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INFLUENCE OF FERMENTATION USING BAKERS YEAST (*Saccharomyces cerevisiae*): ON THE NUTRITIONAL COMPOSITION OF SWEET POTATO (*Ipomea batatas*) PEELS: A POTENTIAL FISH FEED INGREDIENT

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ABSTRACT

Agro-industrial wastes discarded indiscriminately pollute the environment and become hazardous to human and animal health. Microbial fermentation process a viable, efficient approach transforms discarded agro-industrial wastes into useful bioproducts. This study therefore aims at improving the nutrient content of sweet potato peel (SPP) using *Saccharomyces cerevisiae*. White flesh sweet potatoes (*Ipomoea batatas*) were purchased from the local market located at Dutsinma then peeled, cut into pieces and used for the experiment. A total 4kg of sweet potatoes peels was dried and crushed into powder and divide it into 4 equal sample with three parts (Treatment 2, 3, 4) having 1000g of the powder, 1g of yeast (*Saccharomyces cerevisiae)* and 100ml of water each were fermented using solid state fermentation process for 24, 48 and 72 hours respectively while one part (Treatment 1) acted as the control was not fermented. At the end of each specific period of fermentation, dried and milled samples were taken for proximate analysis and mineral determination. Data was collected in triplicates. Fermentation brought about an increase in the crude protein (8.87±1.07) in the 24 hours duration of fermentation. The crude fibre content of the mixed substrate dropped significantly ($P<0.05$) while zinc, iron and potassium values were found to increase. The phytochemical screening revealed the presence of bioactive compounds in the SPP namely; tannins, alkaloids, saponins, glycosides, phenols and saponins. The result of this study revealed that fermentation can bring about desirable changes in the nutrient composition of potato peels.

Key words: Fermentation; sweet potato peel; *Saccharomyces cerevisiae;* proximate analysis; minerals

INTRODUCTION

The price of soya bean meal and corn have been fluctuating, and becoming scarce, resulting in shortages of energy- and protein-based feeds (Chen and Liu, 2020). Attention has been redirected toward the development and promotion of unconventional feeds in order to address this issue. However, due to their lower nutritional value, unstable composition, and anti-nutritional factors, the use of unconventional feeds is limited (Sugiharto and Ranjitkar, 2019).

Currently, several methods are available to improve the palatability and efficiency of unconventional feeds; including fermentation, toasting, blanching and microwaving. In particular, fermentation in particular not only reduces toxin levels and anti-nutritional factors in feed but also improves its nutritional value and digestibility (Wang et al., 2010). In addition to reducing feeding cost, using fermentation to improve unconventional feed sources for animals, it can also promote the efficient use of agricultural and by product resources.

Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant that belongs to the family Convolvulaceae that has gained importance among the major food crops in terms of dry matter production per hectare (FAO, 2021). It is one of the richest and cheapest sources of dietary energy, ranking as the fourth most important The edible tuberous root is long and tapered with a smooth skin whose colour ranges between yellow, purple, cream and white. Its flesh ranges from white to yellow, orange and purple (Joshi et al., 2021). Although the leaves and shoots are also edible, the starchy tubers are by far the most important product in some tropical areas.

Sweet potato peels (SPP) have been exploited as natural antioxidants in food system due to its high content of polyphenols, antioxidants in biological systems, screened as low-cost solid substrates for microbial production of enzymes to be used either in food applications or in other industrial sectors (Schieber,et al.,2001). They are excellent substrate for the production of thermo-stable alpha-amylase, a starch hydrolyzing enzyme extensively used in different food industries and source of antimicrobial agents (Camire, et al., 2009). Irrespective of variety, the use of sweet potato peels

could be applied in the production of biofilms, fertilizers and absorbers (Torres et al.2020). SPP differ greatly from other agricultural by-products because of the presence of both nutritionally and pharmaceutically interesting constituents (Schieber,et al.,2001).

Sweet Potato peel is the main and zero-value waste from potato processing plants, leading to the wastage of resources and environmental pollution (Arachchige et al., 2020). Evaluation of the nutrient composition of SPP revealed that its high starch content makes it a good energy source for animals, whereas its high crude fiber (CF) content and low crude protein (CP) content restricts its use in feed (Song et al., 2021). Also due its high lignin content, it is not readily digestible by animals or humans. Fermentation can be used as an affordable, adaptable, and tried-and-true method to improve the nutritional value and shelf life of food items

According to Sugiharto and Ranjitkar (2019), fermentation is an easy technique that can increase nutritional value and reduce the amount of antinutritional substances in feed ingredients. Wea et al., (2020) stated that the type of starter used and the conditions during fermentation have a significant impact on the increase in nutritional value and decrease in antinutritional components in fermented feed ingredients .Among the types of starter that are often used for the fermentation process of feed ingredients is the yeast *Saccharomyces cerevisiae* (Elghandour et al., 2020). *S. cerevisiae* can produce enzymes such as amylase and proteolytic peptidase (Akamine et al., 2023), which can hydrolyze complex carbohydrates such as cellulose, hemicellulose and lignin into simpler compounds (Otu et al., 2020). Additionally, *S. cerevisiae* is also a probiotic microorganism that can improve the health and productivity of livestock (Vohra et al., 2018). This paper investigates the possibility of enhancing the nutrient composition of sweet potato peel through fermentation using *Saccharomyces cerevisiae*, so as to explore its potential for use as an animal feed or feed ingredient.

MATERIAL AND METHODS

Experimental area

The experiment was carried out in the Laboratory of the Department of Fisheries and Aquaculture, Federal University Dutsin-ma, Katsina State Nigeria. Dutsinma LGA lies on latitude 12◦26'N and longitude 07◦29'E. It is bounded by Kurfi and charanchi local government to the north, Kankia KGA to the east, Safana and Dan-musa LGAs to the west, and Matazu LGA to the southeast.

Sample collection and preparation

The white-fleshed sweet potatoes peel were used for this study. The sweet potatoes were purchased from the Local market located at Dutsinma. The sweet potato were sorted and properly washed to remove dirt and contamination. The sweet potatoes were then peeled, cut into pieces and used for the experiment. A total 4kg of sweet potatoes peels was dried and crushed into powder and divide it into 4 equal sample with three parts (Treatment 2, 3, 4) having 1000g of the powder, 1g of yeast and 100ml of water each were fermented using solid state fermentation process for 24, 48 and 72 hours respectively while one part (Treatment 1) acted as the control was not fermented.

Solid state fermentation involved: Pre-treatment, sweet potato peels are washed, dried and ground into suitable particle size. Inoculation preparation, a suitable microorganism (yeast) is selected and prepared for inoculation. Substrate preparation, the sweet potato peel powder is mixed with water and yeast to create a solid substrate. The fermented sweet potatoes peels was air dry for the period of 3 days.
The fermented dried sweet potatoes peels was then taken to the laboratory and subjected to proximate, mineral and phytochemicals analysis.
At the end of each specific period of fermentation, the fermented sweet potato peels were dried to constant weight in a hot air oven at a temperature of 60o C. The dried fermented substrates were milled, stored in clean dry bottles and were later subjected to proximate composition and mineral analysis.

Proximate analysis

Proximate composition (crude protein, crude lipid, ash content, moisture content, crude fiber content) of the fermented sweet potato peels was carried out using the method described by the Association of Official Analytical Chemist (A.O.A.C, 2012).

Determination of mineral elements

The samples (1 g each) were digested by treatment with HNO_3 and H_2O_2 at 100°C until completed, and diluted in deionized water. Sodium (Na) and potassium (K) contents were determined using Flame photometry, while phosphorus (P), iron (Fe), calcium (Ca) were determined through inductively coupled plasma atomic emission spectrophotometry (ICPAES) using atomic-emission spectrometer (Optima 2500 DV, Perkin Elmer, USA). Digestion, preparation of standards and analysis of samples followed procedures as reported by Juhaimi et al. (2016), with modification. All chemical analyses were performed in triplicate trials.

Phytochemical screening

25g of the sample was weighted and soaked into 150ml ethanol, covered with cotton wool and agitated occasionally for 48hrs, it was filter and the filtrate was evaporated to obtain a crude extract. The crude extracted samples were used for phytochemical screening.
The screening was conducted to find phytochemical components such as tannin, alkaloid, glycoside, of sweet potato peel using the following standard methods.

To observe the presence of tannin, 0.3 g of plant extract was dissolved in 10 mL of ethanol. Subsequently, two drops of ferric chloride ($FeCl_3$) were added to the solution. Changes in the solution to dark blue or dark green indicate tannin content (María et al.,2018)

Alkaloids were assessed by dissolving 0.01 g of plant extract in 5 mL of HCL. The extracts were then homogenized and filtered. As many as three drops of Mayer's reagent were added to the extract, and a white precipitate or red color confirmed the presence of alkaloids (Kgosana, 2019)

Identification of glycoside was performed using the Keller-Kiliani method by dissolving 0.5 g of plant extract in 5 mL of distilled water, followed by adding 2 mL of Keller-Kiliani reagent. A total of 1 mL of sulfuric acid (H_2SO_4) was added to the solution. The formation of a brown ring indicated the presence of cardiac glycoside (Ismail, 2014).

Testing for saponins, the foam height test was used where 1 mL of distilled water was added to 10 drops of the extract dissolved in isopropyl alcohol (20 mg/mL) in a test-tube, shaken vigorously to froth, and then allowed to stand for 10 min. Saponin content was measured as follows: no froth (absence); froth less than 3 mm high (poor); froth 6 mm high (moderate) and froth greater than 8 mm high (abundant) (María et al.,2018)

Testing for flavonoids, the Shinoda test was used. 1 mL of absolute ethanol and 3 drops of concentrated hydrochloric acid were added to 0.5 mL of diluted extract in isopropyl alcohol. Formation of red color indicated the presence of aurones and chalcones. In cases where no colour change was observed, pieces of metallic magnesium were added. The formation of orange, red or magenta coloration indicated the presence of flavones and flavonols, respectively (María et al., 2018)

DATA ANALYSIS

Data was collected in triplicates and analyzed using one way analysis of variance (ANOVA) for significance different using SPSS (version 16). Duncan multiple range test was use for mean separation at $p<0.05$.

RESULTS

Table 1 shows the proximate composition SPP fermented for different duration. It showed that there were no significant difference ($p>0.05$) among the treatments for moisture content. The value for Moisture varied from 7.33 - 10.57%. The sample fermented for 72 hours had the highest value (10.57%) while the sample fermented for 24 hours had the least moisture content (7.33%). The ash content varied from 2.88 - 5.11% with significantly ($p<0.05$) high value recorded for samples fermented for 72 hours while the raw sample had the least value (2.88%). Samples fermented for 24 hours (T2) and 48hours (T3) where not significantly different ($p>0.05$). There was also a significant difference ($p<0.05$) among the value for fat content with values ranging from 4.06 - 6.18. The highest value (6.18%) and the least value (4.06%) were recorded in the 24 hour fermented and raw samples respectively. The result for CP revealed a significant difference among the treatment with the raw sample having the least value (4.08%) and those fermented for 24 hours having the highest value (8.87%).

Table 1: Proximate composition of fermented sweet potato peels

Treatment	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)	CP (%)
CTRL	6.18 ± 0.00^{a}	2.89 ± 0.01^{a}	2.88 ± 0.00^{a}	$9.430.00^{a}$	4.08 ± 0.01^{a}
T2 24hrs	4.50 ± 1.41^{ab}	6.31 ± 4.70^{c}	3.49 ± 0.70^{ab}	7.33 ± 0.71^{a}	8.87 ± 1.07^{b}
T3 48hrs	4.20 ± 0.42^{ab}	5.11 ± 0.90^{b}	4.40 ± 0.14^{ab}	9.32 ± 1.70^{a}	5.71 ± 0.74^{a}
T4 72hrs	4.06 ± 0.18^{b}	4.40 ± 0.14^{a}	5.11 ± 0.90^{b}	10.57 ± 2.10^{a}	6.39 ± 1.58^{ab}

Keys: Mean±Standard Error; values with different superscripts across row are significantly different at ($P<0.5$)

Table 2 shows the mineral composition of fermented SPP in milligram/100g. The result shows that there were no significant difference among the values of the parameters analyzed. The calcium content varied from 2.77-3.02mg/100. The raw sample had the least value (2.77mg/100) while the sample fermented for 24 hours has the highest value (3.02mg/100). Iron content varied from 2.59-2.66mg/100. The sample fermented for 74hours had the highest value (2.66mg/100) while the ones fermented for 48 hours had the least value (2.59mg/100). Zinc content varied from (2.03-2.10mg/100), the sample fermented for 24hours had the highest value (2.10mg/100) while the sample fermented for 48 and 74 hours had the least value (2.03mg/100).

Table 2: Mineral composition of fermented sweet potatoes peels

Treatment	Iron (mg/100g)	Zinc(mg/100g)	Sodium(mg/ 100g)	Potassium(mg/ 100g)	Calcium(mg/ 100g)
CTRL	$0.63\pm.004a$	$2.04\pm0.01a$	$2.64\pm0.15a$	$3.24\pm0.06a$	$2.77\pm0.12a$
T2	$0.60\pm0.16a$	$2.10\pm0.14a$	$2.62\pm0.92a$	$3.39\pm0.35a$	$3.02\pm0.26a$
T3	$0.55\pm0.02a$	$2.03\pm0.18a$	$2.59\pm0.85a$	$3.18\pm0.02a$	$2.96\pm0.119a$
T4	$0.60\pm0.09a$	$2.03\pm0.11a$	$2.66\pm0.04a$	$3.50\pm0.18a$	$2.88\pm0.06a$

Mean values with the same superscript letters along the row were not significantly different at (P<0.5)

Table 3: Phytochemical Analysis

Treatment	Alkaloid	Phenols	Flavanoid	Tannins	Saponinn	Glycocides
CTRL	+	-	+	-	+	+
T2	++	+	+++	-	++	+
T3	++	+	++	-	++	++
T4	++	+	++	++	++	++

KEYS: +++ : Present in highest concentration
++ : Present in higher concentration
+ : Present in lowest concentration
_ : Negative or Absence

DISCUSSION

Recent studies on fermented feeds have concluded that, after fermentation, nutrition is often optimized and is better suited for use in feed than in raw materials (Nan et al., 2022). In this study, the nutrient composition of SPP changed after fermentation, the percentage composition of crude fiber, fat and protein composition of fermented sweet potato peel decreased significantly ($P < 0.05$) while the moisture and ash content increased insignificantly ($P > 0.05$) until the last day of fermentation. The proteolytic activity of the fermenting bacteria may have resulted in the increase in the protein content during the 24hours fermentation period. The crude protein decreased with increase in fermentation period from (8.87- 5.71%). Davidson, et al., 2015 also observed a decrease with increase in fermentation period from (4.93-0.25g).in crude protein after 24 hours of fermentation. The differences observed in these studies could be attributed to different fermenting medium. In the treatment with adding baker's yeast (*Saccharomyces cerevisiae*) as the starter, the results indicate that as the sweet potato peel fermentation period increases, the protein content decreases from 24 to 48hours of fermentation. The decrease in protein content in this treatment is suspected to be related to the growth phase of the halotolerant bacteria, which have reached the stationary phase. The fermentation period required to achieve the highest protein content is observed on the 24hours period. The microbial population reaches its maximum point during the stationary phase. The microbial mass at the stationary phase has reached the threshold of the nutritional support capacity for population growth (Astuti and Wardani, 2016). This suggests that as the fermentation time increases, the protein content increases to a certain point as long as the nutrition is met and decreases when the nutrition is depleted.

Moisture content is a notable factor in fermentation due to its influence on growth, biosynthesis and secretion of various metabolites (Krishna and Chandrasekaran 1996). Low moisture content can cause reduction in solubility of nutrients from the substrate, low degree of swelling and high water tension. Thus, water content is a very significant factor in the fermentation process. High water activity can lead to the decrease in porosity of the substrate, thereby reducing the exchange of gases. On the

other hand, low water activity may result in the reduction of microbial growth and consequent lower production of enzyme (Mahanta, et al., 2008). According to Adegunloye and Oparinde 2017, Ash content represents the total mineral content in foods. Although minerals represent a small proportion of dry matter, often less than 7% of the total, they play an important role from a physicochemical and nutritional composition of food. From our study, there was a significant increase in the ash content as the duration of the fermentation was taking place. This might be due to the non-leakage of the soluble minerals into the fermenting liquid during fermentation (Ogbonnaya, et al., 2010).

The fibre content ranged from 2.89 –6.31%.The raw sample had the lowest value (2.89%) while the sample fermented for 24 hours had the highest value (6.31%). The result showed an increase in fibre content from the 2.89±0.01% (control) to 6.31±4.70% (T2 24hours), this increases in the crude fiber percentage can be explained by the presence of high molecular weight carbohydrates, such as cellulose, which were not broken down by the enzyme system during fermentation. Similar result was also obtained by Kwatu et al., 2025 who recorded 3.70±0.20 for raw sweet potato peel and 6.41±0.10 for potato peel fermented with *S. cerevisiae*, 7.15±0.08 for potato peel fermented with bacteria isolates following a three weeks fermentation period. As the duration of fermentation increased, the fibre content decreased, this could also be due to the activities of microorganisms which are known for the bioconversion of carbohydrates and lignocelluloses into protein and also a softening of the fibrous tissues during fermentation. This is also in line with the findings of Babalola and Giwa (2012) who reported a progressive decrease in the crude fiber of fermented soy beans.

Table 2 shows the result of the mineral composition of fermented sweet potato peel. The mineral content of sweet potato peel, which includes zinc and calcium decreased with increase in fermentation period. According to Odunfa, (1999) the reduction could be due to leaching into the soaking water and microbial utilization .Talaro, (2002) have also reported that some available minerals are utilized by the fermentation organism in the potato mesh. According to Oyarekua, (2013) the minerals decreased with increase in fermentation period due to utilization of these minerals by the various microbes in the sample. The relatively high levels of potassium, sodium, calcium, and iron make sweet potato roots a valuable dietary source for mineral supplementation. However, studies have reported that variations in soil and fertilizer management practices can lead to differences in the mineral content of the sweet potato peel (Joy et al., 2019).

Table 3 shows the result of the qualitative analysis of phytochemicals in the fermented sweet potato peel. Alkaloids, tannins, saponins are known due to the important biological activity attributed to this class of compounds. Most of the extracts analyzed revealed the presence of these in amounts ranging from abundant to poor or absence. From the study, fermented sweet potato peel demonstrated the presence of flavonoid in very high concentration at 24 hours of fermentation

CONCLUSION

Potato peels as a by-product from potato processing are available in large amount and their utilization may eliminate a substantial pollution problem. Based on the findings, fermenting sweet potato peels for 72 hours using *Saccharomyces cerevisiae* resulted in the high levels of potassium and calcium, which are essential minerals for various physiological functions. However, if the goal is to maximize protein content, fermentation for 24 hours would be the optimal duration. Furthermore, the presence of phytochemicals in fermented sweet potato peels suggests potential applications in food, pharmaceutical, or nutraceutical industries. Future studies can explore the specific bioactive compounds and their functional properties to fully harness the potential of fermented sweet potato peels.

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