

Evaluation of the Phytochemicals and Antioxidant Properties of Waste from Maize (*Zea mays*) and Millet (*Pennisetum glaucum*) in Pap Production

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Abstract:

Background: The study was carried out to access the phytochemical and antioxidant properties in wastes material left after maize and millet grain processing. The waste mash was hygienically collected immediately after processing and transferred to the laboratory for analysis. The waste was sundried and packaged.

Methods: Standard analytical procedure was followed to analyze the phytochemical and assaying of antioxidant properties of the waste. The data was subjected to statistical analysis.

Results: The protein content of the millet scored 15.45% while the maize gave 11.40%. The crude fibre content of the maize 7.93% was significantly higher than that of the millet 5.02%. The total phenol of the maize left over mash 69.87 mg per 100g was significantly higher than that of millet 55.28 mg per 100g, while the total flavonoids of maize 253.93 mg per 100g was higher than that of the millet 196.08 mg per 100g. At 10 mg per dl maize waste recorded 68.73; millet 50.43 and gallic acid scored 78.59. The 2,2 Diphenyl-1-picrylhydrazyl (DPPH) reduction activity of the wastes were comparable to the standard, the maize waste had 93.30 mg per dl while millet had 91.38 mg per dl.

Conclusion: Wastes from maize and millet are good sources of protein, crude fibre and the extracts are rich in bioactive compounds.

Key words: phytochemicals; antioxidants properties; maize waste; millet waste; protein

Introduction

Cereal crops such as maize, millet, sorghum play a vital role in the food security and livelihoods of people in Nigeria. They are widely grown in different regions of the country, and their production contributes significantly to the economy of Nigeria. Cereals constitute a major part of human nutrition, being the important source of proteins and energy, particularly in developing countries. Cereals and their products are rich in antioxidant, phytochemicals that make them ideal for developing functional foods and ingredients (Serafini et al., 2002).

However, a significant amount of waste is generated during the processing of these crops. These wastes include materials such as germ, bran, hulls. These materials are by-products of the milling process and are often rich in nutrients such as fiber, vitamins and minerals. More than half of the world's grain production comes from cereals like wheat and rice, which are also a major source of waste in a number of nations (Zhang et al., 2011).

According to Crittenden et al. (2002), these wastes are also a good source of dietary fibers as well as bioactive substances such phenolics, pigments,

flavonoids, tannins, and vitamins. Consequently, the creation of value-added items from food processing wastes, such as food additives and supplements, has received attention from all over the world (Wang and Chen, 2010). These wastes which are typically discarded after processing of food, which if not properly handled are known to constitute environmental hazard.

The problem of food Waste is increasing, involving all sectors of waste management from collection to disposal. Global food waste is

approximately 1.3 billion times per year (Skendi, et al., 2020). It is estimated that more food is wasted in the industrialized countries compared to the developing nations on per Capital basis (Gustavsson et al., 2011). Wastes are collected and mostly dumped or burnt in the Open air. Recently, there is great emphasis on the recovery, recycling and reconditioning of food waste. The efforts are made to convert food waste into value added products (Cattaneo, et al., 2021). This food waste can be converted into useful value-added products like time.

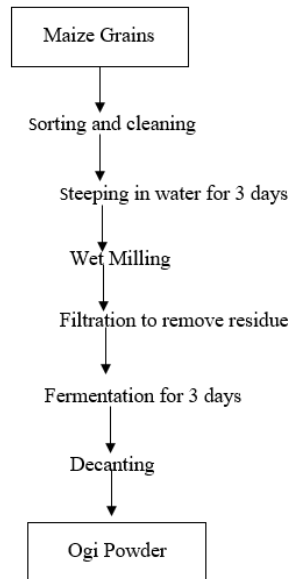


Figure 1: Processing of Ogi from millet grain.

2.2.3.2 Production of extracts from the millet wastes. The wastes were transferred to a clean tray and were oven dried at 105°C for 6 hours. Distilled water, ethanol, methanol, and acetone separately were used to extract bioactive compound like phytochemicals from waste from maize and millet grains according to (Dent et al., 2013) with some slight modifications. Recovered extracts were evaluated in terms of total phenolic compounds, total flavonoid content and antioxidant properties. In brief, an amount of 5g of waste from maize and millet (in triplicate) was extracted with 100 ml of distilled water, ethanol, methanol and acetone respectively, in separate Erlenmeyer flasks and kept for extraction in a water bath at 50°C. After 60 min, the supernatants will be separated by filtration using Whatman filter paper No 1.

2.4 Analysis Conducted on the Residue

2.4.1: Proximate Analysis:

The determination of Proximate Composition including the moisture contents, Ash, carbohydrates, crude fats, fibre and proteins were done using AOAC methods of 2006.

2.5. Analysis of Phytochemical Components

2.5.1 Flavonoid content and Total Phnols

The determination of total flavonoid content of various extracts was carried out using Liu et al. (2002), Adom et al. (2005); and Ofoedum, et al 2024 method. Total flavonoid content was calculated as milligram (mg) of catechin equivalent (CE) per 100 g of sample against a standard curve of catechin.

2.5.2 Carotenoids content

The carotenoids were assessed on cereal by-products using AACC-approved method 14–50 (AACC 2000). Briefly, A saturated mixture of *n*-butanol and distilled water (8:2 ratio) was used for carotenoids extraction. Ten mL of water-saturated butyl alcohol was added to 1 g of different cereal milling by-products, shaken and extracted for 16 h. Extracts were then filtered through Whatman No. 1 filter paper, and absorbance measured at 440 nm using a Spectramax i3x (Molecular Devices, Wokingham, UK) spectrophotometer. A calibration curve was made from pure β -carotene. The carotenoids content was expressed as $\mu\text{g } \beta$ -carotene/g samples.

2.6 Analysis of the Antioxidant Components

2.6.1. Diphenyl-1-picrylhydrazyl (DPPH) assay

The antioxidant activity was determined using the method described by (Yu et al. 2002). The absorbance of the various extracts and control was measured at 515 nm. The lower absorbance of the reaction mixture indicated higher free radical scavenging activity.

Antioxidant activity was calculated as a percentage of radical scavenging activity (% RSA) using the following equation:

$$\% \text{ RSA} = [(A_0 - A_1/A_0) \times 100] \quad (5)$$

{ A_0 =the absorbance of the control reaction containing all reagents except the test compounds.

A_1 =the absorbance in the presence of the tested extracts after 30 min

2.6.2. Ferric-Reducing Antioxidant Power (FRAP) Assay

FRAP assay was carried out according to the literature (Benzie and Strain 2000). The absorbance of the reaction mixture was detected at 593 nm. The standard curve was constructed using FeSO₄ solution, and the results were expressed as mmol L⁻¹ FeSO₄ g⁻¹ dry weight of cereal milling by-products.

2.6.3 2, 2'-Azino-Bis (3-Ethylbenzothiazoline-6-Sulfonic Acid) (ABTS) Assay

The scavenging activity using 2, 2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS^{•+}) was measured by the method described by Li

et al., (2015). The radical scavenging activity (% RSA) of the samples was calculated as follows.

$$\% \text{ RSA} = (1 - A/A_0) \times 100 \quad (6)$$

(A₀ is the absorbance at 734nm of the negative control: A is the absorbance at 734nm of the mixture with sample).

2.7. Statistical Analysis

The data obtained from the analysis was subjected to analysis of variance (ANOVA) while separating the means using Fishers Least Significant difference (LSD) at (P < 0.05).

3.0. Results and Discussion

Samples	Moisture (%)	Crude Fibre (%)	Ash (%)	Crude Fat (%)	Protein (%)	CHO (%)
ABX	11.96 ^a ±0.3143	7.93 ^a ±0.1253	13.45 ^a ±0.0503	4.07 ^a ±0.1527	11.40 ^a ±0.1500	51.19 ^b ±0.4851
ABY	9.89 ^b ±0.1101	5.02 ^b ±0.0764	12.00 ^b ±0.200	2.88 ^b ±0.1607	15.45 ^a ±0.1266	54.62 ^a ±0.6700
LSD	0.6539	0.2881	0.4049	0.4353	0.3854	1.6240

Table 3.1: Proximate Composition of the Samples of wastes from maize and millet processing in Nigeria.

KEYS:

ABX= Maize waste

ABY=Millet waste

LSD= Least significant difference

3.1. Proximate composition of samples of wastes from maize and millet processing in Nigeria

Table 4.1 shows the percentage mean scores for the proximate composition of waste samples from cereals (ABX and ABY). Sample ABX gave the highest mean score for moisture, crude fiber, Ash, crude fat and protein, but lower in carbohydrate (51.19 %) compared to sample ABY with a mean carbohydrate score of 54.62 %. There were also significant differences (p<0.05) in the proximate parameters for all the samples evaluated. In all, Samples ABX performed better than Sample

ABY, However, it was only in Carbohydrate content and protein content that Sample ABY performed better than Sample ABX and also there was difference across all parameters. The wastes were seen to have higher score in carbohydrate followed by protein making them suitable for animal feed and crop fertilizers.

The value obtained in this study compare favorably with the results recorded by (Saldivar 2023), Indicating that reasonable quantity of maize and millet are discarded as waste.

3.2. Phytochemical Analyses

Samples	Total Phenols	Total Flavonoids	Carotenoids
ABX	69.87 ^a ±0.4650	235.93 ^a ±0.9780	12.83 ^a ±0.0625
ABY	55.28 ^b ±0.3800	196.08 ^b ±0.7319	11.42 ^b ±0.1929
LSD	1.1790	2.398	0.3980

Table 3.2 Mean Scores of the phytochemical components of the Samples of wastes from maize and millet processing in Nigeria. (mg/100g).

The means 'abc...' with **different** superscripts within the same column are significantly different (p≤0.05)

KEYS: ABX= Maize waste;

ABY=Millet waste;

LSD= Least significant difference

3.2.1 Phytochemical composition of samples of wastes from maize and millet processing in Nigeria.

The mean scores for the phytochemical components were stated in Table 4.2. The total flavonoids content was highest in all the sample with means scores of 235.95 mg/100g and 196.08 mg/100g for samples ABX and ABY respectively. This is followed by total phenols which is highest in sample ABX (69.87 mg/100g), while carotenoids were lowest in all the samples with 12.83 and 11.42 mg/100g for sample ABX and ABY respectively. There were also significant differences (p<0.05) in the phytochemical composition for all the samples evaluated These results of

this study compliment the research carried out by (Critenda et al, 2002). High level of flavonoids and phenols are known for their antioxidant, anti-inflammatory and anti-cancer properties. They are associated with reduced risk of chronic diseases such as cardiovascular diseases as well as improved cognitive function. In carotenoid composition the both samples performed poorly this could be as a result of longer steeping days encouraging leaching of the colour components and thus the wastes may not be favorably in the production of colouring food materials. This waste can be further used in the production of value-added food products, supplement and pharmaceuticals.

Samples	10 mg/ml	20 mg/ml	40 mg/ml
ABX	12.58 ^a ±0.1419	16.69 ^a ±0.1365	17.79 ^a ±0.1762
ABY	9.13 ^b ±0.0577	12.80 ^b ±0.06429	17.65 ^a ±0.1735
LSD	0.301	0.296	0.4854

Table 3.3: Mean scores of the Phenol contents at different Concentrations (mg/dl)

The means ‘abc...’ with **different** superscripts within the same column are significantly different (p<0.05)

KEYS:

ABX= Maize waste

ABY=Millet waste

LSD= Least significant difference.

3.3 Phenol components of samples of wastes from maize and millet processing in Nigeria at different concentrations (mg/dl)

Table 4.3 shows the percentage mean scores for the phenol composition of waste samples from cereals (ABX and ABY). Sample ABX gave 12.58 mg/dl at 10mg/ml and 17.79 mg/dl at 40 mg/ml. sample ABY at all concentrations recorded the lowest mean scores, thus; 9.13 mg/dl at 10 mg/ml and 17.65 mg/dl at 40mg/ml. There were also significant differences between the two samples (p<0.05) at 10mg/ml and 20 mg/ml.

The phenols present indicate antioxidant, anti-inflammatory and anti-cancer properties and have been associated with potential health benefit such as reducing the risk of cardiovascular diseases. The result increased as the concentration increased and at the 40mg/ml there was no significant difference between the samples (p<0.05). Phenolic compounds are very important bioactive ingredients with health promoting as well as antioxidant properties, a large amount of these compounds are present in waste from maize and millet processing. This result compares with the study of (Kadan et al, 2014 and Ofoedum, et al, 2024).

3.4 The Invitro Antioxidant Assays of the Extracts at different Concentrations (mg/ml)

Samples	10 mg/ml	20 mg/ml	40 mg/ml
CONTROL	78.59 ^a ±0.3972	80.97 ^a ±0.3835	85.09 ^a ±0.3325
ABX	68.73 ^b ±0.3517	75.16 ^b ±0.151	80.52 ^b ±0.2857
ABY	50.43 ^c ±0.1234	54.63 ^c ±0.4461	68.95 ^c ±0.2550
LSD	0.7695	0.8581	0.7165

Table 3.4. Mean scores of Percentages FRAP activities at different Concentration (mg/ml).

The means ‘abc...’ with **different** superscripts within the same column are significantly different (p≤0.05)

KEYS:

FRAP = Ferric reducing Antioxidant Power

Control = Gallic acid

ABX= Maize waste

ABY=Millet waste

LSD= Least significant difference

3.4 FRAP activities at different Concentration (mg/ml).

Table 4.4 shows the percentage FRAP activities for the samples of waste from maize and millet grown in Nigeria analyzed. The control sample which served as the reference standard gave the highest means at all levels of concentrations with significant difference (p<0.05) in all the samples. Sample ABY gave the lowest mean score across all levels of concentrations, and with significant differences (p<0.05) among all the samples. The FRAP activity increases with increase in concentration. In addition to Sample ABX performing better and higher than Sample ABY across all concentration, Sample ABX drifted closer to the controls results

as compared against Sample ABY which drifted far away from the control. The results obtained in this work revealed that the extracts of the wastes from maize and millet during processing have a remarkable potency to donate electron to reactive free radicals, converting them into more stable non-reactive species and terminating free radical chain reactions (Peterson, 2012; Ofoedum, et al 2023). The high antioxidant activity observed in both waste samples implies the consuming or utilizing these materials could contribute to reducing the risk of oxidative stress related diseases such as cardiovascular diseases, cancers and neurodegenerative disorders

Samples	10 mg/ml	20 mg/ml	40 mg/ml
CONTROL	95.23 ^a ± 0.4933	98.30 ^a ±0.100	98.77 ^a ±0.5134
ABX	93.30 ^b ±0.5613	95.16 ^b ±0.7346	94.90 ^b ±0.9834
ABY	91.38 ^c ±0.2306	92.16 ^c ±0.1185	92.48 ^c ±0.236
LSD	1.1047	1.0606	1.6027

Table 3.5: Mean scores of Percentage DPPH activities at different Concentration.

The means ‘abc...’ with **different** superscripts within the same column are significantly different (p<0.05)

KEYS:**Control** = Buthylated Hydroxyl toluene**ABX**= Maize waste**ABY**=Millet waste**LSD**= Least significant difference.**3.5 DPPH activities at different Concentration (mg/ml).**

The mean scores for the percentage DPPH activities for the samples were stated in Table 4.5. Sample ABY had the least score of 91.38% at 10 mg/ml while the control gave the highest mean score of 95.23% with significant differences ($p < 0.05$) between them. The trend continues, showing percentage increase in the DPPH value up to 40 mg/ml with Control recording the highest mean score (98.77%) while sample ABY gave 92.48%. All the samples at each concentration showed significant differences ($p < 0.05$).

3.6 ABTS Scavenging activities at different Concentration (mg/ml).

Table 4.6 showed the mean scores of the percentage ABTS scavenging activities of the samples at different concentrations. The control sample recorded the highest mean scores of 63.13, 70.75, and 73.33% at 10 mg/ml, 20 mg/ml and 40 mg/ml respectively while 47.10, 52.46 and 61.55% at 10 mg/ml, 20 mg/ml and 40 mg/ml respectively for sample ABX. Consequently, sample ABY recorded means scores of 60.67, 68.43, and 72.10% for 10 ml, 20 ml and 40 ml respectively. In all, it can be said that Sample ABY performed better in all concentration unlike the previous results.

Samples	10 mg/ml	20 mg/ml	40 mg/ml
CONTROL	63.13 ^a ±0.0851	70.75 ^a ±0.19079	73.33 ^a ±0.35656
ABX	47.10 ^c ±0.1000	52.46 ^c ±0.2914	61.55 ^c ±0.4597
ABY	60.67 ^b ±0.4651	68.43 ^b ±0.1081	72.10 ^b ±0.9416
LSD	0.6827	0.5136	1.5678

Table 3.6. Mean scores of Percentages ABTS Scavenging activities at different Concentration.

The means 'abc...' with **different** superscripts within the same column are significantly different ($p < 0.05$).

KEYS:**Control** = Buthylated Hydroxyl toluene**ABTS** = 2-2-zino-bis (3-ethylbenzothiazoline-6-sulfonic acid)**ABX**= Maize waste**ABY**= Millet waste**LSD**= Least significant difference**4.0 Conclusion and Recommendation****4.1 Conclusion**

From the study, it was revealed that the maize and millet wastes are rich in fibre and protein which can be utilized in food formulation rather than been discarded as wastes. The extracts of the wastes were found to be rich in antioxidants, phenol flavonoids and carotenoids and as such can be utilized in formulation of food supplements and pharmaceutical goods. The extracts of the wastes are rich in antioxidants because the assays revealed that they are comparable to gallic acid in reduction of free radicals. Hence the waste should be exploited for formulation of food that are beneficial to man rather than been discarded as waste to constitute environmental pollution. This research does not only contribute to scientific understanding of cereal waste but also paves way for meaningful advancements in the realms of nutrition, agriculture and sustainability.

4.2. Contribution to Knowledge

This project work contributes to knowledge by providing information on the benefits and effective utilization of waste from maize and millet wastes in producing animal feeds, it also serves as a frontier in the utilization of these wastes in development of pharmaceutical products that would improve the health of humans and finally it educates on a better

way of using these wastes rather than creating pollution by disposing them.

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