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An Evaluation of Proximate Composition on Cereal Grains for Confectionery and Pasta Production

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Abstract:- Destructive means of measuring the proximate compositions of grains involves crushing of samples and application of chemical reagents on samples leading to losses of food along the food chain. However, this study tends to evaluate the proximate compositions of Quality Protein Maize (QPM) and Sorghum (Sorghum bicolor) using non-destructive and destructive methods. A randomized block design of 6 × 2 × 2 × 3, SPSS 20.0 statistical package, and analysis of variance (ANOVA) were used to analyze the results. The result shows that non-destructive measurement had higher significant values of moisture, protein , fat, fiber, ash and carbohydrate contents are 11.60±0.06%,9.8±0.05%,4.07±0.09%, -, -, 61.37±% and 12.47±0.03%, 8.9±0%, 3.13±0.03%, 2.10±0%, 1.20±%, and 66.60±0.12%, over the destructive measurement with 10.67±0.52%, 10.55±0.13%, 4.95±0.22%, 3.26±0.05%, 1.71±0.01%, 68.87±0.56 and 9.07±0.03%, 11.13±0.06%, 4.83±0.03%, 2.38±0.01%, 1.08±0.01%, and 70.79±0.02% for QPM and sorghum respectively. These results indicates that Non- destructive method was therefore found to be more economical and faster without affecting the actual proximate compositions of the grains, hence recommended for used over the conventional destructive method in Nigeria and elsewhere.

Keywords:- Proximate Composition, Quality Protein Maize, Destructive Method, Protein Content, Sorghum.

I. INTRODUCTION

Cereal grains are described as an essential dietary components providing substantial amount of nutrients including vitamins, dietary fiber, minerals, energy, protein and complex carbohydrates for human and animal consumption particularly in the developing and underdeveloped countries of the world. However, the health benefits of these grains' nutritional compositions are very paramount for human consumption [1].

Cereal grains such as maize, sorghum, rye, barley, millet, oats, wheat and acha are best for human nutrition when put into the form of flour, meal, pastas or flakes. The seeds of these cereal grains consist of three parts namely the germ containing oil (Vitamin E), the endosperm (interior part containing the starch) and the bran which is the protective covering containing fiber. The bran portion also called milled feed is sold mainly as an ingredient for cattle and sheep feeds but has become important as fiber in healthy diet [2]. The amount of germ in cereal grains varies from less than 2 percent in wheat to more than 10 percent in corn and because of high oil content, the germ is often roasted and sold vacuum-packed to prevent its becoming rancid. The germ oil can be pressed out in the milling industries and sold as cooking oil [2]. Foods containing cereal flours have been very important to human nutritional needs since ancient time. In developing countries, most cereal flours are enriched with Vitamin B1, Vitamin B2, niacin and iron. Vitamin D and calcium are also added to flours for use in areas where flour is a primary nutritional source.

Corn or Maize (*Zea mays*) is a plant belonging to the family of grasses, *Poaceae*. It is one of the most important cereal crops used in the human diet in large parts of the world
and an important feed component for livestock which also serves as raw material for manufacture of many industrial products. The products include corn starch, corn oil, corn syrup and products of fermentation and distillation industries. Maize is also used for the production of baby food (cerelac and cheese ball among others), biscuits, cornflakes, panca

maize flour, pizza dough, popcorn and donuts, another form of cornmeal is known as *masa* commonly eaten in Northern Nigeria. *Masa* could be prepared by treating corn with lime (alkalai), this tend to release the corn's niacin into a form the body can use. The resulting whole corn is called hominy and ground treated corn is dried and powdered to make *masa* flour, which is then used to make tortillas and tamales taken else were [3]. Maize is also recently used as biofuel. In terms of total world production, maize on average utility over the last five years outranked paddy rice (*Oryza sativa*) and wheat (*Triticum aestivum*).

The discovery of the quality protein maize (QPM) varieties with Opaque-2 mutant gene by the International Maize and Wheat Improvement Centre in 1964 containing about twice the levels of lysine and tryptophan and 10% higher grain yield than the most modern varieties of tropical maize, brought a great hope in the effort of its improvement as human and animal nutrition [4] - [5]. High level of these two amino acids not only enhances manufacture of complete proteins in the body, but also offers 90% of the nutritional value of skim milk, thereby alleviating malnutrition [6]. QPM has exactly the same qualities as normal maize (NM) in grain texture, taste, colour, tolerance to biotic and abiotic stresses as well as high yield [7]. QPM also looks and performs like normal maize and can be reliably differentiated only through laboratory tests [8]. In 1993, 33 tropical and 22 subtropical QPM lines were released. Hybrids derived from these lines are being tested at the International Research Centre where Central America, China and Mexico are at the fore-front [9]. In Africa, among the 17 countries that breed and promote QPM to the populace are Nigeria, Ghana, Mozambique, South Africa, Burkina Faso, Tanzania, Cameroon, Ivory Coast,Togo, Zimbabwe Ethiopia, Guinea, Kenya, Malawi, Mali, Uganda and Senegal [5] – [6].

Sorghum, one of the cereals that constitute a major source of proteins, calories and minerals for millions of people in Africa and Asia. This cereal is mainly considered as subsistence crop because of its unique tolerance to drought and adaptation to dry tropical and subtropical ecosystems throughout the world. The crop is rich in minerals but with bioavailability vary from less than 1% for some forms of iron to greater than 90% for sodium and potassium. The reasons for this are varied and complex since many factors interact to determine the ultimate bioavailability of a nutrient [10]. Like other grains, sorghum protein is generally low in the essential amino acids such as lysine and threonine [11]. Sorghum, like legume and oil seed meals has some limitations, due to the presence of anti-nutritional factors, such as trypsin and amylase inhibitors, phytic acid, and tannins. These compounds are known to interfere with protein, carbohydrates and mineral metabolism. Most varieties of sorghum have gained universal fame for production of fermented foods, because of the wide adaptability and low cost of production. Sudan seems to have the greatest number of fermented sorghum products. There are about 30 such products that are basically different from one another [11]. Fermentation makes the foods easier to digest and the nutrients easier to assimilate and also it retains enzymes, vitamins and other nutrients that are usually destroyed by food processing [11]. Fermentation has been used for several thousand years as an effective and low cost means to preserve the quality and safety of foods. Fermentation is an oldest known form of food biotechnology. Food fermentations is an important technique in the developing countries where the lack of resources limits the use of recent techniques such as vitamin enrichment of foods and the use of energy and capital intensive processes for food preservation.

Quality Protein Maize (QPM) was developed through convectional maize breeding methods and has about 10% protein like any normal maize (NM) variety [12]. However, its protein has about 70% higher levels of the essential amino acids - lysine and tryptophan. Thus the nutritional quality of its protein is superior to that of normal maize varieties. This is important because non - gastric organisms (including humans, pigs and poultry) are unable to synthesize their own lysine and tryptophan. Hence, they stand to benefit more, nutritionally from QPM than NM [13]-[14]. “Reference [15]” in a study indicate that sorghum grain for poultry feed can be used to replace an improve maize due to the similarity in their proximate compositions which shows that sorghum grain did not adversely affect egg production when maize grain is replaced with sorghum at 15% level, which is one-third of maize, as well as whole replacement of maize (Tables 1)

Table 1: Comparison of Constituents in Maize and Sorghum Grains.

Constituent	Maize (Deccan 103)	Sorghum (ICSV 11)
Protein (%)	9.8	8.9
Starch (%)	71.7	72.3
Sugars (%)	1.4	1.2
Fat (%)	5.2	3.7
Crude fiber (%)	1.4	1.2
Ash (%)	1.3	1.7
Gross energy (cal 100g-1)	414	412

Source: [15]

Non-destructive measurement in this work refers to measurement performed on grain samples (QPM and sorghum) using specialized equipment (Diode array near infrared spectrophotometer (DA7200 NIRS). This equipment ensures ease, economical and rapidity in the evaluation of proximate compositions of the grains without causing any adverse effect or damage on the produce on which the measurement were carried out (no grinding or crushing of samples, no any chemical or reagents application and no hydrothermal treatment on the samples measured). Non-destructive testing (NDT) is a wide group of analytical techniques used in science and industry to evaluate the properties of a material, component or system without causing damage [16]. The terms Non-destructive examination (NDE), Non-destructive inspection (NDI) and Non-destructive evaluation (NDE) are also commonly used to describe this technology [17]. Because NDT does not permanently alter the article being inspected, it is a highly-valuable technique that can save both money and time in product evaluation, troubleshooting and research. Common NDT methods include ultrasonic, magnetic-particle, liquid penetrant, radiographic, spectrophotometer (Near Infrared (NIR), Mid-Infrared (MI) or Far-Infrared (FI) Spectroscopy, remote visual inspection (RVI), eddy-current testing and low coherence interferometry [18] – [19]. NDT is a commonly-used tool in agricultural engineering, forensic engineering, mechanical engineering, electrical engineering, civil engineering, systems engineering, aeronautical engineering, medicine and art.

Mechanical damage is a universal problem which costs the cereal grains, legumes, fresh fruits and vegetables industry millions of dollars annually. In many developed and developing countries, the increasing sophistication of postharvest handling systems provides a continuing challenge to balance the benefits of increased mechanization with minimization of produce damage along the production chain. The advantage of non-destructive instrument offers the possibility towards the measurement of the proximate compositions of cereal grains without any adverse effect on individual products during industrial and experimental analysis. However, because of the ever growing food industry and its demand for high quality of agricultural produce, there is need for the utilization of an advance and accurate techniques of determining the quality of food substance before distribution. To address this problem, DA7200 NIR spectrophotometer was found to be a very useful tool in measuring even a single sample since it is rapid, economical and non-destructive. Therefore, the thrust of this study is to comparatively evaluate non-destructive and destructive measurements of proximate compositions of quality protein maize (QPM) and sorghum necessary for the production of confectionery and pasta during postharvest handling on the factory floor. It will save time and energy.

II. MATERIALS AND EXPERIMENTAL PROCEDURE

The quality protein maize (ART/98-SW6-OB-W) sample used for the determination of proximate compositions was purchased at the Institute of Agricultural Research and Training (IAR and T) Obafemi Awolowo University, Moor Plantation Centre, Ibadan, Nigeria while the sorghum (*Sorghum bicolor*) sample was procured from Apata main market, Ibadan, Oyo State, Nigeria. All samples were placed in polyethylene bag under ambient temperature. The two cultivated grain varieties of quality protein maize and sorghum were used as they were purchased. Non-destructive and the destructive measurements were both carried out at Jaagee Nigeria Limited Laboratory in Ibadan under the same atmospheric condition. However, reagents used for the destructive (conventional) measurement are all of analytical grade and the equipment used throughout the experimental period are sophisticated and automated, some of which include Kjeltec auto nitrogen distillation and digestion apparatus with automatic safety door connected to external titrator (Model: Kjeltec 8200), Fibertec Hot / Hydrolysis unit (Model: 1020), Fibrertec cold extraction unit, (Model: 1021), Soxtec (Model: 2050), Carbolite, muffle furnace (Model: PF 800), Tecator Digester (Model: 801), Cyclotec 1093, general purpose sample milling machine with adjustable particle size, easy, safe handling and recommended for NIR noise level 75DB low maintenance. All the equipment are supplied by Foss in Sweden except for Uniscope laboratory oven, (Model: SM 9023) by Stuart in Japan, Electric weighing balance (Analytical balance machine i.e. Adventure OHAUS) by MELLER in Switzerland Type; PM 2000 and Serial No; H52764 with the sensitivity of ± 0.00lg) and Moisture analyzer (Model: ML-50 with super hybrid sensor (SHS) Technology) by AND Company Limited in Germany.

A. Determination Of Proximate Compositions Of Qpm And Sorghum (Non-Destructive Method)

Diode array near infrared spectrophotometer (DA7200 NIR spectrophotometer or multipurpose analyzer supplied by Perten Instrument Company in Sweden) standardized operation manual and guideline by Association of Official Analytical Chemists (AOAC), [20], food analysis scheme was followed to carry out non-destructive measurements on the QPM and sorghum samples to determine their proximate compositions. The samples were sheared into two portions, one of the sample meant for the destructive approach while the other for the non-destructive means. The non-destructive methods was carried out by measuring about 20 to 30 grammas of the samples (SP_1) in the multipurpose analyzer plate provided for the equipment, followed by placing the sample container on the confined space under the DA7200 NIR Spectrophotometer and then the analyzed button was pressed. The DA7200 NIR ray was observed scanning through the sample as it rotates within it confinement and immediately the results of the proximate compositions were displayed on the equipment screen within 1 to 2 minutes. Each sample was analyzed in triplicates and the quality protein maize and sorghum samples were analyzed for moisture content, carbohydrate, crude protein, crude fiber, crude fat, and ash contents.

B. Determination Of Proximate Compositions Of Qpm And Sorghum (Destructive Method)

For the destructive (conventional) methods, proximate compositions determinations were analyzed as prescribed by Association of Official Analytical Chemists [20], food analysis scheme for cereal grains. Each analysis was carried out in triplicates. A randomized block design of 6 (Parameters) × 2 (Laboratory methods of analysis) × 2 (Grain samples) × 3 (Replicates) making a total of 72 samples used for the experiment. Data obtained were further subjected to statistical analysis to ascertain the significant differences in the values.

C. Statistical Analysis

SPSS statistical package (SPSS 16.00 for windows) was used to analyzed data obtained in this study to compare the obtained values when the two methods were applied. Proximate compositions analysis was replicated three times (n = 3) in both methods. Results presented are mean values of each determination ± standard error mean (SEM). Analysis of variance was performed by one-way ANOVA procedures. Comparisons between the mean values obtained in both methods were determined by Duncan's Multiple Range Test and the significant level was defined at $P < 0.05$.

III. Results and Discussions

A. Moisture content

The result of this study (Table 2) indicate that there were significant differences ($P < 0.05$) in the mean of moisture contents between the two (2) samples (QPM and sorghum) used for the analysis. The comparison in the two grain samples, revealed that non-destructive measurements quantified higher moisture contents of 11.60±0.06% and 12.47±0.03% over the destructive measurements of 10.67±0.52% and 9.07±0.03% for QPM and sorghum respectively. The results obtained were found to be higher than the reported values for maize having 8.92% [21; 22]. This implies that non-destructive method is more advantageous over the destructive method in time of accuracy and rapidity in moisture content determination for the cereal grains used for the experiment.

B. Crude Protein Contents

The result of this analysis shows that there were significant differences in the mean of crude protein content ($P < 0.05$) evaluated for the two grain samples. However, destructive means has higher significant values of 10.55±0.13 and 11.13±0.06% compared with the valued obtained for the non-destructive approach with 9.80±0.00% and 8.90±0.07% for QPM and sorghum respectively. For the non-destructive approach, the trend of this result is in agreement with the previous findings of maize 9.8±0.00% and 8.9±0.00% [15]. while for the destructive measurements, the obtained results are higher that the reported values by the same researchers. Varietal differences and some anatomical variations could be the reasons for the observed differences.

Table 2: Proximate Compositions of Quality Protein Maize (QPM =ART/98-SW6-OB-W) and Sorghum (*Sorghum bicolor*) using Destructive and Non-destructive Methods

Parameter	Sample	Method Used		Remark
		Destructive	Non-destructive	
Moisture Content (%)	QPM Sorghum	$10.67^{d}\pm0.52$ $9.07^{d}\pm0.33$	$11.60^{d} \pm 0.06$ $12.47^{e}\pm0.03$	NS ∗
Crude Protein (%)	QPM Sorghum	$10.55^{d}\pm 0.13$ $11.13^{e}\pm0.06$	$9.80^{c} \pm 0.00$ $8.97^{d}\pm0.07$	∗ ∗
Crude Fat (%)	QPM Sorghum	$4.95^{c} \pm 0.22$ $4.83^{c}\pm0.04$	$4.07^{b} \pm 0.09$ $3.13^{c}\pm0.03$	∗ ∗
Crude Fiber (%)	QPM Sorghum	$3.26^{b} \pm 0.05$ $2.38^{b}\pm0.01$	N / A $2.10^{b}\pm0.00$	- ∗
Ash (%)	QPM Sorghum	$1.71^{a} \pm 0.01$ $1.80^{a}\pm0.01$	N / A $1.20^{a}\pm0.00$	- ∗
Carbohydrate (%)	QPM Sorghum	$68.87^{e} \pm0.56$ $70.79^{f}\pm0.02$	$61.37^{e} \pm 0.35$ $66.60^{a}\pm0.12$	∗ ∗

∗ = Significant different ($P \leq 0.05$), - = Not Comparable, NS = Not significantly different ($P \geq 0.05$), N/A = Not

Available. Values on the same column for each parameter with different superscript are significantly different ($P \leq 0.05$) while those with the same superscript are not significantly different ($P \geq 0.05$) as assessed by Duncan's Multiple Range Test.

C. Crude Fat Content

The crude fat content obtained for the quality protein maize and sorghum in this study, shows significant differences ($P<0.05$) in their respective values when the two methods analysis were compared with each other. The crude fat content for QPM 4.95±0.22% was observed to be significantly higher when the destructive method was used than the recorded value obtained for QPM 4.07±0.09% when the non-destructive approach was applied which is in line with the findings by [22] for maize used in the production of different doughs. Consequently, crude fat content also have higher significant value of 4.83±0.03% for destructive method over the value obtained for sorghum 3.13±0.03% when the non-destructive approach was applied. The trends of non-destructive results were found lower than the reported value by [15]. However, drying and storage processes of the grains samples might have affected the degradation of the crude fat content of the sample used for the experiment.

D. Crud Fiber Content

The crude fiber content of QPM in the destructive measurement was observed to be 3.26±0.05% and 2.38±0.01% for sorghum while the non-destructive means for sorghum has 2.10±0.00% (Table 2). The trend of the observed records in both methods were higher in values as compared with the previous findings for QPM 1.4±0.00% and sorghum 1.2±0.00% by [15]. The implication of higher fiber content for the grains is to help the consumer to be healthier by keeping the bowels working and moving other foods quickly through the body. This also implies that non-destructive techniques of measuring the internal parameters of grain samples does not destroy nor affect the crude fiber contents as well as other nutritional parameters in cereal grains.

E. Ash Content

The result of this study shows that crude ash content of QPM was 1.71±0.01% and that of sorghum was 1.80±0.01% when destructive approach was applied while non-destructive means quantified 1.20 ±0.00% crude ashes content. The trend in destructive measurement value was higher than the previous findings for QPM 1.3±0.00% [15]. While the value obtained for non-destructive means of sorghum was lower than the reported 1.75±0.04% for sorghum flour used for dough formulation by [23].

F. Carbohydrate Content

The mean percent carbohydrate content obtained in this work (Table 2) for QPM and sorghum grains indicate significant differences ($P < 0.05$) in the two samples used for the analysis for both the destructive and non-destructive methods when compared with each other. With the destructive method, percent carbohydrate content of sorghum 70.79 ± 0.02% quantified significant higher value than the value obtained for sorghum 66.60±0.12% when the non-destructive method was used. Consequently, QPM 68.87 ± 0.56% also had higher significant values of carbohydrate content when compared with the value obtained data of QPM 61.37±0.35% when non-destructive approach was applied (Table 2). The trend for destructive measurement is in agreement with the reported range 65 – 75% necessary for the production of pastry products [24], but for the non-destructive approach, quality protein maize carbohydrate value 61.37±0.35% was found to be low when compared with the reported value for maize 71.70±0.70% used for making composite flour and in fermentation for the production of drinks [23]. The reason for the observed differences could be that the sugar plus carbohydrate constituents such as carbon, hydrogen and oxygen components of the varietal grains used are low due to environmental contributions to plant during pollination. It could also be due to low constituent of the two major components of starch (amylase and amylopectin) during germination or possible degradation along processing line.

IV. CONCLUSION

Today, the vital importance of quality protein maize and sorghum to become Africa's food grains contributing essential nutrients to the consumer is indisputable. Research has shown that these cereal grains are essential for the production of inexpensive pasta, confectionery, flour and flake which are cholesterol free, having high protein content, very low saturated fat, high in dietary fiber and moderately high in starch constituent needed for the body metabolism.

The results of this study however, support the research and industrial application of utilizing the non-destructive method to determine proximate compositions of cereal grains (quality protein maize and sorghum) over the destruction (conventional) method especially in a situation where lots of batches are to be evaluated on the factory floor along the food chain, hence, suggests that non-destructive method of proximate compositions determination can economically replace the conventional destructive method effectively without destroying or altering the proximate compositions of the food produce.

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