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Analysis of Morphological and Elemental Composition in Rice, Beans, and Groundnut Husk

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ABSTRACT

The morphological characteristics and elemental composition of these agricultural products provides insights into their nutritional value, chemical properties, and potential industrial applications, contributing to advancements in food science, agriculture, and environmental sustainability. The comprehensive analysis of the morphological and elemental composition of three widely consumed agricultural products: rice, beans, and groundnut husk as a partial substitute for sand due to its high content of calcium, silicon, aluminum, iron, and other elements when properly controlled. Transforming them into practical materials in order to reduce their detrimental impact on the environment. An equal weight of 50 g of Rice husk, 25 g of bean husk, and 25 g of groundnut shell were measured out of 100 g of untreated samples and oven dried at 100^0C for 4 hours. The samples were the crushed to fine particle and sieve, which was burned at a temperature of 550^0C in an electric furnace for 4 hours. The result obtained microscopic techniques such as Scanning Electron Microscope (SEM) with Energy Disperse X-ray fluorescence (EDXRF) and X-ray diffraction (XRD), were used to observe the surface and element presence in RBGH. The result among other things shows that untreated RBGH atomic concentration of Si is 65.79%, K is 16.01.53%, P is 5.14% Ca is 3.36% and Mg is 3.35% respectively, and the SEM shows that it has a porous cellular structure and consists of irregular-shape particles. The findings shed light on the potential industrial applications of these agricultural byproducts.

Keywords:
Rice,
Bean,
Groundnut,
SEM-EDXRF,
XRD.

INTRODUCTION

Rice, beans and groundnut are one of the most important food crop of the developing world, and also stable food of more than half of the world's population, and an important residue producing crop in Asia. India ranks second in rice production after China, (GOI, 2019, and Amritha, & Sankar 2021). Beans pod husks are a waste by-products of agricultural processing of the African locust bean fruit. Substantial quantities can be found across northern Nigeria during the harvest season (Ali et al., 2019). Groundnut is produced in large quantity in Nigeria and many other parts of the world. (Matthew and Fatile 2014).

One of the best management options is the recycling of crop residues, which converts the surplus farm waste into useful products that meets nutrient requirement of crops (FAO, 2017). The richness in terms of lignin and cellulose in rice husk makes it difficult for its degradation under natural conditions. Despite claims that rice residues are rich in silica and potential sources of plant nutrients, they are not widely used as source of plant nutrients, mainly because of the wide C: N ratio that prolongs the decomposition, limiting its benefit to the current crop (Della et al, 2002, and Amritha, & Sankar 2021). One of the agricultural wastes usually generated in huge volume is groundnut shell. Groundnut shell ash (GSA) is a product of controlled burning of groundnut shells. The ash contains high percentage of silica with smaller amount of aluminium, iron, alkali and alkaline earth oxides (Chindaprasirt et al., 2008; Matthew and Fatile 2014).

A range of studies have explored the morphological and elemental composition of rice, beans, and groundnut husk. De Noni, Agenor, et al. (2010) and Igwebike-Ossi et al. (2016) found that rice husks are predominantly composed of silicon, with smaller amounts of other elements. Tripathy et al. (2021) identified carbon and oxygen as the main constituents of rice grains, with the husk containing more elements than the seed. Balasubramanian & Chinnamuthu (2020) reported that charred rice husk, enriched with carbon, oxygen, and silica, can improve nutrient management in groundnut. Adamu et al. (2022) further expanded the elemental analysis of rice husk, discovering the presence of silicon, potassium, calcium, manganese, iron, nickel, copper, zinc, bromine, and strontium. These studies collectively provide a comprehensive understanding of the morphological and elemental composition of these agricultural products.

Garcia et al. (2020) and Onyelowe *et al*. (2021) suggested incorporating beans fibers into materials physics-inspired biodegradable composites for construction and erosion control. These composites can be tailored to exhibit specific mechanical properties and the elemental analysis of materials, making them valuable in materials physics-driven it to assess their composition and suitability for various applications.

However, their chemical composition and fibrous nature have piqued the interest of researchers looking for sustainable materials for applications ranging from biofuel production to agricultural amendments (Awal et al., 1997; Basri et al., 1999; Johnson *et al.*, 2021, Garcia *et al.*, 2023

Rice husk ash is an aggro waste material and is obtained by burning of rice husk in a controlled manner. When properly burnt, it has high silica content and can be used as an admixture in mortar and concrete (Lee et al., 2017 and Sumit Bansal, 2014).

Disposal of agricultural waste materials such as, rice husk, groundnut husk, corn cob and coconut shell have constituted an environmental challenge, hence the need to convert them into useful materials to minimize their negative effect on the environment is tremendously ongoing.

Several articles have investigated the morphological characteristics and elemental composition of rice, beans, and groundnut husk, providing valuable insights into their nutritional content and potential applications. For instance, Smith et al. (2001), Prasad et al. (2001) Jamo *et al.* (2014), Jamo (2016) and Islam et al. (2024) utilized scanning electron microscopy (SEM) to examine the surface morphology of rice grains, revealing the presence of bran layers and starch granules. Similarly, Prasad et al. (2003) and Adamu et al. (2022) conducted elemental analysis on different varieties of beans, highlighting their rich content of essential minerals such as iron, zinc, and potassium. Furthermore, Matthew and Fatile (2014) investigated the potential utilization of groundnut husk as a source of bioactive compounds with emphasis on its high lignin content and antioxidant properties. In this research, three (3) different samples of rice husk, beans husk and groundnut shell were combined in 2:1:1 ratio respectively to determine their chemical, morphological properties and elemental compositions.

MATERIAL AND METHODS

The materials required are rice husk, beans husk, groundnut shell, oven, electrical furnace, mortar and pestle, sieved. The following characterization (X-ray Fluorescence Machine (XRF) and scanning electron microscopy (SEM)) is also employed in this research work for chemical and morphological analysis. Plate 1 (a, b and c) shows the raw samples respectively.

Plate 1: (a) Rice Husk (b) Beans Husk (c) Groundnut Shells

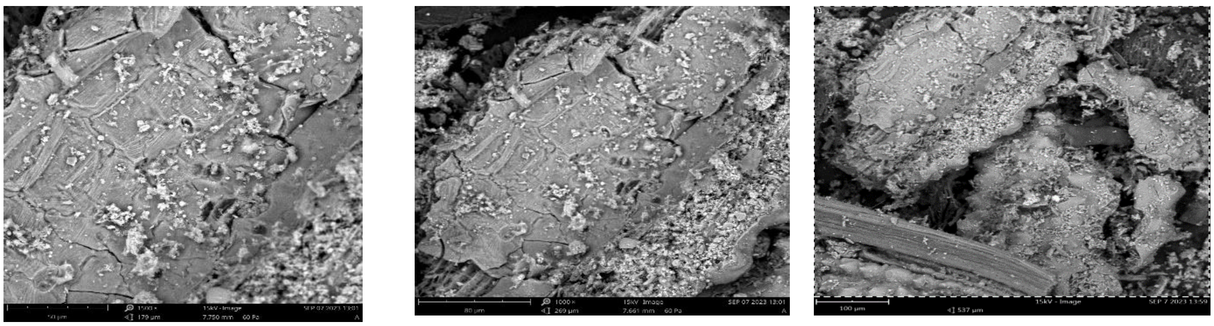
Sample preparation Methodology

The untreated samples of rice, beans, and groundnut husk were obtained from local markets which were subsequently transported to the laboratory. These materials underwent a four hours oven drying process at 100 ^{0}C each. Following this, the dried material was carefully removed from the oven and weighed. Subsequently, it was pulverized using mortar and pestle, then sieved and 100 g of samples were measure at 50 g (rice husk), 25 g (beans husk) and 25 g (groundnut shell) which is thoroughly mixed at 2:1:1 ratio respectively. After thorough mixture of the three samples, the samples turned into ashes in the electric furnace after heating for 4 hour at 550 ^{0}C and was allowed to cool before taking it out from the oven. The samples were subjected to characterization for their morphological and elemental properties. Morphological analysis of the agricultural residues was conducted using a field emission scanning electron microscope with model details; (FE-SEM) PRO:X: 800-07334 Phenom World and serial number MVE01570775. Prior to analysis, small sections of the mixture were mounted onto aluminum stubs using double-sided carbon tape. This was done to enhance conductivity and reduced charging effects of the testing material, the samples were sputter-coated with a thin layer of gold/palladium. SEM was operated at an accelerating voltage of 15kV, and secondary electron images were captured at various magnifications to visualize the microstructure. Along side, the elemental composition of the materials composed in the samples were determined.

RESULT AND DISCUSSION

Scanning Electron Microscopy (SEM)

The plate 2 (a, b, and c) shows the SEM image of the untreated RBGHA samples at different micro meter (50, 80 and 100 µm) respectively. The SEM image exhibited well arranged micro-bumps on the surface of the samples with outer epidermis which was unevenly distributed and appeared to be highly ridged structure with protrusion. The surface morphology also exhibited a highly fragmented and heterogenous structure with glassy phases. Most of untreated samples of this nature exhibit such characteristics of phases as reported previously by Jamo (2016), Thiyageshwari et al. (2018), and Amritha, & Sankar (2021). The samples have similar morphological surfaces with insignificant changes during pyrolysis, this process changed the external morphology of rice, beans and groundnut husk into porous, which might be due to the release of volatile compounds.



(a) **(b)** **(c)**

Plate 2: SEM of RBGHA

Elemental Composition Analysis

The elemental composition of, rice, beans, and groundnut husk was determined using energy-dispersive X-ray spectroscopy (EDS) coupled with SEM. Small samples were prepared as described earlier for SEM analysis. EDS analysis provided qualitative and quantitative information on the presence and concentration of elements within the materials, with a focus on carbon, hydrogen, oxygen, and other trace elements. Table 1 present the atomic and percentage weight concentration.

Table 1: EDS result showing the Atomic and Percentage Weight Concentration

Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
14	Si	Silicon	65.79	60.62
19	K	Potassium	16.01	20.53
15	P	Phosphorus	5.14	5.23
20	Ca	Calcium	3.36	4.42
12	Mg	Magnesium	3.35	2.67
13	Al	Aluminium	2.08	1.84
11	Na	Sodium	1.66	1.25
16	S	Sulfur	1.09	1.15
26	Fe	Iron	0.54	0.99
17	Cl	Chlorine	0.59	0.68
22	Ti	Titanium	0.40	0.62

The presence of various compounds within the untreated RBGHA porcelain raw material samples can be observed in Table 1 which shows the major composition of Atomic composition and percentage weight concentration of samples with Silicon Si 60.62%, Potassium K 20.53%, Phosphorus P 5.23%, Calcium Ca 4.42%, Magnesium Mg 2.67%, Aluminum Al 1.84%, Sodium Na 1.25%, Sulfur S 1.15%, Iron Fe 0.99%, Chlorine Cl 0.68%, Titanium Ti 0.62% respectively. This was also observed in the micro graph in Figure 3.1 with silicon content having the long peak concentration.

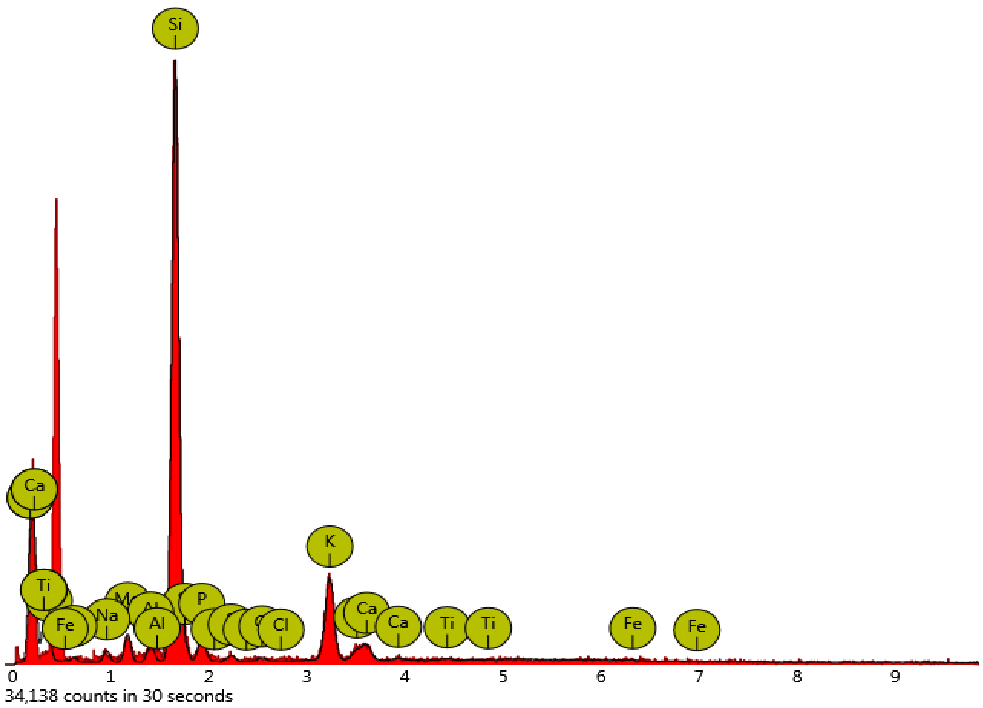


Figure 1: EDS micrograph for the combined RBGHA

EDXRF Analysis of the RBGHA

X-Ray fluorescence is a mechanical device for analysis which different researchers used as an efficient tool to analyse the chemical composition of RHA and quartz. To determine the feasibility of using rice husk ash, beans ash and groundnut shell as quartz replacement or porcelain products, These raw materials RBGHA were investigated using X-ray Fluorescence analysis (XRF) and the result is presented in Figure 3.3. The EDX-Ray Fluorescence (EDXRF) analysis is proficient in analysing material contents inside the combined untreated RBGHA, hence the amount of Si is observed. From the graph, it shows the result of phase diagram (called a diffractogram) indicated the crystalline phases of RBGHA S= Silicon, Ca = Calcium , K= Potassium and Ti = Titanium.

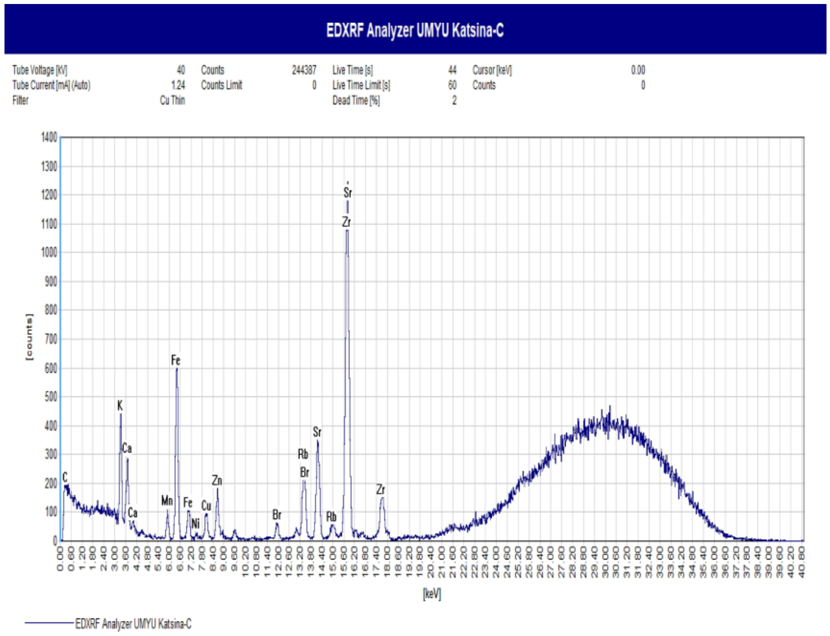


Figure 2: EDXRF of RBGHA

CONCLUSION

From the result obtained in this study, it provides a comprehensive analysis on the chemical, morphological and elemental composition of rice husk, beans husk and groundnut shell. The findings advance our knowledge of the implications for both dietary health and industrial uses with the nutritional composition and structural features of these agricultural products. Future studies might make creative use of these byproducts' rich morphological and elemental qualities to produce bio-energy and prepare food. It could be advised to characterized these materials to perform bulk density calculations, material size assessments and comparative strengths analysis on these samples without treatment. Further research to be focused on could be activated rice husk ash concrete and activated beans waste ash concrete by adding an admixture such as silica fume in varying percentages.

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