Investigating the Impact of Sprouting on the Nutritional and Anti-Nutritional Properties of *Ogi*Madefrom Yellow and White Maize Varieties

Abstract

Ogi, a popular traditional fermented maize gruel in Africa, is a staple food for millions of people for its nutritional value and versatility in culinary applications. This study investigated the effects of sprouting and fermentation on the nutritive quality of ogi produced from yellow and white maize varieties using standard methods analysis. The results showed significant improvements in the nutritional profile of sprouted ogi samples compared to unsprouted ones. The pro-vitamin A ranged from 26.17±0.02 to 31.24±0.03 in unsprouted yellow ogi (UYO and SYO) respectively. The corresponding values for the unsprouted white ogi (UWO) and sprouted white ogi (SWO) are 9.28±0.01 to 11.81±0.03. The protein content of SYO and SWO are 13.73±0.07and 12.02±0.06 respectively compared to UYO and UWO samples (12.33±0.56 and 10.22±0.07).Sample SYO has the highest vitamin A content of 31.24 µg/100g followed by sample UYO which indicated higher amount of vitamin A content in yellow maize products (SamplesUYO and SYO) could be attributed to the maize variety (yellow) containing higher amount of carotenoid compound, a pro-vitamin A.Notably, yellow maize ogi samples exhibited superior nutritional quality compared to white maize ogisamples. Sprouting and fermentation enhanced the bioavailability of nutrients, making ogi a more nutritious and wholesome food option. This study highlights the potential of simple processing techniques to improve the nutritional value of traditional foods, contributing to better nutrition and health outcomes in Africa.

Keywords: Ogi, sprouting, fermentation, nutritive quality, yellow maize, white maize.

1. Introduction

"Cereal-based food,such as *ogi*, plays a vital role in the diets of millions worldwide, particularly in regions where maize is a staple crop. *Ogi*, traditional fermented cereal gruel, is popular across Africa for its nutritional value and versatility in culinary applications. Ogi is a popular fermented semi-solid food of various colour depending on the maize types (white or yellow) used in its preparation"[1]. "Maize (*Zea mays* L.) is one of the most widely consumed cereal crops in Nigeria. It is rich in carbohydrate, supplying over 360 kcal/100 g of calories and contains adequate quantity of protein. It can be cooked, boiled, roasted, made into gruel for *Ogi*and useful in the production of animal feeds"[1].

"*Ogi* is the most popular fermented health food and its consumption cuts across the various segments of the society, including all age groups in many West African countries"[2]. "The three major tribes in Nigeria refer to the fermented gruel (pap) by their different local names: Yourba (ogi), Igbo (akamu), and Hausa (koko). The popularity of this food product is mainly due to its availability, high digestibility and the fact that it supplies the necessary calories required[3]. However, research has shown that a diet based on maize may be deficient in micro-nutrients such as potassium, iron, B complex vitamins, amongst others"[2-3]. "It was reported that 100 g of maize foods consumed could to some extent, contribute in satisfying dietary reference intakes of children and women in energy, proteins, carbohydrates, magnesium, zinc, vitamins B1 and B6. However, it provides very low supply of fats, calcium, sodium, selenium, vitamins C, A and E"[4]. "The processing of maize ultimately increases its shelf life but, a significant loss of micronutrients may occur via heat degradation and/or leaching during processing and this may be associated with under-nutrition and hidden hunger"[5].

"Sprouting and fermentation are both complex biological processes involving many biochemical and physiological reactions, result to significant changes in the nutrient composition and physicochemical properties of grains. Controlled sprouting and fermentation processes can lead to a final product with improved nutritional value, sensor properties, safety, stability and functional qualities"[6-7]. While previous research has explored the effects of sprouting on various grains, including maize, there is paucity of information on the impact of sprouting on the nutritional and ant-nutritional properties of seed based food especially ogi made from different variety of maize. Therefore, the aim of this study is to conduct a comparative analysis of the effect of sprouting on the nutritional and anti-nutritional properties of *ogi* produced from yellow and white maize varieties. By systematically evaluating changes in nutrient content, bioavailability, and anti-nutrient levels following sprouting and fermentation, the study seek to provide valuable insights into the potential of sprouting as a sustainable approach to enhance the nutritional value of *ogi*.

2. Methodology

2.1 Preparation of Maize Grains to *Ogi* Powder

Yellow and white sweet maize grains obtained for the study were sorted and divided into two portions. The first portion was soaked for 24 hours after which the water was decanted and the grains were spread on trays lined with cloth and kept wet by frequent spraying of water at every morning and evening for 2 days. The sprouted maize grains were thereafter re-soaked and washed with clean water. The second portion was steeped in clean water at room temperature for 48 h. The water was decanted from the two portions and the fermented grains were washed with clean water and wet milled using an attrition mill. The wet bran was removed with a muslin cloth and the filtrate was allowed to settle for 24 h to form the starchy sediment *ogi* slurry[8]. The sediment was de-watered in a jute sack using a hydraulic jack. The de-watered mash was pulverized in a granulating machine, dried in a cabinet dryer (55±5°C), and dry milled to pass a mesh sieve of 0.5 mm, as reported[4]. The ogi powder thus prepared were labeled as follows: UYO: Unsprouted Yellow Maize Ogi, SYO: Sprouted Yellow Maize Ogi, UWO: Unsprouted White Maize Ogi and SWO: Sprouted White Maize Ogi respectively.

Figure 1: Pictures of Yellow (A) and White (B) Maize variety

2.2 Determination of proximate composition

"The proximate composition of the samples was determined using the standard methods of the Association of Official Analytical Chemists international"[9]. Crude protein was determined using micro-Kjeldahl method (Method No 988.05), crude fat was determined by the Soxhlet extraction method (Method No 920.39) and moisture content was determined using air oven at 105°C to a constant weight according to Method No 991.02 (Plus 11 Sanyo*Gallenkamp* UK). The ash content was determined by ashing the sample in a muffle furnace (*Gallenkamp 3*) at 550°C for 4 hours (Method No 935.13), crude fibrewas determined by (Method No 978.10). The total carbohydrate was determined by difference according to Equation:

$Totalcarbohydrate$ = 100 – (% $moisture$ + % fat + % $protein$ + % $fibre$ + % ash

Figure 2: Pictures of Yellow ogi(C) and white ogi (D) powder

2.3 Pro-vitamin A: Carotenoids Analysis

Approximately 15 g of each sample added to 3 g of *Celite 454* (Tedia, Ohio, USA), were weighed and successive additions of 25 ml of acetone were added to obtain a paste, which was then transferred to a sintered funnel (5 µm) coupled to a 250 ml

Buchner flask and filtered under vacuum. This procedure was repeated three times until the sample became colourless after which the extract was transferred to a 500 ml separation funnel containing 40 ml of petroleum ether. The acetone was removed by the slow addition of ultrapure water (*Millipore*) to prevent emulsion formation. The aqueous phase was discarded and this procedure was repeated four times until no residual solvent remained (ultrapure water). The extract was then transferred through a funnel containing 15 g of anhydrous sodium sulphate (drying agent) and made up a volume of 50 ml with petroleum ether. Additionally, for the identification and quantification of the pro-vitamin A (carotenoid), 2 ml was removed from the extract and dried in an amber flask under nitrogen flow. The sample was diluted in 100 µl of acetone under shaking in a vortex mixer (*Genie 2Scientific Industries*) and transferred to a 2-ml amber flask for high-performance liquid chromatography (HPLC) analysis. The concentration of the pro-vitamin A carotenoid was determined using the equation reported[10].

$$Carotenoid\ \left(\frac{\mu g}{g}\right) = \frac{Ax * Cs(\mu g\ ml/) * V\ ml)}{Ax * Pg}$$

Where *Ax* = carotenoid peak area, *Cs* = standard concentration, *As* = standard area, *V*= total extract volume, and *P* = sample weight.

2.4 Determination of Anti-nutrients

2.4.1 Oxalate Determination

This determination involved three major steps: digestion, oxalate precipitation, and permanganate titration.

a. *Digestion:* Digestion was effected by suspending 2 g of the sample in 190 mL of distilled water in a 250 mL volumetric flask after which 10 mL of 6M HCl was added and the suspension digested at 100 °C for 1 hour. The solution was cooled, and made up to 250 mL mark in the flask before filtration.

b. *Precipitation:* Duplicate portions of the filtrate were measured into breakers and four drops of methyl red indicator added. Ammonia solution was added in drops until the test solution changed from pink to faint yellow colour (pH 4.0-4.5). Each portion was then heated to 90 °C, cooled and then filtered to remove the precipitate containing ferrous ion. The filtrate was again heated to 90 °C and 10ml of 5% $CaCl_2$ solution was added while being stirred constantly. The solution was then heated and left overnight at 25 °C, and centrifuged at 2000rpm for 5minutes. The supernatant was decanted and the precipitate completely dissolved in 20ml of 25% (v/v) H_2SO_4 solution and filtered.

c. *Titration:* The total filtrate resulting from the digestion of 2 g of sample was made up to a volume of 300 mL. Aliquots of 125 mL of the filtrate was heated until near boiling and then titrated against 0.02 M standardized $KMnO_4$ solution to a faint pink color which persisted for 30 seconds. The calcium oxalate content was calculated using the formula:

Oxalate Content = $\frac{T \times Vme \times Df}{Me \times Mf} \left(\frac{Mg}{100g}\right)$

Where T is the titre of $KMnO_4$ (mL), V_{me} is the volume-mass equivalent, D_f is the Dilution factor= Vt/A Where Vt is the total volume of filtrate (300 mL) and A is the aliquot used i.e. 125 mL, M_e is the molar equivalent of $KMnO_4$ in oxalate and M_f is the mass of sample used.

2.4.2 Phytate Determination

The sample (5 mL) was mixed, cured for 5 hrs and filtered. Aliquots of 250 mL of the filtrate in a conical flask was added to 5.00 mL of 0.30 % ammonium thiocynate, the mixture was titrated with standard iron (III) chloride solution to a persistent brownish yellow coloration that persisted for 4 mins. The amount of phytates was calculated with the equation below:

$$\text{Phytic acid} = \frac{Titre\ value\ x\ 0.00195\ x\ 1.9\ x\ 100}{2}$$

2.4.3 Determination of Trypsin Inhibitors

The method reported by Kakade and Evans (1965) was followed in order to determine the trypsin inhibitor. To do this, weigh 0.2 grams of the samples and place them in a screw-cap centrifuge tube. After adding 10 milliliters of 0.1M phosphate buffer, the mixture was shaken for an hour at room temperature using a UDY shaker. The resulting suspension was filtered using Whatman No. 42 filter paper after being centrifuged for five minutes at 5000 rpm. Phosphate buffer was used to adjust each sample's volume to 2 ml. The water bath was used to keep the test tube at 37 degrees Celsius. To one of the tubes, which was meant to be a blank, six milliliters of 5% TCA solution was introduced. The reaction was stopped after 20 mins by adding 6ml of TCA solution to the experimental tubes and the tubes were shaken. The reaction was allowed to proceed for 1hour at room temperature. The mixture was filtered through *Whatman No. 42* filter paper. Absorbance of filtered sample and trypsin standard solutions was read at 280 nm. The trypsin inhibitor in mg/g was calculated using the formula:

$$\text{T.I. mg/g} = \frac{\text{A standard} - \text{A sample x Dilution factor}}{\text{0.1g x sample wt in g 1000 x sample size}}$$

2.5 Mineral analysis

"The ash of each sample (obtained in a crucible, by igniting 2 g of the samples in a muffle furnace) was digested by adding 5 ml of 2 M HCl, heated slowly for 20 minutes. After heating, it was filtered into a 100 ml volumetric flask. The filtrate was used for the determination of the concentration of each mineral element (potassium, sodium and iron while phosphorus was determined b molbdate method, a colorimetric technique). Buck Scientific - 200 Atomic Absorption Spectrophotometer -AAS (Buck Scientific, Norwalk) was used. The composition of minerals was determined according to the standard method of the Association of Official Analytical Chemists"[9].

3.0 Results and Discussion

Table 1: Proximate Analysis ofOgi Samples

Sample	Moisture (%)	Crude protein (%)	Crudeash (%)	Crude fat (%)	Crude fibre (%)	Carbohydrate (%)
UYO	3.49^{a}±0.02	12.33^{a}±0.56	2.86^{a}±0.02	12.33a±0.01	1.55^{b}±0.02	67.24^{a}±0.09
SYO	5.61^{a}±0.02	13.73^{b}±0.07	3.94^{a}±0.01	12.51^{b}±0.02	1.44^{a}±0.01	64.21^{b}±0.12
SWO	4.22^{b}±0.04	12.02^{c}±0.06	2.69^{b}±0.02	11.16^{c}±0.01	1.42^{c}±0.02	68.46^{c}±0.05
UWO	5.45^{c}±0.04	10.22^{d}±0.07	3.64^{b}±0.01	10.37^{d}±0.02	1.37^{c}±0.02	68.95^{a}±0.19

Values are represented as means of triplicate determinations ± SD. Means with the same superscript within the same column indicate no significant difference (p<0.05).

Proximate composition of the enriched and control samples

"The results of the proximate analysis of the samples presented in Table 1 shows that the crude protein content of sample **SYO** (sprouted yellow ogi) (13.73 %) was significantly higher (p<0.05) than that of the other sampleswhile**UWO**sample (unsprouted white maize *ogi*)has the least amount of crude protein (10.22 %). This same trend was observed for the crude fat.The carbohydrates content ofsamplesSWO and UWOarerespectively 68.46% and 68.95%, which significantly higher than the samples**UYO** and **SYO** respectively. This is in line with the notion that yellow maize type has higher protein and lower carbohydrate content that the white maize of powdered *ogi"*[9].

"The ash content of the sproutedogi samples (**SYO** and **SWO**) were higher than the unsproutedogi samples (**UYO** and **UWO**). This could be due to the endogenous enzymes hydrolyzing the complex carbohydrate to release fibre. The **SYO**sample had the highest ash content (3.94 %) and the least carbohydrate content (64.21 %) while the sample **UYO** had the ash content of 2.86 %and the carbohydrate content of67.24 % which is lower than the value recorded for UWO (68.95). The findings of the present study clearly showed that the higher the protein content of the sample, the lower the carbohydrate content of the sample. This trend is in line with the previous studies"[11-12]

Table2: Pro-vitamin A (Carotenoid) and Calcium Analysis

SAMPLE	PROVITAMIN A	CALCIUM (mg/100g)

UYO	26.17^{b}±0.02	7.22^{b}±0.02
SYO	31.24^{a}±0.03	9.74^{a}±0.01
SWO	11.81^{c}±0.03	6.38^{c}±0.01
UWO	9.28^{d}±0.01	5.77^{d}±0.02

"The results revealed that sample SYO (Sprouted yellow *ogi*) has the highest vitamin A content of 31.24 µg/100g followed by sample UYO (unsprouted yellow *ogi*). The higher amount of vitamin A content in yellow maize products (SamplesUYO and SYO) could be attributed to the maize variety (yellow) containing higher amount of carotenoid compound, a pro-vitamin A. The corresponding low content of pro-vitamin A in sample SWO and UWO respectively can be attributed to the lower carotenoid content of the maize from which the products (*ogi*) were made. Vitamins are major micronutrients needed in our body system to carry out normal body physiological functions. Vitamin A is important for eye functioning (vision)"[13].

"The sample trend was observed in the result of calcium content of the samples investigated. Samples SYO and SWO which are made from the sprouted maize (yellow and white) have the higher amount of calcium content (9.74 and 6.38 g/100g respectively). These observations reinforced the assertion that processing method employed impact on the nutritional quality of the products. The slightly higher calcium content noted in *ogi* made from sprouted white maize could be as a result of enzymatic action that occurred during the sprouting process"[14].

Table 3: Mineral content of Sprouted and Unsprouted ogi from yellow and white maize variety

Samples	Na	K	Ca	Mg	P
UYO	6.9±0.02	15.5±0.05	7.22±0.01	1.26±0.01	0.81±0.02
SYO	1.3±0.01	13.8±0.06	9.74±0.01	9.52±0.02	0.65±0.02
SWO	7.1±0.02	14.4±0.05	6.38±0.01	9.18±0.02	0.57±0.01
UWO	6.8±0.01	15.9±0.06	5.77±0.02	10.39±0.02	0.71±0.02

The results of the mineral composition of the is presented in Figure 1. The sodium content ranged from 6.81 ± 0.23 in UWO to 11.31±0.02 in SYO. The same trends were observed for potassium, calcium and magnesium. Generally, it was observed that mineral content of unsprouted samples were higher than the sprouted samples. Some of these minerals must have being used up during enzymatic reactions taken placed during sprouting leading to decrease in concentrations of theses minerals.The significant higher concentration of phosphorous in unsprouted samples is an indication of bioavailability of these minerals to

the consumers of the products (Ogi). Relatively higher concentrations of ant nutrients: the phytates, tannins and trypsin inhibitors in the unsprouted samples indicate that the available minerals in the food substance might not be bioavailable to the body[15]. Phytate is a stores form of phosphorus in seeds and has strong ability to complex with mineral elements thus making the elements non bioavailable to the animal. Therefore, the significant reductions of these ant-nutrients in the sprouted yellow and white maize samples is clear indication that the available minerals will be readily available to the consumers of the products made from the sprouted maize variety.

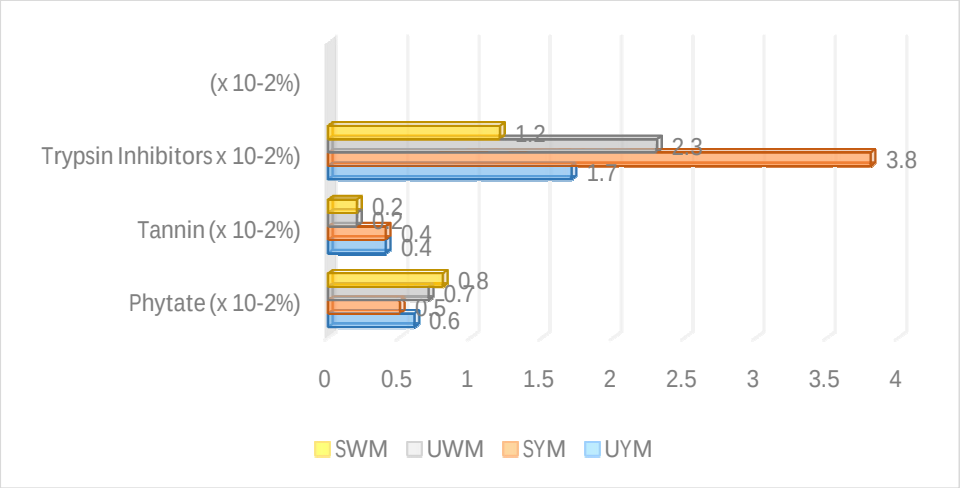

Figure3: Anti-nutrients in Ogi samples

Conclusion

The study revealed that the quality of food products depends on the quality of raw materials used in its preparation as well as the processing method adopted. Yellow maize contains higher nutritional quality than the white maize species. However, sprouting, an enzymatic biochemical reaction improved the nutritional quality of *ogi* irrespective of the maize types employed. Sprouting method should therefore be adopted in the processing of ogi, a common staple food in the west Africa. The sprouting will reduce the anti-nutritive factors in the seeds and thereby improve the bioavailability of the mineral elements present in the food formulation.

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