# The nutritional composition of four rice varieties grown and used in different food preparations in Kassena-Nankana district



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***Research Paper***

# The Nutritional Composition of Four Rice Varieties Grown and Used in Different Food Preparations in Kassena-Nankana District, Ghana

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***Abstract:*** *The proximate and mineral contents of rice varieties namely IR12979-24-1, JASMINE-85, WITA-9, and ANDY-11 were studied in this work with a view to recommending them to farmers and consumers in Kassena-Nankana and its environs, and to find out why these varieties are used in different food preparations. Results obtained for proximate composition were expressed as mean and standard deviation of the values in percentage as follows, 14±4.88 moisture, 1.08±0.16 fat, 6.83±0.52 crude protein, 0.39±0.27 crude fiber, 1.41±0.65 ash, 76.04±5.78 carbohydrates. Results obtained for mineral content were expressed as mean and standard deviation of the values in mg/kg as follows, 95.86±29.39 calcium, 60.20±32.96 sodium, 18.17±2.86 iron, 555.09±207.69 magnesium, 2.89±0.74 manganese, 1415.34±392.75 potassium, 10.89±0.96 zinc, 26.69±9.18 copper, 0.24±0.01 lead, and 2.4±0.58 cadmium. From a background survey, it was revealed that these rice varieties are used in different food preparations. The rice variety IR12979-24-1 is most suitable in preparing rice balls. JASMINE-85 is suitable in preparing jollof rice, WITA-9 is suitable in preparing waakye and ANDY-11 more suitable in preparing plain rice. Also, it was revealed in this research that the suitability of the rice varieties in different food preparations depended on their carbohydrate (starch) and moisture contents. From results of the chemical components of the four rice varieties, it is recommended that their cultivation and consumption should be on an increase in Kassena-Nankana District and its environs.*

**Keywords:** Oryza sativa, rice varieties, proximate analysis, elemental analysis,

## Introduction

What people consider proximate varies, but usually include water, carbohydrates, proteins, dietary fibres, fatty acids, ash, dietary minerals and alcohol. What makes proximate particular is that the total of their presence in food must always sum up to 100%. The nutritional information on food containers usually specifies the nutrients in terms of proximate, but these seldom add up to 100%, indicating that the manufacturer left out some of the insignificant ones such as water [1].

Enwere in 1998 reported that rice is not a complete food from nutritional standpoint due to its low protein content hence its combination with other foods of high protein content is nutritionally complementary [2]. Most rice consumers prefer milled white rice despite the valuable food contents of brown rice which are lost when the bran are removed during milling. Health conscious people in the European Countries where rice is not a staple food prefer brown rice. However, since consumers are becoming wiser in their choice of quality of product, the quality of the products becomes the choice determinant factor. Quality of rice does not only imply the physical appearance or qualities, rather it encompasses both the chemical and cooking characteristics. Therefore, there is need to put the nutritional values derivable from rice into consideration when choosing a particular rice variety [3].

Rice has been rightly considered as the queen among cereals for its nutritional quality and higher digestibility [4]. The digestibility of dry matter in dogs was significantly ($P < 0.01$) reduced when rice was replaced by alternative cereals. Additionally, the digestibilities of protein, fat and total dietary fibre decreased ($P < 0.01$) in dogs when rice was replaced by pearl millet-based diet. The dry matter voided in faeces increased ($P < 0.05$) in dogs when rice was replaced by the alternative cereals. Faecal ammonia concentration was higher ($P < 0.05$) on the rice-based diet [5].

The analysis of trace elements in rice is a vitally important area of research, given the vast numbers of people who depend on it as a major food source. Worldwide, more than 415 million metric tonnes of rice was consumed in 2006-2007, making it one of the world's most important crops. Rice is a staple food for around half the world's population. It provides the major source of calories, particularly in Asian countries. In Korea, for example, around 400g of rice is consumed per person per day [6]. With more than 30 billion people dependent on rice as a substantial part of their diet, the analysis and monitoring of its composition is vital. The determination of trace elements is a particularly important area in terms of both nutrition and toxicology [7].

Some trace elements are beneficial. Iron and zinc deficiencies are extremely widespread in humans, and also some farm animals. Therefore, the study of these two micronutrients in rice is extremely important for monitoring improvements in nutrition in the developing world [7]. The presence of other trace elements in rice is often an indication of pollution. Copper for example, an essential micronutrient for rice and humans can occur in elevated levels in polluted soils. Too much copper in rice can cause conditions such as black roots and a decrease in tillering efficiency, resulting in yield reductions of around 18-25% [8]. The levels of the heavy metal cadmium in rice are of particular concern. Cadmium enters the soil in a variety of ways, including from operational and former extractive mines, untreated sewage and combustion by-products. Readily taken up by rice and other crops, cadmium presents a major hazard to human health. The effects of cadmium ingestion are wide ranging. It damages the liver and kidneys and also softens and weakens bones. Cadmium may also be a risk factor in the development of prostate or lung cancer. As a consequence, many people suffered the characteristic symptoms of chronic cadmium poisoning, including renal dysfunction and osteomalacia [7].

Intake calculations performed indicates that rice may contribute considerably to the daily requirements of the essential elements such as copper (Cu), iron (Fe), magnesium (Mn), selenium (Se), and zinc (Zn) if rice consumption is high [9]. Trace elements are known to play an important role in the function of the body's immunity system. zinc (Zn) is reported to be crucial for normal development and function of neutrophils, natural killer (NK) cells and T-cell [10,11]. Iron (Fe) supplementation in children has been shown to improve the body's ability to fight infections [12].

The nutritional adequacy of essential elements in foods depends on both their content as well as their bioavailability. Bioavailability of an element reflects a fraction of the total amount of the ingested element that exists in the absorbable form for storage or physiological use. For food of cereal nature, such as rice, the main determinant of the bioavailability of elements is phytic acid (myo-inositol-1, 2, 3, 4, 5, 6- hexa-kis-phosphate). Phytic acid, regarded as an anti nutrient compound reduces the absorption of Fe and Zn in the intestine by forming complex salts with these elements that are insoluble and could not be absorbed [13,14].

Rice provides more than one fifth of the calories consumed worldwide. This annual plant also possesses the main source of calories and protein for more than half of the world's population providing some 700 calories/day/person for about 3,000 million people, most of them living in developing countries [15]. Rice has been the staple food of the Thai people from ancient time. Thais eat both glutinous and non-glutinous rice, prepared as meals, as snacks, as desserts and as drinks [16].

In Ghana, rice has become one of the most important staple foods and it contributes a lot of nutrients to the welfare of mankind. The hope for better nourishment of the population will depend on the development of better varieties, improved methods of rice production, diseases and pests control, proper storage and rice processing [17]. In West Africa, *oryza glabrrima* is the dominant species of rice grown in deep- water areas of the Niger and Sokoto River basins. *Oryza glabrrima* seeds are broadcast or dibbled after the ground has been hoed. In most fields, *oryza glabrrima* is grown in a mixed stand with *oryza sativa*. *Oryza sativa* is grown mainly in irrigated areas and in mangrove swamp areas [18,19].

The West Africa Rice Development Association (WARDA) has also carried out trial of rice varieties and crops protection system in different agro-climatic zones throughout West Africa. In spite of the fact that different rice varieties are widely cultivated in Ghana, there is still an increase in the influx of foreign or imported rice varieties into the country. It is therefore, imperative to introduce some of the new varieties developed through breeding processes such as the four rice varieties under study to farmers and subsequently to consumers. Therefore, the objective of this study is to investigate the chemical composition (proximate and mineral elemental contents) of the four selected rice varieties.

This research work is aimed at comparatively analyzing four different rice varieties cultivated at Bium, a community in the Kassena Nankana District for proximate chemical components such as crude protein, crude fibre, crude fat, crude ash, moisture and total carbohydrate as well as mineral elements such as Calcium (Ca), Sodium (Na), Iron (Fe), Magnesium (Mg), Manganese (Mn), Potassium (K), Zinc (Zn), Copper (Cu), Lead (Pb) and Cadmium (Cd). The piece of work is carried out to determine the nutritional composition of the selected rice varieties, and also to determine why the different varieties of rice are suitable for the preparation of a particular meal as well as to compare the nutritional values of the selected rice varieties and educate farmers and consumers on its production and consumption respectively.

## Material and Methods

Four rice varieties, JASMINE 85, WITA-9, ANDY-11 and IR12979-24-1, commonly known as Perfume, Vita 9, Thailand and Ninety days respectively were used in this research work. The rice varieties were cultivated in the year 2009 on a rice field at Bium, a community in the Kassena Nankana District of Upper East region, Ghana. The paddy of each variety was harvested at maturity, cleaned, dehulled and milled to obtain milled rice. A portion of the milled rice sample was then ground to obtain rice flour suitable for analysis. The rice flours were analyzed for percentage proximate and mineral element contents.

**Proximate Analysis:** This was performed according to the methods employed by [20].

**Elemental Analysis:** Each of the powdered rice sample (2.0g) was first digested using nitric acid and perchloric acid in a volume ratio of 2:1. The digested sample was transferred into a 100ml volumetric flask and made up to mark with distilled water, filtered and analyzed in accordance to the methods prescribed by the Association of Analytical Chemists [21].

## Results and Discussion

The data obtained were expressed as overall mean and standard deviation of the mean for each parameter analyzed. From the above results, it is evident that the most abundant mineral component of the four rice varieties is potassium, and lead being the least mineral element. Potassium (K) represents a very important macronutrient of living organism. The concentration of K ions is most frequently associated with regulation of action potentials and intercellular signaling in electrically active cells. The K channels are involved in multiple functions in both excitable and non-excitable cells. These cellular regulations include regulation of membrane potential, signal transduction, insulin secretion, hormone release, regulation of vascular tone, cell volume and immune response [22]. There is no international limit which reflects the concentration of potassium in plants. However, the average intake of Potassium is 2300 mg/day for adult women and 3100 mg/day for adult men [23]. The results of this study showed a range of 756.82mg/kg to 1710mg/kg with and standard deviation ± 392.75 for tested samples which are absolutely within the permissible range.

The synthesis of metallothionein is induced by the essential metals copper and zinc in the liver and kidney, but also by cadmium, which may replace these metals or share the protein with them. Cadmium is present in most organs, but the highest concentrations are found in the kidney, where it accumulates with age in proportion to the total body cadmium burden [24,25,26]. The effects of cadmium on the kidney take the form of renal tubular dysfunction and subsequent pathological changes. The former is reflected by failure to resorb substances normally, and results in proteinuria, aminoaciduria, glucosuria and decreased renal tubular absorption of phosphate. Cadmium excretion and low molecular weight proteinuria are early indicators of renal cadmium damage [27].

**Table 1: The Elemental Content of the Four Rice Varieties in mg/kg (ppm)**

| Sample | Cd | Ca | Mg | K | Na | Mn | Zn | Cu | Fe | Pb |
|---|---|---|---|---|---|---|---|---|---|---|
| IR12979-24-1 | 1.67 | 46.96 | 241.01 | 756.82 | 29.03 | 3.05 | 10.00 | 14.07 | 17.97 | 0.22 |
| JASMINE-85 | 2.93 | 100.51 | 540.54 | 1720.00 | 48.06 | 4.00 | 10.51 | 22.48 | 21.35 | 0.24 |
| WITA- 9 | 1.99 | 112.34 | 620.16 | 1474.00 | 48.02 | 2.51 | 10.53 | 32.08 | 19.67 | 0.25 |
| ANDY-11 | 3.01 | 123.64 | 818.65 | 1710.52 | 115.68 | 2.00 | 12.50 | 38.13 | 13.67 | 0.25 |
| MEAN | 2.4 | 95.86 | 555.09 | 1415.34 | 60.20 | 2.89 | 10.89 | 26.69 | 18.17 | 0.24 |
| Standard Deviation | ± 0.58 | ± 29.39 | ± 207.69 | ± 392.75 | ± 32.96 | ± 0.74 | ± 0.96 | ± 9.18 | ± 2.86 | ±0.01 |

**Table 2: The Proximate Composition of the Four Rice Varieties**

| Sample | % Moisture | % Fat | % Crude Protein | % Crude Fibre | % Ash | % Carbohydrate |
|---|---|---|---|---|---|---|
| IR12979-24-1 | 8.50 | 1.20 | 6.01 | 0.16 | 0.86 | 83.27 |
| JASMINE-85 | 13.50 | 1.10 | 6.82 | 0.76 | 0.93 | 76.89 |
| WITA-9 | 22.00 | 0.80 | 7.08 | 0.53 | 2.48 | 67.11 |
| ANDY-11 | 13.00 | 1.20 | 7.42 | 0.11 | 1.37 | 76.90 |
| MEAN | 14.25 | 1.08 | 6.83 | 0.39 | 1.41 | 76.04 |
| Standard Deviation | ± 4.88 | ± 0.16 | ± 0.52 | ± 0.27 | ± 0.65 | ± 5.78 |

Nutritional essentiality of cadmium has not yet been proven. However, low cadmium concentration in diet or drinking-water is known to be required to maximize the growth of animals [28]. The generally accepted normal limit of cadmium in plants ranges between 0.2mg/kg to 0.8mg/kg and toxic content of cadmium is between 5.00mg/kg to 30.00mg/kg. The Joint Food and Agricultural Organization/World Health Organization Expert Committee on Food Additives recommends that 7µg of cadmium/kg of body weight should be regarded, provisionally, as the maximum tolerable weekly intake of cadmium. For a 65-kg man, this corresponds to a dietary intake of 65µg/day [25]. The results obtained in this work for cadmium range between 1.67mg/kg to 3.01mg/kg ± 0.58. Though these values fall outside the permissible range, it lies far below the toxicity range.

Calcium (Ca) is one of the most important macronutrients mostly obtained from various dietary sources. Apart from its crucial role in the body’s metabolic process, Ca along with Phosphorus is a structural component of bones, teeth, and soft tissues [29]. Binding of Calcium ions on the surface of human growth hormone provides considerable thermodynamic stability to protein by changing the secondary structure of protein [30]. Cellular Calcium is involved in various regulatory functions like regulation of muscle and nerve functions, glandular secretions, and blood vessel dilation and contraction. Ca deficiency is responsible for weakness of the bones and thus bones are more prone to fracture. It can produce skeletal muscles spasm and abnormality in heart beat and can even cease functioning of heart. Ca intoxication is rare but when occurs is characterized by hypercalcemia, which causes constipation, kidney stones, appetite loss, nausea, vomiting, abdominal pain, confusion, seizures, and even coma [31]. To the Food and Nutrition Board, the recommended daily intake of Ca is 1000 mg/day [32]. In this work, the amounts of calcium in the four varieties were found to range from 46.96mg/kg to123.64mg/kg with standard deviation ± 29.39.

Magnesium helps in the formation of bones and teeth, and assists the absorption of calcium and potassium. Where calcium stimulates the muscles, magnesium is used to relax the muscles. It is further needed for cellular metabolism and the production of energy through its help with enzyme activity. It is used for muscle tone of the heart and assists in controlling blood pressure. Together with vitamin B 12, it may prevent calcium oxalate kidney stones. It helps prevent depression, dizziness, muscle twitching, and pre-menstrual syndrome. It can help prevent the calcification of soft tissue and may help prevent cardiovascular disease, osteoporosis, and certain forms of cancer, and it may reduce cholesterol levels. Magnesium assists the parathyroid gland to process vitamin D, and a shortage here can cause absorption problems with calcium [33].

A recent study that looked at the role of dietary magnesium in human health found that low levels of magnesium can increase the risk of stroke by up to 25% [34]. A severe deficiency caused by mal-absorption, chronic alcoholism, renal dysfunction, or the use of certain medications can cause neuromuscular manifestations, and personality changes can occur. Many cardiovascular problems are indicated with magnesium in short supply and rapid heartbeats as well as fatigue, irritability, and seizure can occur. Insomnia, poor memory, painful periods, depression, hypertension and confusion may also indicative of magnesium in short supply. It is used for the management of premature labor, and for the prophylaxis and treatment of seizures in toxemia of pregnancy. A deficiency may also be a contributing factor to incontinence in older people and bedwetting in children [33].

The permissible limit underneath is the Recommended Dietary Allowance (RDA) stated as 400mg/day for males 19-30years, 420mg/day for females 19-30 years, 310mg/day for males above 30years and 320 mg/day for females above 30years. In supplementation it is normally taken in dosages of 750mg/day - 1,000mg/ day [35]. The results obtained in this work showed that the amounts of magnesium in the four rice varieties range from 214.01mg/kg to 818.65mg/kg ±207.69 with ANDY-11 having the highest value of 818.65mg/kg making it a very good source of magnesium supplement.

Sodium (Na) is a very important macronutrient of human body system. The most common dietary source of sodium is common table salt (NaCl). It has got the prime role in the maintenance of normal physiology in all living organisms. A lack of sodium intake is incompatible with survival. An adequate intake of sodium is required for optimal growth. Distribution of intracellular and extracellular fluid volumes are dictated by sodium and either a deficiency or excess of sodium will alter overall fluid balance and distribution [36]. Na depletion is characterized by mood changes, muscle cramps, fatigue, hair loss, hypotension and dehydration [37]. The observed amounts of Na in the four rice samples were in the range of 29.03mg/kg to 115.68mg/kg ± 32.96. There is no international limit which reflects concentration of Na in plants. However, the recommended daily allowance (RDA) for Sodium in food as stated by the United States Department of Agriculture is less than 2400mg of sodium per day [38].

Manganese (Mn) is an essential trace element. It plays a pivotal role in growth, skeleton formation and has reproductive functions. Mn intoxication is responsible for Parkinsonism which usually becomes progressive and irreversible, reflecting to some extent the permanent damage of neurologic structures [39]. Manganese is also known to be both an activator and a constituent of several enzymes. Those activated by manganese are numerous and include hydrolases, kinases, decarboxylases and transferases, but most of these enzymes can also be activated by other metals, especially magnesium. Signs of manganese deficiency include impaired growth, skeletal abnormalities, disturbed or depressed reproductive function, ataxia of the newborn, and defects in lipid and carbohydrate metabolism. Average basal or normative requirements for manganese have not been established. The threshold toxicity level is also unknown. Thus, a safe range of mean population intake for manganese cannot be proposed [28]. However, Friedman and coworkers, (1987) suggested that the minimal requirement for manganese based on obligatory losses in young men consuming a semi-purified manganese-deficient formula diet was 0.74 mg/day [40]. In other text, the permissible limit of manganese for plants is estimated as 200ppm. In this work, the concentration of manganese was found to range from 2.00g/kg to 4.00mg/kg ± 0.74 which is far less below the permissible limit stated by Muhammad and coworkers, (2010).

In human, Zinc (Zn) is classified as one of the most abundant essential nutrients. It is found in all body tissues mostly in muscles and bones (85%), 11% in the skin and the liver while the remaining Zn is distributed in all the other tissues [41]. There are more than 300 Zn dependent body proteins. Zn acts as anti inflammatory, antioxidant, bone resorptive, important for cell signaling, release of hormones and in apoptosis. Zinc deficiency in human mostly occurs in pregnancy and is characterized by growth failure, impaired parturition (dystocia), neuropathy, decreased cyclic food intake, diarrhoea, and dermatitis, hair loss, bleeding tendency, hypotension, seizers and hypothermia [42]. Acute Zinc toxicity causes abdominal pain, nausea, vomiting and diarrhea. Chronic exposure of Zinc elicits copper deficiency [23]. The concentrations of Zn were found to be in the range of 10.00mg/kg to 12.50mg/kg ± 0.96. The World health Organization tolerable limit of zinc in food is 60mg/kg which falls well above the values obtained in this work [43]. The tolerable upper limit for zinc intake is 40mg/day [44].

Copper (Cu) is another essential micronutrient. Many human body proteins are dependent on copper. These include superoxide dismutase, ceruloplasmin, lysyl oxidase, cytochrome oxidase, tyrosinase and dopamine-β-hydroxylase. Cu is necessary for proper working of immune system [45]. During infections, the generation of interleukin-2 by activated lymphocytic cells is dependent on Cu. Systemic decrease in Cu levels causes cellular iron (Fe) deficiency [46]. Cu toxicity in infancy is based on improper liver functioning. Cu deficiency affects Fe transport in the body tissues and is responsible for a hypochromic microcytic anemia similar to that produced by Fe deficiency. The various rice varieties exhibited notable amounts of Cu range from 14.07mg/kg to 38.13 mg/kg ± 9.18 within the W.H.O. permissible limit (40mg/kg) of Cu in food. The recommended dietary allowance (RDA) for Cu is 340–900 µg /day.

Iron (Fe) is the most abundant essential trace element of human body tissues. Its optimal concentration is required for the survival of plants, animals and microorganisms [46]. The world health organization has reported that approximately 46% of the world's children and 48% of pregnant women are suffering from anemia. The Fe deficiency causes irreversible alterations of brain functions and affects immune response in many ways [47]. Most of the body iron is taken by hemoglobin (57.6%) and non-heme iron complexes (33%) including ferritin and hemosiderin. In this present work, the four rice varieties had Fe concentrations ranging from 13mg/kg to 21mg/kg ± 2.86. The permissible limits 36mg/kg- 241mg/kg[33]. Food and Nutrition Board has recommended the daily iron intake as 8 mg/day for male, 18 mg/day for female and 27 mg/day during pregnancy [23]. Considering concentration of Fe in the four rice varieties, it is evident that all the varieties are not very good sources of Fe since the value obtained for each variety lies outside the permissible limit. Hence, consumers will have to resort to Fe supplementation.

A requirement for lead (Pb) for the function of an enzyme or an essential metabolic pathway has not yet been demonstrated [28]. However, Pb has been reported to reduce uric acid excretion [48]. It is also reported in other text that reduced activities of $Na^+$ /$K^+$ exchanging ATPase and (Ca, Mg)- ATPase in red cell membranes has been the reason for the microcytic anaemia that develops after lead depletion [49]. Epidemiological studies indicate an association between an elevated body burden of lead and increased blood pressure in adults. Again Pb is known to have two kinds of toxicological effects on the kidney been reversible renal tubular dysfunction, occurring mostly in children with acute exposure to lead and usually associated with overt central nervous system effects, and irreversible chronic interstitial nephropathy characterized by vascular sclerosis, tubular cell atrophy, interstitial fibrosis and glomerular sclerosis. Severe lead toxicity causes sterility, abortion and neonatal mortality and morbidity. Gametotoxic effects occur in both male and female experimental animals, but the potential for such effects in humans is unknown [28]. The permissible limit of lead in food is 10mg/kg [43]. Lead concentrations in the four rice varieties range from 0.22mg/kg to 0.25mg/kg ± 0.01 which were far below the permissible limit. Mean dietary intakes of children have been reported to be in the range 9-278 µg of lead/day and for adult's 20-282 µg/day [28].

The results obtained for carbohydrate content of the four rice varieties range from 67.11 to 83.27% with an overall mean and standard deviation of 76.04 ± 5.78. The values are in accordance with those earlier recorded by [3] [4] [50] [51] [52] [53]. These high values of percentage carbohydrate indicate that, the four rice varieties are very good sources of carbohydrate.

The crude protein contents range from 6.01 to 7.42% with an overall mean and standard deviation of 6.83

± 0.52. These levels of proteins in rice are very essential as proteins form the basic building blocks for cells and tissue repairs in the body. Also, the results recorded for the four rice varieties are in agreement with the results earlier recorded by [3,51,54] but higher than were obtained by [50]. Fat in rice is a good source of linoleic acid and other essential fatty acids and rice does not contain cholesterol [52]. The results obtained for the four rice varieties range from 0.80% to 1.20%, with a mean and standard deviation of 1.08 ± 0.16%. These values are lower than those obtained by [3,51,54]. The incidence of a wide range of diseases in man has a relationship with the absence of fibre in diet [55]. The presence of fibre in diet increases the bulk of feaces, which has a laxative effect in the gut. The standard content of fibre in rice is 0.5 – 1.0% for well milled rice [3]. The results obtained for the four rice varieties range from 0.11 to 0.76% with an overall mean and standard deviation of 0.3 ± 0.27. These values are lower when compared to those reported by [51,52,54,56] and two of the values fall within the range given for the standard content of fibre in rice.

The results for ash contents range from 0.86 to 2.48% with a mean and standard deviation of 1.41 ± 0.65. Ash contents in rice reflect the mineral elements. The values recorded for the ash contents of the four rice varieties are in accordance with those reported by [3,50,51]. Moisture content, invariably affects the quality and palatability of rice grains [3]. The results obtained for the four rice varieties range from 8.50% to 22.00% with a mean and standard deviation of 14.25 ± 4.88. These results are in agreement with those earlier reported by [3,54]. From the above interpreted results, the suitability of the rice variety IR12979-24-1 in rice ball preparation could be attributed to the high amount of carbohydrate (83.27%) coupled with low moisture content. The high amount of carbohydrate signifies high level of starch, and this has the advantage of making the individual grains stick to each other to enhance easy molding in balls. Similarly, the low carbohydrate (starch) content of WITA- 9 (67.11%) could be the advantage it has over the other varieties in waakye preparation since waakye is best enjoyed when the individual grains remain separated from each other after cooking. The low starch content will do well to prevent sticking of the grains together. The two varieties of rice, JASMINE-85 and ANDY-11 have approximated moisture contents of 76.89% and 76.90% which could explain why they are more suitable in preparing similar foods such as jollof rice and plain rice respectively.

## Conclusion

This work has revealed that the four rice varieties have considerable amount of nutrients such as carbohydrate, which is a good energy source, protein for repair of worn out body tissues, crude fibre for effective digestibility of food, as well as fat and mineral elements which contribute to the recommended dietary allowance. The carbohydrate (starch) contents of the four rice varieties supported their use in the various food preparations in Kassena Nankana District. The variations between the parameters studied in this work and other authors can be attributed to factors such as species differences, fertilizer application, and soil nutrients availability. The milling process of rice also affects its mineral content [57]. Due to the nutritive value of the four rice varieties, the production and consumption of these rice varieties are recommended to farmers and consumers for derivation of the above-mentioned nutrients.

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