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THE EFFECTS OF FERMENTATION ON THE NUTRITIONAL AND ANTI-NUTRITIONAL CONSTITUENTS OF IRISH POTATO PEELS

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Abstract
The study was carried out to determine the effects of fermentation on the nutritional and the anti-nutritional constituents of Irish potato (Solanum tuberosum) peels. 300g of peels were naturally fermented at room temperature. Isolation was done and the physico-chemical parameters of the fermenting medium were also analysed. A total of seven (7) microorganisms` species were isolated. Four of them (4) were bacteria while three (3) were fungi. The isolated microorganisms and their percentage of occurrence include: Lactobacillus fermentum, 4 (40%), Bacillus subtilis, 3(30%), Micrococcus luteus, 2 (20%), Klebsiella sp, 1(10%), Saccharomyces cerevisiae, 3(42.90%), Aspergillus fumigatus, 1(14.20%) and Penicillium chrysogenum, 3(42.90%). A decrease in pH with corresponding increase in titratable acidity (TTA) was observed during the period of fermentation. The result of the proximate composition revealed that protein was high (27.70%) as compared to the unfermented sample (14.11%) and the crude fibre content was 27.50% as compared to the unfermented sample (16.27%). There was a decrease in fat, ash, carbohydrate and moisture content of the fermented sample. The effect of fermentation on the anti-nutritional content showed a decrease in phytic acid, phytate, trypsin inhibitor activity (TIA) and oxalate content in the fermented sample. This study further proved the beneficial effect of fermentation on Irish potato peels by improving the nutritional constituents and reducing the anti-nutritional factors. Thus, potato peels can be useful in animal feed production.

Key words: Fermentation, Isolation, Identification, Proximate Composition, Anti-nutrient.

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1. INTRODUCTION

Irish potato (*Solanum tuberosum*) is the world's fourth largest food crop after wheat, rice and maize (Hofler and Ochieng (2008)), Nigeria being the fourth biggest producer in Sub Saharan Africa (FAO, 2008). Potato, as further described by the Food and Agricultural Organization (2008), is a carbohydrate rich food providing source of dietary energy and some micro nutrients to consumers. In Nigeria, potatoes are responsible for more than half the total carbohydrate requirements of the population in localities where potato is cultivated and consumed as staple food, in comparison with other roots and tubers. The protein content of potato is very high and in many developing countries, especially in urban areas, rising levels of income are driving a nutrition transition towards more energy dense foods, as part of that transition. As a consequence the demand for potato is increasing. About 5-20% of waste potato by-products from potato cultivation could be utilized for bio-ethanol production (Limatainen *et al*., 2004, Adarsha *et al*., 2010). Beside this vast industrial application, potato peels are being discarded from various kitchens, cafeterias, and industries as a zero value waste.

Fermentation as described by Yuan *et al*. (2008) is the conversion of carbohydrate into alcohols and short chain fatty acids by microorganisms' enzymes. Fermented foods are those foods that have been subjected to the action of microorganisms or enzymes so that desirable biochemical changes cause significant modification in the food. Fermented foods from plant or animal origin are an intricate part of the diet of people in all

parts of the world. According to Anon (1996) two billion people have been estimated to be deficient in one or more micro-nutrients. The Food and Agricultural Organization, amongst other influential organization, has recognized that the problem of food security cannot be tackled in isolation. Fermentation technologies play an important role in ensuring the food security of millions of people around the world, particularly marginalized and vulnerable groups and this is achieved through improved food preservation, increasing the range of raw materials that can be used to produce edible food products and removing anti-nutritional factors to make food safe to eat.

Many waste products have been salved through fermentation. For instance, in Sudan a wide range of waste products are fermented to produce edible food products. These include bones, hides and locusts (Dirar, 1992). In Indonesia a variety of waste products are fermented to produce nutritious food products e.g. tempe-bongkrek is a protein rich food that is made in Indonesia by fermented peanut and coconut press-cake, remaining after oil extraction (Steinkraus, 1996). Investigation carried out by Ojokoh (2007) on the nutrient and anti-nutrient content of mango peels which is a zero waste product, revealed an increase in the protein content of the fermented ripe mango peels and there was no considerable difference in the fat and carbohydrate content while there was decrease in fibre content. Anti-nutrients such as tannin and phytate were also found to decrease in the fermented samples. The role played by microorganisms in fermentation, as explained by Ojokoh (2007), could either be positive or negative. The positive effects are generally regarded as part of the fermentation processing, namely product preservation, flavour development and reduction of anti-nutrient, enhancing the nutrient, vitamins, essential amino acids and protein, by improving protein and fiber digestibility. The negative effects include spoilage of food products and contamination by pathogenic microorganisms.

2. MATERIALS AND METHODS

Procedure for fermentation

Irish potatoes were obtained from south-gate of the Federal University of Technology Akure, Nigeria. They were washed in sterile distilled water and peeled. 300g of the peels were placed into a clean bowl containing 2 litres of distilled water and then allowed to ferment for 3days at room temperature (Ojokoh, 2007).

Isolation of microorganisms

Serial dilution of the broth sample was done and 1ml of each serially diluted fermentation broth were plated on Nutrient agar, deManRogosa Sharpe agar and Potato dextrose agar. The plates containing the nutrient agar were incubated in an inverted position at 37^0C for 24hours and plates containing the deManRogosa Sharpe agar were incubated in an anaerobic jar for 48hours, while plates containing potato dextrose agar were incubated at 27^0C for 72hours. The analyses were done at 0hours, 24hours, 48hours and 72hours. (Buchanan and Gibbons, 2007). Pure, sub-culture isolates were subjected to series of microbiological and biochemical tests which include: Gram stain, catalase, oxidase, coagulase, spore staining, motility, starch hydrolysis and sugar fermentation (Fawole and Oso 2001). References were made to Bergey"s Manual of Systematic Bacteriology for proper identification of bacteria isolates while macroscopic and microscopic examination were done for the identification of fungi isolates (Seifat, 2008).

Determination of the physico-chemical parameters of the fermentation broth

The pH of the broth was measured using a pH meter (Hanna multi-parameter-HI-9828) fitted with glass electrode using buffer solution of pH 4 and pH 7 for standardization while the titratable acidity (TTA) was determined by titrating the sample against 0.1M NAOH using phenolphthalein as the indicator. This

procedure was carried out at 0hour, 24hours, 48hours and 72hours respectively (Iland*et al*., 2000).

Proximate and anti-nutrient analysis of the fermented and unfermented potato peels

The determination of the proximate and anti-nutritional constituents for the fermented and unfermented sample was performed according to AOAC (2012) procedures for moisture, ash, fat, crude fibre, protein, carbohydrate, phytate and oxalate, while trypsin inhibitor activity was determine using (ISO, 2001) procedure for anti-nutrient analysis.

Statistical analysis

Triplicate results for various samples and mean values obtained for different samples were analysed using one way ANOVA by Turkey's HSD test ($p< 0.05$) using statistical software MINITAB version 14 for windows.

3. RESULTS

Microbial analysis

The bacteria isolated during the fermentation period as shown in Table 1 shows that *Lactobacillus fermentum* (40%), a lactic acid bacteria, predominates the fermenting medium followed by *Bacillus subtilis*(30%), as compared to *Micrococcus luteus* (20%) and *Klebsiella* sp. (10%), that were affected by the acidified environment.

Table 2 presents the percentage of occurrence of the isolated fungi, which indicates that *Saccharomyces cerevisiae* (42.9%) and *Penicillium chrysogenum* (42.9%) are dominant, while at least occurred *Aspergillus fumigatus* fungus 14.2%).

Table 1: Isolated bacteria and their percentage occurrence during fermentation of Irish potato peels

Bacteria isolates	No. of isolates	% of frequency occurrence
Lactobacillus fermentum	4	40
Bacillus subtilis	3	30
Micrococcus luteus	2	20
Klebsiella sp.	1	10
Total	**10**	**100**

Table 2: Isolated fungi and their percentage occurrence during fermentation of Irish potato peels

Fungi isolates	No. of isolates	% of frequency occurrence
Sacccharomyces cerevisiae	3	42.9
Aspergillus fumigatus	1	14.2
Penicillium chrysogenum	3	42.9
Total	**7**	**100**

Table 3: Changes in pH and titratable acidity during fermentation of Irish potato peels

Time (Hours)	pH	Titratable acidity (mol/dm^3)
0	7.18	0.0059
24	5.52	0.011
48	5.40	0.022
72	5.24	0.037

The proximate composition results of the fermented and unfermented Irish potato peels.

The result of proximate composition of the fermented and unfermented sample, as indicated in Table 4, shows that the peels varied significantly in their nutritional contents. The fermentation of the peels increased the protein content of the sample (27.70 ± 0.33) compared to the unfermented sample (14.11 ± 0.11). The crude fibre also increased significantly from 16.27 ± 0.03 to 27.54 ± 0.01 after fermentation. There

was a decrease in the moisture, ash, fat, carbohydrate and energy value of the fermented sample.

Anti-nutrient composition results of the fermented and unfermented Irish potato peels

The anti-nutrient composition such as phytate, phytic acid, oxalates and trypsin inhibitor of the fermented and unfermented Irish potato peels, as shown in Table 5, revealed that the phytates and phytic acid composition of the unfermented and fermented samples decreased from 10.71 ± 0.04 to 7.21 ± 0.09 and 3.01 ± 0.02 to 2.15 ± 0.12 respectively, while oxalates and trypsin inhibitor content decreased from 24.76 ± 0.02 to 13.05 ± 0.02 and 37.01 ± 0.00 to 12.98 ± 0.21 respectively.

Table 4: Proximate composition of fermented and unfermented Irish potato peels (%) ± SD

Parameters	Fermented sample	Unfermented sample
Protein	27.70 ± 0.03	14.11 ± 0.11
Crude fibre	27.54 ± 0.01	16.27 ± 0.04
Moisture	8.85 ± 0.03	12.48 ± 0.07
Ash	4.14 ± 0.01	6.39 ± 0.28
Fat	7.42 ± 0.09	9.24 ± 0.06
Carbohydrates	24.32 ± 0.13	41.48 ± 0.13
Energy value (calories)	1159.34 ± 0.26	1287.37 ± 0.40

Table 5: Anti-nutrient composition of fermented and unfermented Irish potato peels (mg/g) ± SD.

Parameters	Fermented sample	Unfermented sample
Phytates (mg/g)	7.21 ±0.09	10.71 ±0.84
Phytic acid (mg/g)	2.14 ±0.12	3.01 ±0.02
Oxalates (mg/g)	13.05± 0.02	24.76± 0.02
Trypsin inhibitor (%)	12.98 ±0.21	37.01 ±0.00

4. DISCUSSION

A variety of microorganisms were isolated during the fermentation and this is in agreement with the assertion of Oyeyiola (2002) that a variety of microorganisms are responsible for the fermentation process in a fermented product by playing an essential role in bringing out the biochemical changes during fermentation. A total of seven (7) microorganism were isolated out of which four (4) were bacteria and three (3) were fungi. The isolates, according to Leahy and Colwell (2005), were adapted to Irish potato environment, resulting an acquiring of genetic information as would be expected in microorganisms isolated from specific environments. This suggests that the isolates may use the Irish potato carbohydrate as a carbon source. The presence of *Lactobacillus* sp, *Bacillus* sp and *Micrococcus* sp., as stated by Adeniyi *et al*. (2005), were typical of the microflora of fermenting Irish potato peels and have been implicated in its fermentation. The occurrence of *Klebsiella* sp. may be due to contamination. Although *Klebsiella* sp., according to Le Bouguenec and Schouler (2011), belonged to the *Enterobacteriaceae* family which is a group of bacteria normally found in soils, water, fruits, vegetables, grains, trees, crops and plants.
The decrease in pH with the corresponding increase in titratable acidity could be a result of the dominance of the environment by lactic acid bacteria which degraded carbohydrates inducing the acidification of the medium. This is in agreement with the investigation carried out by Adeniyi*et al.* (2005). The disappearance of *Klebsiella* sp. after 24hours and *Micrococcus luteus* after 48hours may be attributed to the acidified environment caused by the production of lactic acid by *Lactobacillus fermentum*. Lactic acid bacteria, as described by Sonomoto and Yokota (2011). are a group of Gram positive bacteria that are of economic importance because they are applied extensively in both the production and preservation of a wide variety of food products.
The proximate analysis results of the fermented samples revealed an increase in the protein content which may be attributed to the biosynthesis of proteins and essential amino acids by the fermenting organisms, as supported by several investigators, while increase in crude fibre may be due to the utilization of other nutrients such as carbohydrates and biosynthesis of polysaccharides for cell wall build up by the fermenting microorganisms. As they proliferate although this is in disagreement with the work of various researchers, but similar trend was also reported by Azokpota*et al.* (2006). The decrease in carbohydrate and ash content may be due to the utilization of some of the sugars and mineral elements by the fermenting organisms for growth and other metabolic activities, while a decrease fat content observed may be due to the degradation activities of the fermenting organisms especially moulds, in which lipolytic activities are well known (Ogunshe*et al.*, 2007).

Decrease in fat content has been reported by Odunfa (1985) to be desirable, since high amount of fatty acids in food can cause rancidity thereby making food taste sour. The decrease in energy value observed in the fermented sample as compared to unfermented sample indicates that fermentation is an exothermic reaction. An exothermic reaction, as defined by Anne (2016), is a chemical reaction that releases energy in form of heat. This is also in line with the report of Hesseltine and Wang (2005).

There was a general decrease in the anti-nutrient composition of the fermented sample as compared to the unfermented sample. Fermentation according to Ali *et al*. (2003) is one of the processes that decrease the level of anti-nutrient in food grains. Phytic acid is one of a number of anti-nutrients in cereals and legumes that blocks mineral phosphorus which is not readily bioavailable in human. It is also known as chelating agent that form a compound which is referred to as phyate and which inhibits trypsin needed for protein digestibility in the small intestine (Singh and Krikarian, 1992), while oxalate reduces calcium absorption (Wolfe, 1992). The reduced phytic acid was due to the phytase activities of the fermenting microorganisms, fact that is in agreement with the report of Ojokoh (2007). Trypsin inhibitor decreases protein digestibility. A reduction in trypsin inhibitor after fermentation had been reported by several investigators (Osman 2004;Ejigui*et al*. 2005).

5. CONCLUSION

This study revealed that improvement in the nutritional quality and efficient reduction of the anti-nutrient content (phytate, oxalate and trypsin inhibitor activity) can be achieved through the fermentation of Irish potato peels. Therefore fermentation can cause an increase in the range of raw materials or zero waste value products that can be used to produce edible food products in large quantity and removing of the anti-nutritional factors thereby making it safe for animal consumption.

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