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Asian Journal of Research in Biosciences

Volume 5, Issue 2, Page 35-42, 2023; Article no.AJORIB.1466

Proximate Levels and Phytochemical Contents in Selected Cereals Sold in Wukari Local Government Area of Taraba State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original research Article

Received: 22/10/2023
Accepted: 29/12/2023
Published: 29/12/2023

ABSTRACT

Research has indicated that consumption of whole grain foods can significantly reduce the risk of some chronic health conditions such as type II diabetes, cardiovascular disease, and cancer Therefore, the present study evaluated the proximate constituents and the levels of phytochemicals in rice, maize and millet procured from Wukari Local Government Area of Taraba state. Three cereal samples were procured (rice, maize and millet), air dried and analyzed for proximate and phytochemical contents using AOAC and HPLC respectively. The result for proximate analysis revealed the presence of six proximate components in their respective amounts. These were ether

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extract, crude protein, crude fibre, Ash, Moisture, nitrogen free extract (soluble Carbohydrates). The results of protein showed no significant difference at $p \geq 0.05$ in all the samples, except millet 2 and millet 3 that showed significant difference with rice (1 to 3) and maize 1. Results of fat showed no significant difference between rice (1 to 3), maize (1 to 3) and millet 2, while millet 1 and 2 significantly differ from all the samples except millet 2. The results of fibre showed no significant difference rice (1 to 3) and millet (1 to 3), while maize (1 to 3) showed significant difference with millet 1 and rice (2 and 3) at $p \leq 0.05$. There is no significant difference ($p>0.05$) in ash content of maize and rice samples, while millet showed significant difference at $p \leq 0.05$ with rice (1 to 3) and maize (2 and 3). The results of alkaloids and tannins showed significant difference rice, maize and millet. However, there is significant difference in saponins presence in rice, maize and millet at $p \leq 0.05$. There is significant difference in oxalates, phytates, tarpenes, glycosides and flavonoids present in all the samples, while phenolics showed no significant difference among all the samples. This study revealed the varying and appreciable levels of food constituents and health promoting components in sample analyzed. This indicated the nutritional qualities of the samples analyzed.

Keywords: Proximate components; phytochemicals; cereals; nutritional quality.

1. INTRODUCTION

"Humans depend on variety of plants as food sources, but since ancient times it has been cereals which proved most important amongst them" [1]. "Cereal, also known as grain, is any member of the grass family (*Poaceae*) that is cultivated for its edible starchy brans or fruit seeds" [2]. "Rice, maize, sorghum, millet, and wheat are the most important cereals which make up a majority of human daily diet. Cereals are nutritionally important sources of dietary protein, iron, vitamin B complex, vitamin E, carbohydrates, fibre and traces of minerals important for both humans and animals" [3]. "A review of related literatures indicated that cereals generally consist of about 95% of K, Mg and Ca, together with a large number of other elements which are present in trace quantities. Almost all the mineral elements required by the body are present in cereal grains" [4]. "Cereal grains also provide significant amounts of mineral elements such as K, Ca, Mn, and Zn which 1have demonstrable functions in the metabolism of human body" [5]. "During the past few decades, research publications from universities, governmental, nonprofit health, industrial, and trade organizations have encouraged increased consumption of whole grain food products due to their positive health benefits" [6,7]. "Soluble bran in cereals is helpful for lowering blood cholesterol levels and also prevent cardiovascular diseases. Cereals also help to prevent cancer, constipation, colon disorders and high blood sugar" [8]. "The successful production, storage and usage of cereals have contributed immensely to the global development, in which maize was ranked first and rice ranked second most important grains in the world" [9].

"In Nigeria, the most important cereals are sorghum, millet, rice, maize and wheat and of all these, maize remains the most popularly grown and consumed in all ecological zones of the country" [10]. "The outer structures of grains, in particular the pericarp seed coat and aleurone layers, contain much higher levels of phytochemicals such as phenolic compounds, phytosterols, tocols, betaine and folate, than the germ and endosperm" [11]. "Phenolic compounds are the most diverse and complex class of phytochemicals in cereal grains" [12,13]. "They include numerous derivatives of benzoic and cinnamic acids as well as flavonoids, flavones and flavanols, anthocyanidins, avenanthramides, lignans and alkylresorcinols. In most grains phenolic acids are concentrated in the bran and embryo cell walls and exist mostly in an insoluble bound form, free and soluble-conjugated forms being minor entities" [14, 15]. There is little information on proximate and phytocheimical content of selected cereals in Wukari, Taraba state. Therefore, the present study evaluated the proximate constituents and the levels of phytochemicals in rice, maize and millet procured from Wukari Local Government Area of Taraba state.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Three cereal samples (rice, maize and millet) were procured from the local market in Wukari, Taraba State. The samples were air dried and taken to the Central Research Laboratory Wukati, Taraba State for proximate and phytochemical contents analysis using AOAC and HPLC respectively.

2.2 Determination of Moisture Content

Moisture content was determined by weighing 2 g of feeding stuff with a silica dish which has been previously ignited and weighed, dried in an oven (Genlab MINO/30 UK) for 24 hours at 1000°C to constant weight and then cooled in a desiccator each time just before weighing.

Calculation: % moisture =100 x (wt of dish + feedstuff before drying) – wt of dish + feedstuff after drying) wt. of feed stuff taken

2.3 Determination of Ash Content

A silica dish was heated at 6000°C, allowed to cool in a desiccators and weighed. 2-4g of dried milled feedstuff was transferred into the dish. The dish and feedstuff were then weighed. The dish and feedstuff were afterwards transferred to a heater in a fume cupboard and the less volatile organic materials were burned off. When smoking stopped, the dish was placed in a cool muffle furnace (Vecstar ECF3, UK). The temperature of the furnace was increased to 6000°C and maintained until whitish-ash remained. The dish was then placed in a desiccator and allowed to cool and weighed.

Calculation: % Ash = wt. of dish + ash – wt. of dish x 100 wt. of feeding stuff used [16]

2.4 Protein Determination (Kjeldahl Method)

Nitrogen in sample was converted to ammonium-nitrogen by digestion with sulphuric acid using a catalyst. The ammonia liberated when this digest was reacted with sodium hydroxide removed by steam distillation and collected with 1% boric acid-indicator mixture then titrated with 0.01M HCI to give % Nitrogen in the sample. 2g of the dried sample was transferred to a kjeldahl flask and add the catalyst tablets or 4g mixture of $Na_2SO_4/CuSO_4$. 25 mls–30 mls concentrated Sulphuric acid was then added, swirled gently and taken to the heater and heated gently at first until frothing stops; then more strongly until a near clear solution resulted. The mixture was allowed to cool and transferred into a 250ml volumetric flask and was not make up to the mark.

2.5 Determination of Ammonium Nitrogen

The distillation apparatus was streamed out for about 10 mins. The volume of digest was made up to the mark. The flask was shaken properly. 25mls of the sample digest was placed into Kjeldahl flask and mixed with 25mls of 40% sodium hydroxide solution. The mixture was mounted unto a distillation unit, heated with constant flow of water. The liberated ammonia was collected with 10ml boric acid indicator. The mixture was placed in a conical flask and placed at the condenser. When the boric acid-indicator mixture turned green, the distillation was allowed to go on for another 5mins. At the end of the time, the conical flask was removed and its content was titrated with 0.0IN hydrochloric acid until the original colour of the boric acid-indicator mixture restored.

Calculation: % N = 0.00014 x titre x 50 x 100 wt. of sample taken % protein = % N x 6.25 [17]

2.6 Determination of Fat

Oil was extracted from sample with petroleum spirit under controlled conditions. A flask was dried in an oven at 1000°C and allowed to cool in a desiccator and weighed. 3g of the sample was weighed and ground to pass a 1 mm mesh sieve into a thimble and plunged with cotton wool. The thimble was then placed with its contents into the extractor. Extraction was done with petroleum spirit for at least 4 hr and the residue was transferred from the thimble to a small mortar, ground lightly and returned to the extracted apparatus. The mortar was washed with a small quantity of petroleum spirit and the washings were added to the flask. The extraction continued further for an 1 hr. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was disconnected and placed in an oven at 1000°C for 2 hr and then allowed to cool and weighed.

Calculation: Multiply the increase in weight by 100 and divide by the weight of the sample taken. The result gives the percentage w/w of oil in the sample [18].

2.7 Determination of Fibre

Oil was removed from 2 g of the sample by grinding to pass a 1mm mesh sieve, either by Soxhlet extraction (by stirring), setting and decanting three times with petroleum spirit. The air-dried fat-free material was transferred into a flask or beaker. 100 ml of TCA (Trichloroacetic acid) measured at room temperature was added. It was then boiled by re-fluxing gently for 30 min,

maintaining constant volume by the flow of water. An 11 cm Whatman No. 541 filter paper was fitted into a Buchner funnel, at the end of the 30 min boiling period, the acid mixture was allowed to stand for approx. 1 min and poured into the prepared funnel. The insoluble matter was washed with boiling water until the washing was neutral to litmus paper. It was then transferred to the filter paper and the residue into a crucible. The crucible and its contents were dried at 1000°C. It was then allowed to cool in a desiccator and weighed. The crucible was then placed in a cool muffle furnace and the temperature was increased to 5000°C. The temperature was maintained until ashing was completed. The crucible was then removed from the muffle furnace, cooled in a desiccator and weighed.

Calculation: Multiply the loss in weight on ignition by 100. The result gives the percentage of fibre in the sample [19].

2.8 Carbohydrate Determination

% CHO = 100% - (% moisture + % ash+ % protein + % fat + % cf) [20]

2.9 Determination of Phytochemicals

About 2 g of the sample was weighed and dissolved with hexane in a 1.0ml vial. The prepared sample was then injected into a Buck scientific (USA) BLC10/11 High Performance Liquid Chromatography (HPLC) system with a fluorescence detector (excitation at 295 nm and emission at 325 nm) and an analytical silica column (25 cm x 4.6mm ID, stainless steel, 5 µm) was used to analyse phytochemicals. The mobile phase used was hexane:tetrahydrofuran:isopropanol (1000:60:4 v/v/v) at a flowrate of 1.0ml/min. Standard samples were also prepared using similar method. Concentration of phytochemicals in samples was calibrated using authentic standards. Using the results obtained the concentration of phytochemicals in the sample was calculated, using the formula below:

[PHYTO] = [A SAMPLE x [STD] (ppm) x V HEX (ml)]/ [A STD x Wt SAMPLE (g)]

Where;
[PHYTO] = concentration of phytochemicals in ppm
[STD] = concentration of standard
A SAMPLE = area of sample
A STD = area of standard
V HEX = volume of hexane
Wt SAMPLE = weight of sample

2.10 Statistical Analysis

The results of this study were represented as mean ± SD. The results were subjected to analysis of variance (ANOVA) using statistical package for social sciences (SPSS version 25). Group means were compared for significance at $P<0.05$. Means along the same row having different superscript were statistically significant.

3. RESULTS AND DISCUSSION

3.1 Results of Proximate Analysis

Table 1 shows the proximate composition of rice, maize and millet purchased from three different markets within Wukari local government area. Rice 1, Maize 1 and Millet 1 represent samples bought from Wukari old market while Rice 2, Maize 2 and Millet 2 represent samples bought from Wukari new market, and Rice 3, Maize 3 and Millet 3 represent samples bought from Dorowa market. Protein determination in this study showed no significant difference at $p \geq 0.05$ in all the samples, except millet 2 and millet 3 that showed significant difference with rice (1 to 3) and maize 1. Results of fat showed no significant difference between rice (1 to 3), maize (1 to 3) and millet 2, while millet 1 and 2 significantly differ from all the samples except millet 2. The results of fibre showed no significant difference rice (1 to 3) and millet (1 to 3), while maize (1 to 3) showed significant difference with millet 1 and rice (2 and 3) at $p \leq 0.05$. There is no significant difference ($p>0.05$) in ash content of maize and rice samples, while millet showed significant difference at $p \leq 0.05$ with rice (1 to 3) and maize (2 and 3). There is no significant difference in moisture content of all the samples except maize (1and 3) which showed significant difference at $p \leq 0.05$ with rice (1 to 3). The results of carbohydrates showed no significant difference in all the samples.

3.2 Results of Phytochemical Analysis

Table 2 shows the phytochemical composition of rice, maize and millet purchased from three different markets within Wukari local government area. Rice 1, Maize 1 and Millet 1 represents the

samples bought from Wukari old market. While Rice 2, Maize 2 and Millet 2 represents samples bought from the Wukari new market. And Rice 3, Maize 3 and Millet 3 represent samples bought from Dorowa market. The results of alkaloids and tannins showed significant difference rice, maize and millet. However, there is significant difference in saponins present in rice, maize and millet at $p \leq 0.05$. There is significant difference in oxalates, phytates, tarpenes, glycosides and flavonoids present in all the samples, while phenolics showed no significant difference among all the samples.

Millet has the highest phytochemical content except glycoside in rice which is the highest followed by maize with second highest phytochemical content, while rice has the least phytochemical content.

"Cereals are nutritionally important sources of dietary protein, iron, vitamin B complex, vitamin E, carbohydrates, fibre and traces of minerals important for both humans and animals" [21]. "The successful production, storage and usage of cereals have contributed immensely to the global development, in which maize was ranked first and rice ranked second most important grains in the world" [22].

"In the present study, the proximate composition of all cereals was reported to be similar. However, each one has its special feature. While all the six food substances – water, mineral matter (ash), protein, fat, and carbohydrate were found in cereals, they occurred in different quantities. Some contained large quantities of protein and others practically none. While certain ones have considerable fat, others possess comparatively small quantities. A characteristic of all cereals, however, is that they contain a large amount of carbohydrate and a small amount of water" [23]. "Research has shown that consumption of whole grain foods can significantly reduce the risk of some chronic health condition such as type 2 diabetes, cardiovascular disease and cancer" [24,25].

The proximate analysis carried out in this study as shown in Table 1 revealed that millet has the highest of all the nutrients such as protein, fat, fibre and ash contents, with the exception of carbohydrate and moisture that rice is the richest, followed by maize with second highest of all the parameters except fat, while rice has the highest carbohydrate content followed by maize. This suggests the millet may be the best source of protein, fat, fibre and ash, rice may be the best source of carbohydrate and moisture and maize may be the less desirable source of nutrient when compared to rice and millet. This result is similar to the findings of [26] and [27], which equally revealed the presence of fats, proteins, fibre, ash, moisture and carbohydrate as shown in Table 1.

The results also revealed various ranges for food components in rice as follows; carbohydrates (70 to 76%), protein (9 to 13%), crude fat (2 to 3%), crude fibre (3 to4%), moisture (6 to 7%). Also in maize, carbohydrates (70 to 75%), protein (11 to 14%), crude fat (2 to 3%), crude fibre (2 to 3%), moisture (4 to 5%) and Ash (3 to 4%) and in Millet, carbohydrates (68 to 71%), protein (13% to 16%), crude fat (3 to 4%), crude fibre (3 to 4%), moisture (5%) and Ash (4 to 5%). These findings align with the research conducted by [28] who found that "the proximate composition of some cereals was reported to be similar". "However, each one has its own special features. While all the five food substances- water, minerals, ash protein, fat and carbohydrate are to be found in cereals, they occurred in different quantities" [29]. Also the amount of protein in millet tends to be higher (i.e from 13 to 16%) than that in rice and maize for the three different markets and it increases from market 1 to market 3 respectively. This is in accordance with the report of [30], who reported that millet are classified with maize sorghum, and rice. However, shows to be a better source of protein. Meanwhile the present study revealed that there was no significant difference in the fats, fibre, moisture and ash content in the cereals used. This can be likened to the findings of which revealed that the proximate compositions of cereals were similar.

Phytochemocal analysis in the present study revealed that alkaloids and tannins showed significant difference in rice, maize and millet. However, there was significant difference in saponins present in rice, maize and millet at $p \leq 0.05$. There was also a significant difference in oxalates, phytates, tarpenes, glycosides and flavonoids present in all the samples, while phenolics showed no significant difference among all the samples.

Millet had the highest phytochemical content except glycoside in rice which was the highest followed by maize with second highest phytochemical content, while rice had the least phytochemical content. The result of phytochemicals suggest that millet may exert the highest antioxidant activity followed by maize and rice may exert the least antioxidant activity.

Table 1. Proximate composition of samples purchased from different markets

Samlpe	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)	Carbohydrates (%)
Rice 1	9.21±0.014[a]	2.22±0.00[a]	3.62±0.00[a,b]	2.56±0.00[a]	6.50±0.00[b]	75.91±0.05[a]
Rice 2	12.64±0.01[a]	2.52±0.02[a]	3.75±0.01[b]	2.76±0.00[a]	6.12±0.01[b]	73.83±0.02[a]
Rice 3	13.30±0.00[a]	2.30±0.00[a]	3.89±0.01[b]	2.83±0.01[a]	6.56±0.01[b]	71.67±0.00[a]
Maize 1	11.23±0.01[a]	2.50±0.25[a]	2.22±0.00[a]	3.95±0.00[a,b]	4.46±0.21[a]	75.12±0.06[a]
Maize 2	14.03±0.01[a,b]	2.15±0.21[a]	2.55±0.00[a]	3.33±0.00[a]	4.76±0.01[a,b]	73.20±0.02[a]
Maize 3	14.13±0.01[a,b]	2.20±0.00[a]	2.56±0.01[a]	3.15±0.01[a]	4.12±0.01[a]	71.36±0.27[a]
Millet 1	13.14±0.01[a]	3.35±0.00[b]	3.55±0.00[a,b]	4.65±0.00[b]	5.00±0.00[a,b]	71.08±0.04[a]
Millet 2	15.78±0.01[b]	3.00±0.00[a,b]	3.55±0.00[a,b]	4.65±0.00[b]	5.00±0.00[a,b]	69.26±0.01[a]
Millet 3	15.05±0.00[b]	3.40±0.00[b]	3.70±0.00[b]	4.80±0.00[b]	5.00±0.00[a,b]	68.05±0.00[a]

**Results are expressed as mean ± standard deviation of means obtained. Results with same alphabet superscript in same column are not statistically significant while results with different alphabet superscripts in same column are statistically significant at p ≤ 0.05.*

Table 2. Result of phytochemical analysis of samples purchased from three different markets

Sample	Alkaloids	Tannins	Saponins	Oxylates	Phylates	Terpenes	Flavonoids	Glycosides	Phenolics
Rice 1	0.29±0.01[a]	0.54±0.01[a]	0.29±0.01[a]	0.14±0.00[a]	0.98.50±0.00[a]	0.46±0.01[a]	0.52±0.01[a]	0.24±0.01[a]	17.23±0.01[a]
Rice 2	0.33±0.01[a]	0.72±0.01[a]	0.36±0.01[a]	0.30±0.00[b]	1.22±0.02[a]	0.55±0.01[a]	0.95±0.01a,b	0.35±0.02b,c	18.02±0.02[a]
Rice 3	0.39±0.01[a]	0.97±0.01[a]	0.43±0.01[a]	0.23±0.01[a]	1.89±0.01[a]	0.62±0.01[a]	0.84±0.01a,b	0.46±0.02[c]	19.26±0.01[a]
Maize1	0.52±0.01[b]	1.54±0.01[b]	0.56±0.00[b]	0.39±0.01[b]	2.15±0.01[b]	1.22±0.01[b]	1.15±0.01[b]	0.32±1.22[b]	21.23±0.01[a]
Maize2	0.62±0.01[b]	1.50±0.00[b]	0.62±0.01[b]	0.48±0.01[b]	2.74±0.01[b]	1.24±0.01[b]	1.29±0.01[b]	0.28±0.01[b]	21.90±0.01[a]
Maize3	0.74±0.01[b]	1.40±0.01[b]	0.75±0.01[b]	0.53±0.01[b]	3.05±0.01b,c	1.36±0.00[b]	1.45±0.00[b]	0.22±0.00[a]	22.00±0.00[a]
Millet1	0.82±0.01[b]	5.36±0.01[c]	1.79±0.00[c]	4.73±6.37[c]	4.65±0.01[d]	2.70±0.01[c]	3.56±0.01[c]	0.24±0.01[a]	24.86±0.02a,b
Millet2	1.85±0.00[c]	6.07±0.70[c]	2.55±6.00[d]	3.95±6.00[b]	3.78±0.01[c]	2.37±0.01[c]	3.12±0.01[c]	0.15±0.01[a]	24.06±0.01a,b
Millet3	1.96±0.00[c]	5.44±0.00[c]	2.57±0.01[d]	4.80±0.00[c]	4.95±0.00[d]	2.96±0.01[c]	3.82±0.01[c]	0.19±0.01[a]	24.93±0.03a,b

**Results are expressed as mean ± standard deviation of means obtained. Results with same alphabet superscript in same column are not statistically significant while results with different alphabet superscripts in same column are statistically significant at p ≤ 0.05.*

4. CONCLUSION

This study revealed varying and appreciable levels of food constituents and health promoting components in the samples analyzed. This indicated the nutritional qualities of the samples analyzed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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