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COMPARATIVE STUDIES ON NUTRITIONAL, MINERAL AND VITAMIN COMPOSITIONS OF MATURE AND IMMATURE COCONUT WATER

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ABSTRACT

There are so many myths about coconut water's therapeutic and curative properties. To obtain facts on the nutritional and Health potentials of coconut (Cocos nucifera) water, a comparative study of proximate, mineral and vitamin compositions of mature and immature Cocos nucifera water was carried out using Standard Analytical Techniques and Atomic Absorption Spectrophotometer (AAS). The proximate composition result revealed higher levels of protein (0.57 ± 0.02 %) and total energy (91.17 KJ/100g) in the immature than the mature sample. In comparison, the moisture (94.95 ± 0.04 %), ash (0.81 ± 0.02 %), and fatty acid (0.144 ± 0.03 %) compositions of the mature sample were higher than that of the immature. The mineral evaluation revealed that potassium was the most abundant mineral element in mature and immature coconut water, with concentrations of 28.64 mg/100g and 27.96 mg/100g, respectively. This was followed by P (4.66 mg/100g, 12.10 mg/100g), Na (3.08 mg/100g, 3.75 mg/100g), Ca (2.71 mg/100g, 3.05 mg/100g), Fe (1.07 mg/100g, 1.04 mg/100g), Cu (1.20 mg/100g, 0.99 mg/100g), Mg (0.56 mg/100g, 0.84 mg/100g), Zn (0.23 mg/100g, 0.35 mg/100g) and Mn (0.015 mg/100g, 0.009 mg/100g) for mature and immature samples respectively. Immature coconut water had higher contents of vitamin A (0.44 mg/100g), while the mature sample had higher levels of vitamin C (7.46 mg/100g) and E (3.65 mg/100g). The low sodium and high potassium levels of mature and immature coconut water with Na/K ratio <1 suggest their intake may exert a remarkable anti-hypertensive effect on humans. They are also good sources of nutrients, vitamins, and natural energy boosters.

Keywords: Coconut water, Immature, Mature, Minerals, Proximate, Vitamins

INTRODUCTION

There is an increasing interest worldwide, especially in developing countries like Nigeria, in using natural products like drinks, food, fruits and vegetables to solve health challenges. This has become inevitable as a result of the economic downturn, which has

affected the cost of synthetic drugs, making it inaccessible to the poor and vulnerable masses, which constitute a high percentage of the population of most developing countries. Apart from the high cost of these drugs, the masses also battle with the side effects associated with their use since they are chemicals and have adverse effects. This has necessitated the current research work by food chemists and related researchers on nutritional, medicinal and potential health benefits of some locally available, utilized and under-utilized plant foods and drinks.

Coconut (*Cocos nucifera L.)* is one of the Arecaceae family's most essential nut-bearing palm crops. This plant is grown worldwide with the Arecaceae family's most crucial nut-bearing palm crops, cultivated intensively in the tropical world. Among coconut-producing countries, India ranks as the third largest producer after Indonesia and the Philippines, with a total production of 11.4 million tons (MT) of nuts annually (Abdulhanan *et al*., 2020). Both tall and dwarf coconut varieties are grown throughout the world. Tall varieties (approximately 95 % of total coconut grown worldwide) are slow-growing, cross-pollinated, and usually take 6-10 years to fruit after planting, whereas the dwarf varieties (approximately 5 % of total coconut grown worldwide) are relatively fast-growing, mostly self-pollinated and fruits usually within 4-5 years after planting (Eugueran *et al.,* 2023).

Coconut parts such as outer coconut husk (mesocarp), middle stony hard brown shell (endocarp), and inner soft white edible endosperm are used for different commercial purposes (Appaiah *et al.*, 2014). The endosperm is either edible as a solid white kernel or a clear nutritious liquid (coconut water) (Appaiah *et al.*, 2014). Among all these coconut-derived products, coconut water is emerging as a popular refreshing drink worldwide because of its excellent sweet aroma, high nutritional value and

proven health-protective properties (Coulibaly *et al.,* 2023).

Coconut water comprises 5-9 % of total soluble solids (TSS) and 80 % of soluble sugars dominated by glucose, sucrose and fructose (Eugueran *et al.,* 2023). Other important constituents are minerals, amino acids, enzymes, organic acids, fatty acids, vitamins, and phenolic compounds. Regarding the number of constituents in coconut water, minerals come after the sugars. Minerals constitute 0.4-1.0 % (w/v) of coconut water (Coulibaly *et al.,* 2023). The amount of minerals in coconut water dramatically varies with the nut age and cultivar type (Coulibaly *et al.,* 2023). There is a general belief that tender (immature) coconut water is nutritionally rich and bears mostly health-protective nutrients (Appaiah *et al.,* 2014).

The study evaluates the nutritional, mineral and vitamin contents of mature and immature coconut water grown in Anambra State, Nigeria. The information obtained from the survey will serve as robust scientific evidence to support or refute some medicinal-related claims surrounding coconut water, contribute to Sustainable Developmental Goals (SDGs) 3, and give insight into the potential health benefits of coconut water.

MATERIALS AND METHODS

Samples Collection and Treatment

Matured coconuts (*Cocos nucifera L.)* were purchased from Eke Awka market in Awka South LGA, Anambra State. At the same time, the immature ones were obtained from a coconut plantation at Ikenga in Aguata LGA, Anambra State and taken to Alpha Research Laboratory, Awka, Anambra State, where the mature and immature coconut shells were cracked separately. Their respective water drained directly into a Buchner funnel fitted with a Whatman filter paper (No. 42). The filtrate was collected in

an airtight plastic bottle and stored in the refrigerator at 4 ^{o}C before the analysis.

Proximate Analysis

Ash, moisture, crude fat, crude protein (N × 6.25), crude fibre, and carbohydrate (by difference) were determined by the methods of the Association of Official Analytical Chemists (AOAC) (2010). All proximate analyses of the samples (mature and immature coconut water) were carried out in triplicate and reported in percentages. All chemicals were of analytical grade.

Mineral Analysis

One (1) cm^3 of mature and immature coconut water samples were measured respectively into 10 ml of digestion mixture (Nitric acid, sulphuric acid, perchloric acid in the ratio of 2:2:1). The mixture was heated to dryness. The digest was allowed to cool down to room temperature, and 10 ml of de-ionized water was added. The mixture was filtered using No. 42 Whatman filter paper into a 50 ml volumetric flask and made to mark with de-ionized water. The solution was used for mineral analysis using an Atomic Absorption Spectrophotometer (Biotech Engineering, Phoenix 986- UK). Specific metal standards (Accu Standards, USA) in the linear range of the metal were used to calibrate the equipment. All the minerals determined were reported in mg/100g.

Vitamin Analysis

Vitamins A, C and E were determined according to AOAC (2010) procedure. All vitamin analyses of the samples were carried out in triplicate and reported in percentages. All chemicals were of analytical grade.

RESULTS AND DISCUSSION

Table 1: Proximate composition (%) of mature and immature coconut water

Parameter (%)	Mature coconut water	Immature coconut water

Moisture	94.95 ± 0.04	94.14 ± 0.04
Ash	0.65 ± 0.02	0.81 ± 0.03
Fats/Oil	0.18 ± 0.03	0.13 ± 0.01
Crude fibre	0.00	0.00
Crude protein	0.31 ±0.02	0.57 ± 0.02
Carbohydrate	3.75 ± 0.05	4.51 ± 0.05
Fatty acid	0.14	0.10
Energy (KJ/100g)	75.68	91.17

The fatty acid values were obtained by multiplying the crude fat value of each sample by 0.8 (i.e., crude fat × 0.8). The energy values were calculated by adding the carbohydrate × 17 KJ, crude protein × 17 KJ and crude fat × 37 KJ for mature and immature coconut water.

The proximate composition of mature and immature *Cocos nucefera* water is presented in Table 1. The moisture content of mature and immature *Cocos nucefera* water was 94.95 % and 94.14 %, respectively. These values agree with the moisture content (94.96 %) of coconut water marketed on the streets of Abidjan, as reported by Coulibaly *et al*., (2023). The high moisture level suggests that mature and immature *Coco nucifera* water cultivated in Anambra State, Nigeria, could help improve kidney health (Jiannan and Wang, 2021), and keep one refreshed and hydrated (Coulibaly *et al*., 2023). The ash content (0.81 %) of the immature sample was found to be higher than that of the mature (0.65 %), indicating that the immature sample contained more mineral elements than the mature sample (Ajenu *et al.*, 2021). The crude fat values in mature and immature *Cocos nucifera* water were 0.18 % and 0.13 %, respectively. These values are low when compared to that found in cucumber (0.55 %) (Agatemor *et al.,* 2018) and pawpaw (1.12 %) (Ajenu *et al.,* 2021), but similar to that found in carrot juice (0.2 %) (Ajenu *et al.,* 2021). The samples' crude protein values were 0.31 % and 0.57 % for mature and immature *Cocos nucifera* water. This shows that the immature sample had higher protein

content than the mature sample. The protein content of mature and immature *Cocos nucifera* water is low when compared to that found in *Cocos nucifera* meat (10.22 %) (Abdulhanan *et al.,* 2020), while that of mature coconut water is almost equal to that found in watermelon (0.34 %) (Etejere and Olayinka, 2018). The carbohydrate value of the immature sample was higher than that of the mature sample. The carbohydrate was obtained by the difference between 100 and the summation of other parameters. No crude fibre was found in the mature and immature samples, suggesting that mature and immature *Cocos nucifera* water cannot help maintain gastrointestinal tract health (Aremu *et al.,* 2024). The calculated fatty acids of the mature and immature samples were found to be 0.14 % and 0.10 %, respectively. The metabolizable energy in the immature (91.57 KJ/100g) was higher than that of the mature (75.68 KJ/100g). This implies that consuming immature *Cocos nucifera* water provides more energy than the mature.

Table 2: Mineral composition (mg/100g) of mature and immature coconut water

Mineral (mg/100g)	Mature coconut water	Immature coconut water
Calcium	2.71 ± 0.00	3.05 ± 0.00
Magnesium	0.56 ± 0.05	0.84 ± 0.00
Potassium	28.64 ± 0.00	28.00 ± 0.00
Phosphorus	4.66 ± 0.00	12.10 ± 0.00
Manganese	0.02 ± 0.00	0.01 ± 0.00
Sodium	3.08 ± 0.05	3.75 ± 0.03
Copper	0.12 ± 0.00	0.09 ± 0.00
Zinc	0.02 ± 0.00	0.04 ± 0.00
Iron	0.01 ± 0.00	0.01 ± 0.00
Na/K	0.11	0.13
Ca/P	0.58	0.25

Na/Mg	5.50	4.46

Na/K = Sodium to potassium ratio; Ca/P = Calcium to phosphorus ratio; Na/Mg = Sodium to magnesium ratio.

Table 2 shows the result of the mineral composition of mature and immature *Cocos nucifera* water. Potassium (K) was the most abundant mineral element of all the minerals evaluated, with concentrations of 28.64 mg/100g and 28.00 mg /100g for the mature and immature samples, respectively. This was followed by phosphorus (P) (4.66 mg/100g and 12.10 mg/100g), sodium (Na) (3.08 mg/100g and 3.75 mg/199g) and calcium (Ca) (2.71 mg/100g and 3.05 mg/100g). Magnesium (Mg), manganese (Mn), copper (Cu), zinc (Zn) and iron (Fe) were detected but with concentrations < 1.00 mg/100g in both the mature and immature samples. The concentrations of Ca, Mg, P, Na, and Zn were higher in the immature sample than the mature, while the concentrations of K and Cu were higher in the mature sample than in the immature. The exact concentration of Fe was found in the mature and immature samples. The level of K in mature and immature coconut water is low when compared to that found in fruit juices like watermelon (118.22 mg/100mL), orange (169.20 mg/100mL) and pineapple (120.65 mg/100mL) (Adewoyin *et al.,* 2022). Potassium is an essential constituent of cells and body fluids, which play vital roles in controlling heart rate and blood pressure, while sodium is necessary for osmoregulation (Aremu *et al.,* 2024). The sodium-to-potassium ratio plays a crucial role in regulating blood pressure. The Na/K ratio of mature and immature *Cocos nucifera* water was 0.11 and 0.13, respectively. Regular consumption of mature or immature *Cocos nucifera* water can regulate blood pressure since a Na/K ratio of less than one is recommended for blood pressure regulation, as reported by Aremu *et al.,* (2024). Calcium is an essential mineral required for bone

formation and neurological function of the blood (Amadou *et al.*, 2022). At the same time, phosphorus is crucial for the growth, maintenance and repairs of all tissues and cells and for the production of the genetic building blocks, DNA and RNA (Amadou *et al.*, 2022). Phosphorus is always found with calcium, contributing to blood formation and the body's supportive structure (Aremu *et al.*, 2024). Ca/P may be an important determinant of calcium absorption and retention because of the regulatory mechanisms that control calcium and phosphorus homeostasis within the body (Loughrill *et al.*, 2017). A low Ca/P ratio may adversely affect calcium balance, increasing the risk of bone fracture and osteoporosis (Loughrill *et al.*, 2017). The values of the Ca/P ratio for mature and immature *Cocos nucifera* are below 1. The Na/Mg ratio of mature and immature coconut water was 5.50 and 4.46, respectively. These values are within the optimal value range of 2-6. The values of the studies' Ca/P, Na/K and Na/Mg ratios indicate that mature and immature coconut water could be consumed to improve energy and regulate blood pressure naturally.

Table 3: Mineral safety index (MSI*) of Na, Ca, Mg, Cu, Zn, Fe and P in mature and immature coconut water

Mineral	RAI (mg)	TV of MSI	Calculated value (CV)	
			Mature	Immature
Calcium	1200	10	0.02	0.03
Magnesium	400	15	0.02	0.03
Potassium	Nil	Nil	Nil	Nil
Phosphorus	1200	10	0.04	0.10
Manganese	Nil	Nil	Nil	Nil
Sodium	500	4.8	0.03	0.04

Copper	3	33	1.32	0.99
Zinc	15	33	0.04	0.09
Iron	15	6.7	0.01	0.01

RAI = Recommended Adult intake; TV = Table value (Standard mineral safety index); * No standard MSI for potassium and manganese

The mineral safety index (MSI) values of mature and immature *Cocos nucifera* water are shown in Table 3. The standard MSI for the elements are Ca (10), Mg (15), P (10), Na (4.8), Cu (33), Zn (33) and Fe (6.7) (Jonathan *et al.*, 2019). The MSI values of all the minerals in mature and immature *Cocos nucifera* water were more significant than the calculated value. This indicates that none of the minerals in the samples were high enough to cause harm when consumed.

Table 4: Vitamin concentrations (mg/100g) of mature and immature *Coco nucefera*

Vitamins (mg/100g)	Mature Coco nucefera	Immature Coco nucefera
Vitamin C	7.46	6.82
Vitamin E	3.65	1.64
Vitamin A	1.3×10^{-4}	4.4×10^{-4}

Table 4 presents the concentrations of vitamins (C, E and A) in mature and immature *Cocos nucifera* water. The result showed that the concentration of vitamin C in mature and immature coconut water was 7.46 mg/100g and 6.82 mg/100g, respectively. The level of vitamin C in the samples is low when compared to that found in cucumber (143.36 mg/100g), watermelon (72.90 mg/100g) and pawpaw (60.3 mg/100g), as reported by Omoniyi and Alli (2021), but high when compared to that found in turmeric (1.7 mg/100g) (Ajenu *et al.,* 2021). Vitamin E in mature coconut water (3.65 mg/100g) was higher than in the immature (1.64 mg/100g). The vitamin E content in the samples is higher than that found in cucumber (0.075 mg/100g) and watermelon

(2.00 mg/100g) (Ajenu *et al.*, 2021). Vitamins C and E are antioxidant nutrients that defend the body against free radical damage, and free radical damage is one of the causes of diseases such as cancer, cardiovascular, neurological, pulmonary, rheumatoid arthritis, and nephropathy (Ajenu *et al.*, 2021). The concentration of vitamins C and E in the samples suggests that they have antioxidant properties, and their intake may defend the body against harmful diseases caused by free radicals. Vitamin A was 0.00013 mg/100g and 0.00044 mg/100g for the mature and immature samples. These values are low when compared to those found in watermelon (90.98 mg/100g) and cucumber (26.48 mg/100g) (Ajenu *et al.*, 2021). The vitamin A content in the samples analyzed does not meet the dietary allowance of 0.7 to 0.9 mg for adults and 0.3 to 0.4 mg/day for children (Alli and Omoniy, 2021). Vitamin A is needed for eye health, and its amount in coconut water requires supplementation.

CONCLUSION

The proximate analysis showed that mature *Cocos nucifera* water had a higher moisture concentration, ash, crude fat, and fatty acid concentration. In contrast, the crude protein, carbohydrate, and energy contents were higher in immature *Cocos nucifera* water. No crude fibre was present in both the mature and immature samples. The mineral analysis revealed that concentrations of Ca, Mg, P, K, and Na were higher in the immature sample. The Cu, Zn, Fe, and Mn content ranged between 0.01 to 0.12 mg/100g in both the mature and immature samples. Vitamins C and E were higher in the mature sample, while vitamin A was higher in the immature sample. Vitamins C and E in mature and immature *Cocos nucifera* water were within the recommended dietary allowances except for vitamin A. The Na/K ratio indicates that regular mature or immature coconut water

consumption may regulate blood pressure. Mature and immature *Cocos nucifera* water are good sources of nutrients, mineral elements, vitamins C and E.

RECOMMENDATIONS

The present study focused on mature and immature coconut water's nutritional, mineral, and vitamin compositions in Anambra State, Nigeria. Further studies should be conducted on the anti-nutritional and antioxidant capacity of coconut (*Cocos nucifera*) water and meat.

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