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Physicochemical Properties of Un-parboiled Oryza Species Cultivated in Igbemo-Ekiti, Ekiti State, Nigeria

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Abstract

The amounts of carbohydrate, protein, crude fat, crude fiber, ash, and mineral elements (Calcium, Magnesium, Iron, Potassium, Sodium, and Zinc) in two kinds of rice grown in Igbemo-Ekiti, Ekiti State, were determined in this study. Using Gc-Ms spectrometric analysis, the fatty acids contained in the oil of *Oryza sativa* and *Oryza glaberrima* were identified. On a dry weight basis, the estimated carbohydrate content of rice samples ranged from 71.41 ± 0.37 to 74.02 ± 0.35 %, with no significant difference in carbohydrate content amongst the examined species, with *Oryza glaberrima* having the highest carbohydrate content. Protein levels ranged from 7.06 ±0.35 to 7.11 ± 0.20 %, with *Oryza sativa* having the highest protein content. The crude fat levels in the tubers ranged from 6.26 ± 0.04 to 7.18 ±0.17 %, with *Oryza sativa* having the highest level. The crude fiber content ranged from 3.02 ±0.32 to 3.77± 0.38 %, with *Oryza sativa* having the highest level and the ash content ranging from 0.51± 0.07 to 0.92± 0.32 %. Calcium, sodium, and potassium concentrations were all fairly high in both species. The Gc-Ms chromatogram indicated a wide range of bioactive chemicals, the majority of which were fatty acids. Linolenic acid, Arachidic acid, Palmitic acid, palmitoleic acid, Myristoleic acid, and Capric acids were some of the primary chemical components detected in *the Oryza sativa* chromatogram, however monounsaturated and polyunsaturated fatty acids were found in lesser amounts. Linoleic acid, oleic acid, palmitoleic acid, Myristoleic acid, Elaidic acid, Linolelaidic acid, stearic acid, and Behenic acid have been discovered in *Oryza glaberrima*, making them more favorable in nutrition and diet. The two *Oryza* types were found to be high in fatty acids, protein, and mineral content.

Keywords: Proximate; Mineral analysis; Fatty acid; Gc-Ms.

1. Introduction

Oryza (rice) species are grown worldwide and they are staple food for about a half of the world's population. They are nutritious grain crops which contain carbohydrates, proteins, lipids, minerals, etc. Rice straw is an important animal feed in many countries. It is grown in cool climates in the mountains of Nepal and India, and under irrigation in the hot deserts of Pakistan, Iran and Egypt [1] There are two cultivated rice species: *Oryza sativa*, grown worldwide, and *Oryza glaberrima*, grown in West and Central Africa. *O. sativa* has many ecotypes (cultivars) adapted to various environmental conditions. Rice species are farmed all over the world and are a staple diet for over half of the world's population. They are nutrient-dense grain crops that are high in carbs, proteins, lipids, minerals, and other nutrients. In many places, rice straw is an important animal feed. It is produced in mild regions in Nepal and India's highlands, as well as in the hot deserts of Pakistan, Iran, and Egypt, where it is irrigated. Agnoun, *et al.* [1] *Oryza sativa*, which is grown all over the world, and *Oryza glaberrima*, which is grown in West and Central Africa, are the two types of cultivated rice. Many ecotypes (cultivars) of *O. sativa* exist, each adapted to a different habitat. The morphology, physiology, and biochemistry of *O. sativa* have been researched extensively over time, and physical and chemical qualities vary depending on factors such as soil conditions and climate [1]. However, the requirement to compare two species of locally cultivated *oryza* in Igbimo, Ekiti state, Nigeria, compelled this study to add to the library of information on *oryza* variants currently available [2].

2. Materials and Methods

2.1. Getting a Sample

Rice samples of *Oryza sativa* and *Oryza glaberrima* were obtained in Igbemo Ekiti, Ekiti State, Nigeria, on July 25th, 2021. Igbemo Ekiti is a town in the Ifelodun Local Government Area of Ekiti State, notable for local rice cultivation and the manufacturing of local un-parboiled rice. 7.6812° N and 5.3881° E are its coordinates.

2.2. Obtaining a Sample

Using a laboratory scale grinder (Sumeet CM/L 2128945), ten kilograms of rice species were dehusked and pulverized into fine powders, then sifted through a 300-mesh sieve to obtain rice powder. For further investigation, the powdered samples were sealed and stored in airtight containers [3].

2.3. Proximate Composition Assessment

The moisture, crude fibre, crude protein, ash, crude fat, and carbohydrate content of the samples were measured using AOAC techniques [4]. Triplicates of each determination were made. The percentages were used to report the approximate values.

3. Mineral Analysis

The standard methods from [4] was used. After dry ashing and dissolving the ash in 25mL of 10% HCl acid, the elemental elements (Ca, Zn, Fe, Mg, K, Na, Cu, and Mn) in rice powder were evaluated using an atomic absorption spectrophotometer (AAS) (AAS Buck Scientific Model 210 VGP and Flame Photometer FP 902 PG, England).

3.1. Extraction and Quantification of the Active Components of the Oil in Rice Flour

The conventional method of extraction utilized involves soaking in n-hexane. This method of extraction was designed to extract the lipid content of the powdered sample. Approximately 20 g of moisture-free sample was introduced into a cleaned, dried beaker, and 200 mL of n-hexane was poured into the beaker. They were allowed to stay for five days. The beaker was sealed with aluminium foil to prevent the n-hexane from escaping into the atmosphere due to its high volatility. The mixture was then sieved into a pre-weighed beaker after five days and the filtrate concentrated in a water bath. The beaker containing the concentrate was then placed in an oven at 105^0C for 2 hours and cooled in a desiccator prior to weighing. The extracted oil composition was determined by using a gas chromatography-mass spectrophotometer (GC-MS).

3.2. Analytical Statistics

The mean and standard deviation were obtained by doing the proximate and mineral analyses three times.

4. Results and Discussion

4.1. Proximate Composition

The results of the proximate analysis of *Oryza sativa* and *Oryza glaberrima* in % are presented in Table 1. It is apparent that *Oryza sativa* had higher ash (0.92±0.32 %), fat (7.18±0.17%), moisture (9.61±0.02 %), fiber (3.77±0.38 %) and protein (7.11 ±0.02 %) contents as well as lower carbohydrate (71.41 %±0.37) content when compared to the values of *Oryza glaberrima*. The carbohydrate values ranging from 71.41±0.37 to 74.02±0.35 % showed high values although they are lower than the values quoted by Edeogu, *et al.* [5]; Eggum, *et al.* [6]; Oko and Ugwu [7]. They analysed the proximate compositions of staple food crops in Ebonyi State. These lower contents of carbohydrate in the samples examined may be attributed to their high moisture content which of course affected their milling qualities [8]. These species are good sources of energy due to their high content of carbohydrate as shown in table 1 and 2. The low ash content values indicated that the two species examined in this study have low mineral composition which range from 0.51 to 0.92%. The crude protein contents obtained in this study range from 7.06±0.35 to 7.11±0.02 % and are higher than those reported by Edeogu, *et al.* [5]; Eggum, *et al.* [6]; Oko and Ugwu [7]. Therefore, they are more nutritious than those earlier reported as stated above. The higher crude fibre content of the species examined in this study indicated that they are easily digested since fibre were implicated in aiding quick digestion of food in the stomach. These values are higher than those reported by Edeogu, *et al.* [5]; Eggum, *et al.* [6]; Oko and Ugwu [7]. Generally parboiling of rice reduces the nutrition qualities of rice and this is established since the species examined in this study were not parboiling.

Table-1. Proximate content of *Oryza sativa* and *Oryza glaberrima*

Proximate contents (%)	*Oryza sativa*	*Oryza glaberrima*
Moisture	9.61± 0.02	9.13 ±0.58
Crude fat	7.18 ±0.17	6.26 ±0.04
Crude fibre	3.77 ±0.38	3. 02 ± 0.32
Crude ash	0.92 ±0.32	0.51 ±0. 07
Crude protein	7.11 ±0.02	7.06 ±0.35
Carbohydrate	71.41 ± 0.37	74.02 ±0.35

Mean ± standard deviation of triplicate determinations.

Table-2. Mineral element composition of *Oryza sativa* and *Oryza glaberima* in mg/100g

Mineral elements	*Oryza sativa*	*Oryza glaberrima*
Sodium (Na)	4.27 ± 0.01	4.86 ± 0.02
Calcium (Ca)	10.63 ± 0.35	12.62 ± 0.14
Potassium (K)	5.91 ± 0.28	7.55 ± 0.28
Zinc (Zn)	0.12 ± 0.01	0.19 ± 0.01
Magnesium (Mg)	0.72 ± 0.01	1.22 ± 0.02
Copper (Cu)	0.03 ± 0.02	0.02 ± 0.03
Iron (Fe)	0.06 ± 0.03	0.09 ± 0.28
Manganese (Mn)	0.03± 0.02	0.03± 0.03

4.2. Mineral Element Composition of *Oryza sativa* and *Oryza glaberima*

Essential mineral elements play an important role as a cofactor for certain enzymes involved in metabolism and cell growth, most of them involved in the metabolism of proteins, carbohydrates, lipids, and energy. They are also necessary for growth, development, muscle and nerve function, normal cellular functioning, and synthesis of some hormones and connective tissue.

The sodium content, as presented in table 2 of *Oryza sativa* (*O. sativa*), 4.27 ± 0.01 mg/100g, is slightly lower than that of *Oryza glaberrima*, which is 4.86 ± 0.02 mg/100g. Hence *O. glaberrima* is a better source of sodium than its counterpart specie. The current Dietary Guidelines recommend consuming no more than 2,300 milligrams of sodium per day. Special recommendations for those with high blood pressure, who are African American, middle aged, or elderly, are advised to consume no more than 1,500 milligrams of sodium per day. The recommended daily allowance (RDA) of sodium is 1500 mg [9, 10]. Both rice specie investigated in this study have low amounts of sodium when compared with the RDA of sodium. Sodium is the principal cation in intracellular fluids that controls acid-base balance and is involved in maintenance of osmotic pressure of body fluids [11]. It is important for co-regulating ATP with potassium [8]. The sodium values obtained in this study are higher than those reported by Ibukun [12]. This large difference might be as a result of fertilizer application, rate of parboiling and the amounts of soil nutrients all of which affect the mineral contents of rice which were not applied on the species examined in this study. Calcium concentration in the rice species were 10.63 ± 0.35 mg/100g and 12.62 ± 0.14 mg/100g for *Oryza Sativa* and *Oryza glaberrima* respectively. The RDA value for calcium in an adult male is 1000mg [10]. Calcium content of both samples per 100g is lower than the RDA. Calcium is an important constituent of body fluids and is a coordinator among inorganic elements particularly potassium, magnesium, or sodium where calcium is capable of assuming a corrective role when such metals are in excessive amount in the body [13]. Calcium, phosphorus and vitamin D combine together to prevent rickets in children and osteomalacia (the adult rickets) as well as osteoporosis (bone thinning) among older people [14]. High dietary calcium levels can influence the bioavailability and absorption of many trace elements particularly the divalent cations, such as magnesium, manganese, and zinc, but it is unlikely that these effects are commonly severe enough to have clinical impact [15]. *O. glaberrima* has a higher potassium content (7.55 ± 0.28 mg/100g), than *O. Sativa* which is 5.91 ± 0.28 mg/100g, as shown in table 2. Potassium values observed in per 100g of these rice species are low in comparison to the recommended daily allowance (RDA) of potassium (4700mg). Potassium is the main intracellular cation that controls osmotic pressure and is a systemic electrolyte essential for co-regulating adenosine triphosphate (ATP) with sodium. The depolarization and contraction of the heart require potassium [11], very crucial in maintaining the blood fluid volume and plays a major role in skeletal muscles [11]. The recommended daily allowance (RDA) of potassium is 4700 mg [10].

Zinc is among the required elements for humans. Levels obtained in the present study for *O. Sativa and O. glaberrima* is (0.12 ± 0.01 mg/100g) and (0.19 ± 0.01 mg/100g) respectively. Zinc level is low in both samples analyzed. However, from the recommendation set out by NRC/NAS, the daily requirement of zinc can easily be met by supplementing this with foods high in potassium, sodium, calcium and Phosphorus. High doses of zinc can be harmful. Zinc supplements can decrease the amount of high-density lipoprotein (HDL) circulating in the blood, increasing risk of heart disease. Excess zinc interacts with other minerals, such as Cu and Fe, decreasing their absorption. In animals, zinc supplements decrease the absorption of iron so much that anaemia is produced [16]. If patients are given 150 mg of zinc per day, copper deficiency may result. Intakes of zinc only 3.5 mg/day above the RDA decrease copper absorption [17]. Zinc content of the samples used in this research was below the RDA; therefore, they may not increase the risk of neither heart disease nor decrease iron absorption nor cause copper deficiency.

Magnesium is one of the ten essential minerals with an RDA of 400 mg/day for healthy adult males and 320 mg/day for healthy adult females [18]. The Mg content of *O. Sativa* and *O. glaberrima*, as presented in table 2 is 0.72 ± 0.00 and 1.22 ± 0.00 (mg/100g) respectively. Mg is used in so many biological functions, where it is function as a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation [19, 20]. Magnesium is needed for energy production, oxidative phosphorylation, and glycolysis. It contributes to the structural development of bone and is required for the synthesis of DNA, RNA, and the antioxidant glutathione. It protects mitochondria, which is the storehouse of energy, from the dangerous oxidants. It is found that this mineral also plays a role in the active transport of calcium and potassium ions across cell membranes, a process that is important to nerve impulse conduction, muscle contraction, and normal heart rhythm [20]. Both rice species have low Copper content of 0.03 ± 0.02 mg/100g and 0.02 ± 0.03 mg/100g for *O. sativa* and *O. glaberrima*, compared with the established RDA for Cu in normal healthy adults, that is 5 mg/day [19]. It is an essential trace element in plants and animals. The human body only contains about 150 mg of this vital mineral. It is absorbed in the gut and then transported to the liver bound to albumin. After processing in the liver, it is distributed to other tissues in a second phase. It transports in liver involves the protein ceruloplasmin, which carries the majority of copper in blood. Ceruloplasmin also carries Copper that is excreted in milk and is particularly well absorbed as a Cu source [19]. Copper is an essential constituent of several enzymes such as cytochrome oxidase, monoamine oxidase, catalase, peroxidase, ascorbic acid oxidase, lactase, tyrosinase, and superoxide dismutase (SOD). Moreover, due to its presence in a wide variety of enzymes, Cu is involved in many metabolic reactions. For instance, the presence of Copper in the SOD helps in the conversion of superoxide to oxygen and hydrogen peroxide [21].

Iron is the most abundant metal in the human body. Body Fe content is approximately 3-4 g, which almost corresponds to a concentration of 40-50 mg of iron per kilogram of body weight [22]. The iron content, as shown in table 2, of *O. Sativa* is 0.06 ± 0.03 mg/100g, while that of *O. glaberrima* is 0.09 ± 0.28 mg/100g. The established RDA for iron in normal healthy adults is 8 mg/day for men and post-menopausal women and 18 mg/day for menstruating women [19]; (this is due to lose a lot of blood during their monthly period). Both rice species analyzed in this study have the same amount of manganese, which is 0.03 ± 0.02 mg/100g. Manganese is a trace mineral that is present in tiny amounts in the body. It is one of the most important nutrients for human health. The average human body contains about 12 mg of manganese. About 43% of it is found in the skeletal system, with the rest occurring in soft tissues including liver, pancreas, kidneys, brain, and central nervous system. It helps the body to form connective tissue, bones, blood-clotting factors, and sex hormones. In animals, manganese protects heart mitochondrial lipids against peroxidation [23]. Manganese is an essential trace element because it is an activator of several metalloenzymes, including arginase, pyruvate carboxylase, glutamine synthetase, and one form of superoxide dismutase (SOD). Manganese also is a nonspecific activator of several other enzymes. The RDA for manganese is 4.0 mg/day [19].

The role of trace elements in biological processing may provide vital clue for understanding the etiology of some diseases such as cancer. The ability of trace elements to function as substantial affecter in a variety of the processes necessary for life, such as regulating homeostasis and prevention of free radical damage, can provide an answer to the definite correlation between content of trace elements and many common diseases. Rivero, *et al.* [24], reported that as greater amount of rice bran is removed from grain during milling and polishing, more vitamins and minerals are lost. The values obtained for minerals are largely higher than the values obtained by Ibukun [12]. This huge difference might be as a result of fertilizer application, rate of parboiling and the amounts of soil nutrients all of which affect the mineral contents of rice.

Fig-1. Chromatogram of extracted oil of Oryza *sativa*

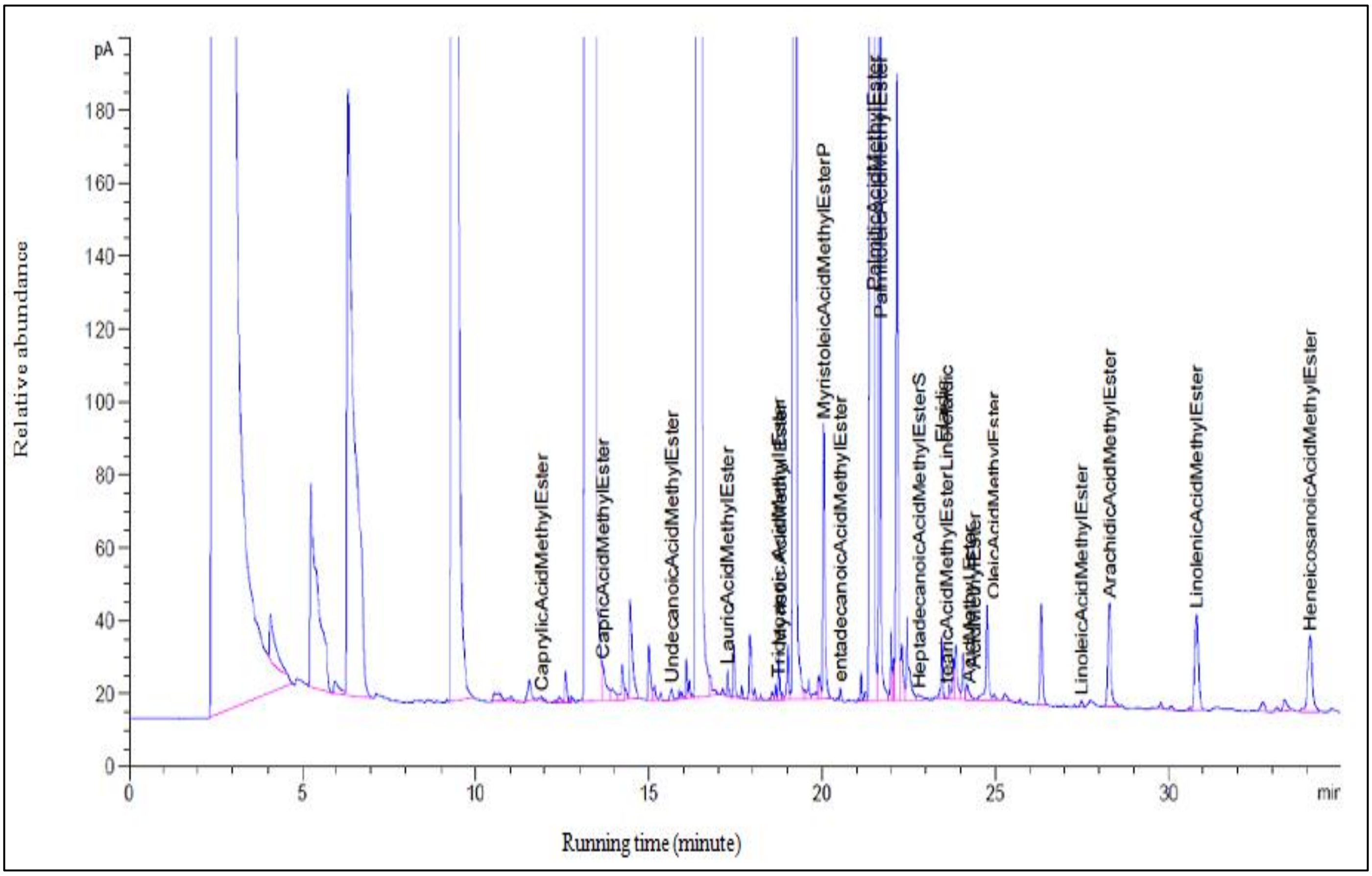

Fig-2. Chromatogram of extracted oil of *Oryza glaberrima*

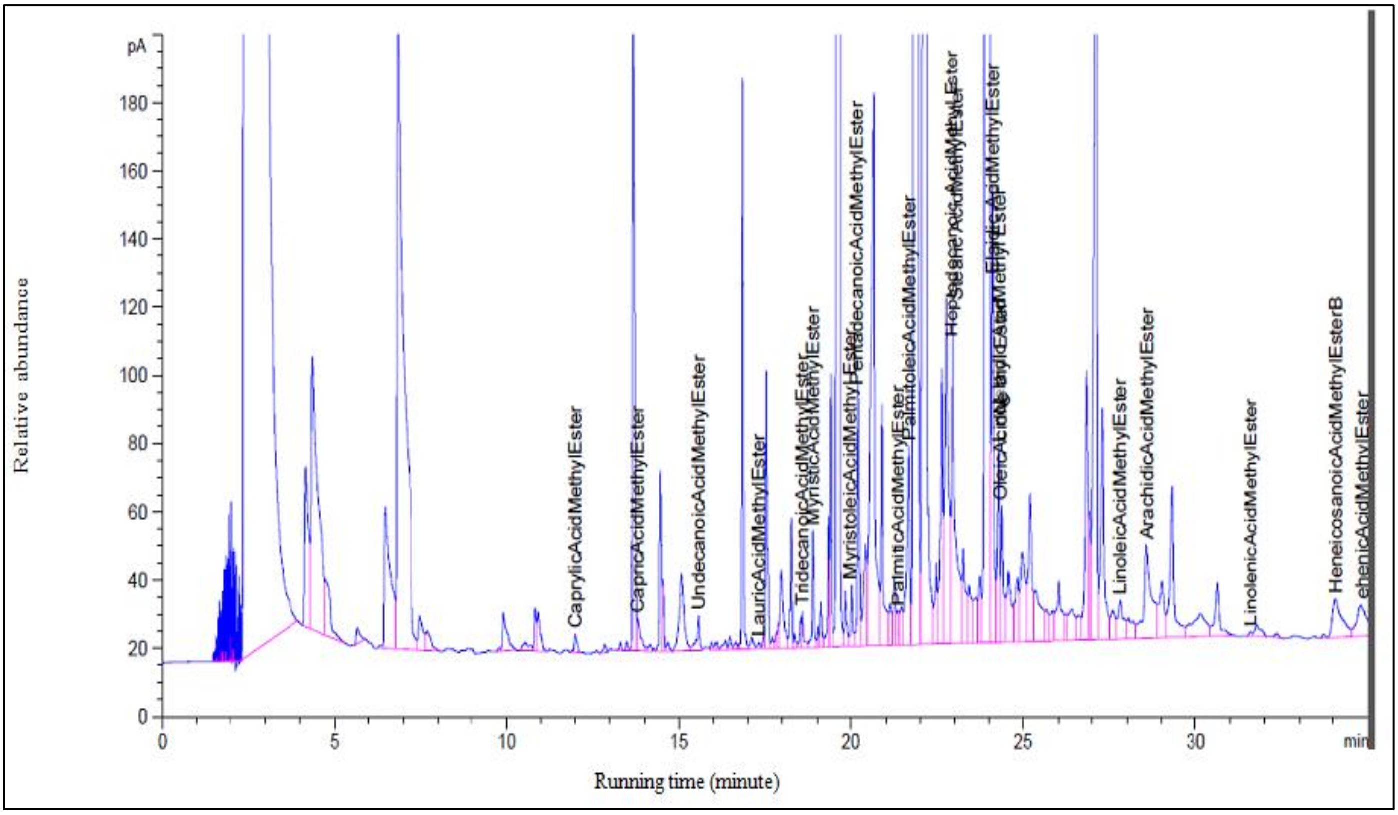

Table-3. Some of the detected compounds detected in the GC-MS screening of the oil extract of *Oryza sativa*

% Quality	Quantity (mg/g)	Retention Time (Minutes)	Compound Name	Type of Fatty Acid
11.578	115.78	3.886	Butyric acid methyl ester	Saturated
2.304	23.04	13.671	Capric acid methyl ester	Saturated
3.747	37.47	20.040	Myristoleic acid methyl ester	Monounsaturated
69.777	697.77	21.477	Palmitic acid methyl ester	Saturated
4.719	47.19	21.668	Palmitoleic acid methyl ester	Monounsaturated
1.048	10.48	28.287	Arachidic acid methyl ester	Saturated
1.221	12.21	30.807	Linolenic acid methyl ester	Polyunsaturated
3.343	33.43	34.082	Heneicosanoic acid methyl ester	Saturated

Table-4. Compounds detected in the GC-MS screening of the oil extract of *Oryza glaberrima*

% Quality	Quantity (mg/g)	Retention time (minutes)	Compound names	Type of Fatty Acid
36.962	369.62	3.886	Butyric acid methyl ester	Saturated
2.595	25.95	13.790	Capric acid methyl ester	Saturated
1.204	12.04	20.017	Myristoleic acid methyl ester	Monounsaturated
2.129	21.29	20.194	Pentadecanoic acid methyl ester	Saturated
1.786	17.86	21.674	Palmitoleic acid methyl ester	Monounsaturated
17.984	179.84	22.748	Heptadecanoic acid methyl ester	Saturated
14.514	145.14	22.944	Stearic acid methyl ester	Saturated
2.925	29.25	24.090	Elaidic acid methyl ester	Monounsaturated
3.894	38.94	24.265	Linolelaidic acid methyl ester	Monounsaturated
0.711	7.11	24.356	Oleic acid methyl ester	Monounsaturated
1.280	12.80	27.791	Linolenic acid methyl ester	Polyunsaturated
3.321	33.21	28.569	Arachidic acid methyl ester	Saturated
0.063	0.63	31.576	Linolenic acid methyl ester	Polyunsaturated
5.311	53.11	34.045	Heneicosanoic acid methyl ester	Saturated
1.783	17.83	34.772	Behenic acid methyl ester	Saturated

4.3. GC-MS Analysis of the Oil Extracted from *Oryza sativa* and *Oryza glaberima*

The oil extract was analyzed using a Shimadzu GC-MS-QP2010 machine. Eight identified fatty acids were revealed in the extract of *Oryza sativa* and there were fifteen compounds detected between retention times ranging from 3.886-34.00 mins in the extract of *Oryza glaberrima*. The compounds chromatograms were shown in figures 1 and 2 and compounds identities were found in tables 3 and 4. In tables 3, of the compounds identified, palmitic acid methyl ester was the most abundant compound having quality 69.777% and 697.77mg/g in quantity, followed by Butyric acid methyl ester (11.578% quality and 115.78 mg/g quantity) and the least abundant compound was linolenic acid methyl ester (1.221%). From table 4, butyric acid methyl ester was 36.962 % in quality and 369.62 mg/g in quantity, heptadecanoic acid methyl ester (17.984 % quality, quantity of 179.84 mg/g), stearic acid (14.514 %). The Myristoleic acid, and Palmitoleic acid are monounsaturated fatty acid (MUFA) which are have been found to be nutritiously healthy fats and oils for the heart and therefore prevent cases of diabetes, heart diseases [25]. Linoleic acid is a good polyunsaturated fatty acid which is needed in diet because it is good for the heart, nerve function, blood clotting, brain health, and muscle strength. They are essential fatty acids, which the body cannot synthesize but they are needed for body functions, so a person must get polyunsaturated fatty acid (PUFA) from diet unlike the saturated ones that cause cardiac vascular diseases. Palmitic acid may be added as additives in drug formulation. Myristoleic acid is an omega-5 which when consumed improves long-chain omega-3 fatty acids levels in plasma phospholipids, which could exert improvement of cardiovascular health parameters in humans [26], furthermore, previous study has shown that Elaidic acid might provide prominent metastatic potential to colorectal cancer cells, which shows important implications for the treatment of colorectal cancer cell [26]. Linolelaidic acid is an isomer of Alpha-linolenic acid which is popular for preventing and treating diseases of the heart and blood vessels. It is used to prevent heart attacks, lower high blood pressure, lower cholesterol, and reverse "hardening of the blood vessels" (atherosclerosis) [27]. Oleic acid synergistically enhances cancer drug effectiveness [28].

5. Conclusion

This study has revealed that the *Oryza sativa* and *Oryza glaberrima* examined have appreciable oil extracts which contain very important bioactive chemical compounds that are important in human diet and may be used as drugs which were found to be better than other local species reported by previous researchers.

Comparatively, it will be safe to ascertain that *Oryza glaberrima* is more nutritious than *Oryza sativa* due to its higher polyunsaturated and monounsaturated fatty acid content. The mineral composition has also revealed that the *Oryza sativa* and *Oryza glaberrima* are enriched in essential macro and micro elements although not up to the recommended daily allowance (RDA) but can definitely be used to as natural sources of important mineral components for effective functioning of the body and wellness and they have higher mineral composition than other previous local species reported.

Oryza sativa and *Oryza glaberrima* have established the fact that they have considerably moderate crude fibre content which aids bowel wellness and digestion as well high carbohydrate content for provision of energy for effective metabolism in the body and enhance functional cellular activities.

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