improvements without altering desired quality, nutrient composition required in clean-label, sustainable food innovations. Future studies should focus on the choice of starter cultures, explore ways to scale up industrial use, and dig deeper into how fermentation, structure, and function work together in different tuber systems.

References

Almeida, R.L.J. dos Santos Pereira, T., de Andrade Freire, V., Santiago, Â.M., Oliveira, H.M.L., de Sousa Conrado, L. and de Gusmão, R.P. (2019). Influence of enzymatic hydrolysis on the properties of red rice starch. *International journal of biological macromolecules*, 141, pp.1210-1219.

Bamidele, O.P. (2025). Effects of Natural Fermentation Time on Chemical Composition, Antioxidant Activities, and Phenolic Profile of Cassava Root Flour. *Applied Sciences*, 15(15), p.8494.

Buzera, A.K. (2024). Production and Characterization of Potato Flour and Its Application in Noodles Processing (Doctoral dissertation, JKUAT-COANRE).

Gao, S., Liu, H., Sun, L., Cao, J., Yang, J., Lu, M. and Wang, M. (2021). Rheological, thermal and in vitro digestibility properties on complex of plasma modified Tartary buckwheat starches with quercetin. *Food Hydrocolloids*, 110, p.106209.

Kasaye, T., Melese, A., Amare, G. and Hailaye, G. (2018). Effect of fermentation and boiling on functional and physico chemical properties of yam and cassava flours. *Journal of Agricultural Science and Food Research*, 9(4), p.1000231.

Kumoro, A.C., Widiyanti, M., Ratnawati, R. and Retnowati, D.S. (2020). Nutritional and functional properties changes during facultative submerged fermentation of gadung (Dioscorea hispida Dennst) tuber flour using Lactobacillus plantarum. *Heliyon*, 6(3).

Nanyonjo, A.R., Kawuki, R.S., Kyazze, F., Esuma, W., Wembabazi, E., Dufour, D., Nuwamanya, E. and Tufan, H. (2021). Assessment of end user traits and physicochemical qualities of cassava flour: A case of Zombo district, Uganda. *International Journal of Food Science and Technology,* 56(3), pp.1289-1297.

Noort, M.W., Renzetti, S., Linderhof, V., du Rand, G.E., Marx-Pienaar, N.J., de Kock, H.L., Magano, N. and Taylor, J.R. (2022). Towards sustainable shifts to healthy diets and food security in sub-Saharan Africa with climate-resilient crops in bread-type products: *A food system analysis*. *Foods, 11*(2), p.135.

Obi, C.N., Okezie, O. and Ukaegbu, T. (2019). Fermentation reduces cyanide content during the production of cassava flours from sweet and bitter cassava tuber varieties. *Asian Food Science Journal*, 2019, pp.1- 10.

Oyeyinka, S.A., Adeloye, A.A., Olaomo, O.O. and Kayitesi, E. (2020). Effect of fermentation time on physicochemical properties of starch extracted from cassava root. *Food Bioscience*, 33, p.100485.

Paixão e Silva, G.D.L., Bento, J.A.C., Oliveira, A.R., Garcia, M.C., Soares Júnior, M.S. and Caliari, M. (2021). Pasting and thermal properties of fermented cassava (Manihotesculenta Crantz). *Journal of Food Science and Technology,* 58(4), pp.1441-1448.