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Health Benefits of Nutritional Composition of Cocoyam (*Colocasia esculanta*) Tuber and Leaves: A Comparative Study

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Abstract: This study investigated the proximate composition, phytochemical content, and amino acid profiles of cocoyam (*Colocasia esculenta*) tuber and leaves. Proximate analysis revealed that the samples contained 16.63% crude protein, 3.19% fat, 8.38% ash, 6.37% crude fiber, 6.51% moisture, and 58.94% carbohydrate on average. Phytochemical screening identified the presence of oxalates, saponins, alkaloids, flavonoids, tannins, and cyanide in varying concentrations. Amino acid profiling showed that the samples contained all essential amino acids with leucine (6.99%), lysine (4.46%), and isoleucine (4.21%) being the most abundant. Glutamic acid (10.29%) and aspartic acid (8.87%) were the predominant non-essential amino acids. The total amino acid content ranged from 54.84 to 74.85 g/100g protein. Essential amino acid scores indicated that most amino acids met or exceeded FAO/WHO reference values, with phenylalanine + tyrosine having the highest score. The study reveals that cocoyam tubers are excellent sources of energy, while the leaves are significantly higher in protein and essential amino acids than other widely consumed leaves,highlighting its potential as some nutrient-dense food source rich in essential amino acids and carbohydrates.

Keywords: Amino acid composition, nutritional value, phytochemical properties, cocoyam (*Colocasia esculenta*)

Introduction

Cocoyam (*C. esculenta* L.) is a tuberous root crop belonging to the aroid family (*Araceae*). This herbaceous monocotyledonous plant is characterized by its underground stem (corm), net-veined, palmately divided broad leaves with long petioles, spadix inflorescence, and a superficial but fibrous root system [1]. Cocoyam is a significant staple food with substantial nutritional and economic importance in tropical and subtropical regions of Pacific Islands, Asia and Africa [2].

There are many varieties of cocoyam, but the most important ones are the *Colocasiaesculenta* (taro) and the *Xanthosomasagittifolium* (tannia) [3]. These species have gained prominence in global agriculture, with taro ranking as the fifth most harvested root crop worldwide. Cocoyam cultivation has persisted for an extended period, meeting the nutritional needs of approximately 400 million people worldwide, particularly in developing countries across Asia, the Pacific Islands, and West Africa [4].

Taro is commonly produced in Africa by smallholder, resource-limited and mostly female farmers. Africa has consistently dominated global taro production, contributing over 70% of the world's output for the past two decades. In 2019, Africa's share stood at 72.27% (7.6 million tonnes) of total global production, despite a slight decline from 76% in 2000. Taro ranks third in importance among root and tuber crops in most African countries, following cassava and yam [2].

Nigeria is the largest producer of cocoyam in the world, accounting for about 31.04% of total world output [5;6]. Nigeria leads global cocoyam production, contributing approximately 5.49 million metric tonnes annually, representing 45.9% of global output and 72.2% of West African production [7, 8]. The significance of cocoyam extends beyond mere production figures. It plays a vital role in food security, particularly for smallholder, resource-limited farmers, many of whom are women. Expansion in cocoyam production has the potential of bridging the widening demand and supply gap for the product and enhancing the income generating activities and standard of living of the rural farmers' families, predominantly the susceptible group [9].

Despite the recognized nutritional benefits of cocoyam as food in tropical regions, there is a significant gap in understanding its proximate, phytochemical, and amino acid compositions, which can limit the potential for cocoyam to be effectively utilized in addressing malnutrition and food insecurity, particularly in developing countries (Africa) where it is cultivated. Additionally, the presence of antinutritional factors such as oxalates and phytates poses challenges to its consumption and nutritional efficacy. Therefore, this research aims to systematically analyze the proximate, phytochemical, and amino acid compositions of cocoyam tubers and leaves, providing critical insights that could enhance its utilization in food products and contribute to improved dietary practices among vulnerable populations.

Materials and Methods

Collection of the samples

Preparation of the samples

The samples were gotten from Otukpo modern market, Benue state. The cocoyam tuber and leaves were cut to smaller pieces and dried in an oven at Muhammadu Buhari Technical Centre for Excellence, Federal University of Lafia, Nasarawa State, Nigeria. It was dried for a six-day period at 110 ℃. They were ground into fine powder using an electric blender and stored in a refrigerator until use.

Proximate composition

The moisture, ash, crude protein (N x 6.25), crude fat, crude fibre and carbohydrate (by difference) were determined in accordance with the standard methods [10]. All proximate analyses of the sample flours were carried out in triplicate and reported in %. All chemicals were of Analar grade. All results were on dry weight (*dw*) basis.

Anti–nutritient content determination

The contents of oxalate, saponins, alkaloids, flavonoids, tannins, cyanide, phytate, and total phenols were determined on each of the sample flours by methods described by standard method [11].

Amino acid analysis

The amino acid analysis was by Ion Exchange Chromatography (IEC) [12], using the Technico Sequential Multisample (TSM) Amino Acid Analyzer (Technicon Instruments Corporation, New York). The period of analysis was 76 min for each sample. The gas flow rate was 0.50 mL min^{-}1 at 60^{o}C with reproducibility consistent within ± 3%. The net height of each peak produced by the chart recorder of the TSM (each representing an amino acid) was measured and calculated. Amino acid values reported were the averages of two determinations. Nor–leucine was the internal standard. Tryptophan was determined after alkali (NaOH) hydrolysis by the colorimetric method.

Determination of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P–PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo [13]:

$$plm = \sum_{i=1}^{n=1} pliXi \quad --------(1)$$

Where:

pIm = the isoelectric point of the mixture of amino acids; *Xi* = the mass or mole fraction of the amino acids in the mixture; *pIi* = the isoelectric point of the *i*th amino acids in the mixture;

The quality of dietary protein was measured by finding the ratio of available amino acids in the sample protein compared with the needs expressed as a ratio. Amino acid score (AAS) was then estimated by applying the formula [14]:

$$AAS = \frac{mg\ of\ amino\ acid\ in\ 1g\ of\ test\ protein}{mg\ of\ amino\ acid\ in\ reference\ protein} \times \frac{100}{1} \quad ----- (2)$$

The predicted protein efficiency ratio (P–PER) of the seed sample was calculated from their amino acid composition based on the equation developed by Alsmeyer *et al.* [15] as stated thus;

P–PER = –0.468 + 0.454 (Leu) – 0.105 (Tyr) - - - - - - - - - - - - - - - - - - - (3)

Statistical analysis of the samples

The energy values were calculated by adding up the carbohydrate x 17 kJ, crude protein x 17 kJ and crude fat x 37 kJ for each of the samples. The fatty acid values were obtained by multiplying crude fat value of each sample with a factor of 0.8 (i.e. crude fat x 0.8 = corresponding to fatty acids value. Errors of three determinations were computed as standard deviation (SD) for the proximate composition. Standard deviation and percentage of coefficient of variation for they samples were also determined.

Results and Discussion

Proximate composition of cocoyam tuber and leaves

The proximate analysis of cocoyam tubers and leaves revealed significant differences in crude protein content. Cocoyam tubers contained 8.38% crude protein, while leaves had a much higher content of 24.87%, indicating that cocoyam leaves offer three times the protein content of the tubers (Table 1). This finding underscores the potential of cocoyam leaves as a valuable dietary supplement for plant-based diets.

Comparatively, the protein content in the tubers and leaves of cocoyam from this study was higher than values reported for related studies by some researchers [16, 17, 18]. For example, Adeyanju *et al.* found 1.8% protein in taro tubers and 20.2% in taro leaves, while Wada *et al.* recorded 10.10% protein for purple cocoyam tubers. These variations highlight the nutritional potential of cocoyam cultivated in the North Central region of Nigeria, particularly Benue State, where protein levels are notably higher compared to samples from the South-South region. The study also noted that fermentation can elevate protein levels, as reported by Igbabul *et al.* [19], with protein content rising from 15.61 to 18.75% over time. Moreover, the higher protein levels in cocoyam leaves compared to tubers indicate that integrating the leaves into diets may substantially enhance protein intake, benefiting populations that depend heavily on plant-based nutrition. This study found fat contents of 3.77% in cocoyam tubers and 2.61% in leaves, higher than previously reported values from other regions. Compared to findings by some researchers [16, 17], which recorded fat levels below 1%, the results here highlight a superior fat profile for cocoyam in North Central Nigeria. Processing methods like fermentation were noted to increase fat content, as observed by Igbabul *et al.* [19]. These findings suggest that cocoyam cultivated in Benue offers better nutritional potential than samples from other regions. This study found ash content values of 14.22% for cocoyam tubers and 2.53% for leaves, with a mean of 8.38%. The high tuber ash content suggests a rich mineral profile, potentially beneficial for preventing mineral deficiency diseases such as anemia and goiter. These values are notably higher than those reported by Wada *et al.* [17], Awa and Eleazu [20], who found tuber ash contents of 3.25% and 1.7%, respectively. The findings indicate regional variations, with cocoyam from North Central Nigeria (Benue) showing higher ash content compared to the South-South region (Niger Delta). Fermentation was observed to reduce ash content, as noted by Igbabul *et al.* [19], where values decreased from 4.82 to 1.92%. Despite these variations, the high tuber ash content emphasizes the potential of cocoyam as a mineral-rich food source.This study found crude fiber contents of 9.36% for cocoyam tubers and 3.38% for leaves, with a mean of 6.37%. These values are significantly higher than those reported by Wada *et al.* [17] and Adeyanju *et al.* [15], where tuber fiber levels ranged from 1.0 to 2.14%. The high fiber content, particularly in tubers, suggests potential benefits for digestive health and protection against conditions such as constipation and colon diseases. Fermentation was noted to reduce fiber content, as reported by Igbabul *et al.* [19], where crude fiber levels decreased from 0.73 to 0.19%. The breakdown of cellulosic materials during fermentation, as highlighted by Gowthamraj *et al.* [21], contributes to this decline. Despite regional and processing variations, the results underscore cocoyam's potential role as a dietary fiber source for improved digestion and disease prevention.

This study found moisture content of 6.21% for cocoyam tubers and 6.81% for leaves, significantly lower than the 61.91% and 63.53% reported by Wada *et al.* [17] for fresh varieties. The results align with values typical of dried cocoyam products, indicating better storage potential and reduced spoilage risk. Fermentation further lowers moisture content, as noted by Igbabul *et al.* [19]. These findings suggest that low moisture levels in cocoyam products enhance shelf stability. This study found carbohydrate contents of 58.07% for cocoyam tubers and 59.81% for leaves, with a mean of 58.94%. These values are significantly higher than Adeyanju *et al.* [16], who reported 23% for taro corms and 21% for leaves. Wada *et al.* (2019) found carbohydrate levels of 85.36% for green cocoyam and 84.76% for purple varieties, which are higher than our findings but consistent with Bradbury & Holloway [22], who reported values ranging from 70-88%. Onyeike *et al.* [23] observed higher carbohydrate content in raw cocoyam compared to heat-processed samples. Fermentation has been linked to an increase in carbohydrate levels, as noted by Igbabul *et al.* [19]. The high carbohydrate content found here underscores cocoyam's significance as an energy-dense staple food and highlights its nutritional and economic importance in regions where it is consumed.

Table 1: Proximate composition of cocoyam and leaves

Parameter (%)	Sample I	Sample J	Mean	SD	CV%
Crude protein	8.38	24.87	16.63	11.66	70.10
Fat	3.77	2.61	3.19	0.82	25.71
Ash	14.22	2.53	8.38	8.27	98.70
Crude Fibre	9.36	3.38	6.37	4.23	66.38
Moisture	6.21	6.81	6.51	0.42	6.52
Carbohydrate	58.07	59.81	58.94	1.23	2.09

Sample I: Cocoyam tuber, **Sample J:** Cocoyam Leaves

Table 2: Anti-nutritive composition of cocoyam tubers and leaves

Parameter (%)	Sample I	Sample J	Mean	SD	CV%
Oxalate	11.54	0.88	6.21	7.54	121.38
Saponins	0.41	0.54	0.48	0.09	19.35
Alkaloids	5.69	6.02	5.86	0.23	3.98
Flavonoids	9.5	4.08	6.79	3.83	56.44
Tannins	6.55	1.02	3.79	3.91	103.29
Cyanide	0.49	1.11	0.8	0.44	54.80

Sample I: Cocoyam tubers, **Sample J:** Cocoyam Leaves

Anti-nutritive composition

This study found a mean oxalate concentration of 6.21%, with cocoyam tubers containing a significantly higher level (11.54%) compared to leaves (0.88%) as shown in Table 2. These findings contrast with higher values reported by Olatunde *et al.* [24] and Adane *et al.* [25], who noted oxalate levels up to 243.06% in raw taro. Variations in oxalate levels may result from differences in plant parts, species, and growth conditions [26]. Processing methods like fermentation have been shown to reduce oxalate content, as indicated by Igbabul *et al.* [19]. The moderate oxalate levels found in this study suggest a nutritional advantage, as high oxalate concentrations are linked to kidney stone formation and calcium deficiency-related issues 27; 28]. The lower oxalate levels in leaves particularly highlight their potential as a safer dietary component. This study observed a mean saponin concentration of 0.48%, with tubers containing 0.41% and leaves 0.54%, indicating similar bioactive potential across samples. The low coefficient of variation (19.15%) suggests limited variability between samples. Compared to this study, Olatunde *et al.* [24] reported higher saponin levels in both southern Nigeria and eastern Uganda, while Enechi *et al.* [28] noted a significantly higher content of 9.94%. Saponins are valued for health benefits, including cholesterol-lowering, antioxidant, and anticancer properties [29]. However, high concentrations may cause bitterness and digestive discomfort. Igbabul *et al.* [19] demonstrated that fermentation reduced saponin levels from 0.63% to 0.13%, highlighting the potential of processing to improve cocoyam product taste and digestibility. Variations in saponin content may arise due to plant variety or environmental conditions. The study found that the alkaloid content in cocoyam tubers (5.69%) and leaves (6.02%) averaged 5.86%, with minimal variation (coefficient of variation: 3.98%), suggesting consistency in alkaloid levels between the samples. This contrasts sharply with Okechukwu & Ogah [30] who reported much higher alkaloid content (32.87%) in fresh cocoyam inflorescence. Alkaloids, known for their medicinal properties such as anti-inflammatory and antimicrobial effects, also serve as plant defense mechanisms. However, excessive consumption (above 20 mg) can be toxic. Fermentation significantly reduces alkaloid content (from 0.11% to 0.03%), enhancing safety and palatability. Other studies show variations in alkaloid levels, with Awa & Eleazu [20] reporting lower values (3.68%) and Enechi *et al.* [28] higher (6.62 ± 0.03). Despite these differences, both fresh and processed cocoyam samples are deemed safe for consumption. The mean flavonoid concentration is 6.79 %, with a high coefficient of variation (56.44%). Cocoyam tubers contain more flavonoids (9.5 %) compared to Cocoyam leaves (4.08 %). Awa & Eleazu [20] reported crude protein content for raw cocoyam tuber to be 0.88 which is less than that conducted in this study. Flavonoids are known for their antioxidant properties and role in reducing oxidative stress, which is linked to chronic diseases such as cardiovascular disease and cancer [31]. The observed variation could be due to differences in plant part, harvesting time, or environmental factors, which are known to affect flavonoid concentrations [32].

The study found a mean tannin concentration of 3.79%, with higher levels in tubers (6.55%) than leaves (1.02%), leading to significant variability (103.17%) as shown in Table 2. Tannins offer antimicrobial and antioxidant benefits but may hinder nutrient absorption. Comparisons with previous studies show varied tannin levels, with some reporting lower (0.02%–0.90%) and others higher (7.38%). Processing methods like boiling and fermentation reduce tannin content, improving digestibility. The findings highlight the stronger functional potential of cocoyam tubers due to their higher tannin content. The study found a mean cyanide content of 0.80%, with higher levels in leaves (1.11%) than tubers (0.49%) and moderate variability (54.80%). Cyanogenic glycosides in plants can release toxic cyanide, though small amounts are usually detoxified in the body. Fermentation significantly reduces cyanide levels, enhancing food safety. Chronic exposure has been linked to neurological disorders, while acute toxicity inhibits energy production, affecting the brain and heart. The findings highlight the importance of proper processing to minimize cyanide risks in cocoyam consumption.

Amino acids profile

Table 3 shows the amino acid profile of cocoyam tuber and leaves**.** Leucine, an essential amino acid crucial for muscle synthesis, was higher in leaves (7.61 g) than tubers (6.36 g), with a mean of 6.99 g and low variability (CV%: 12.64%). This aligns with findings by Temesgen *et al.* [33], who reported leucine concentrations between 6.54 and 9.78 g/100g in taro samples. The results confirm that cocoyam leaves provide a superior source of leucine, supporting metabolic health, muscle growth, and endurance [34-36]. Cocoyam leaves contained higher lysine levels (5.57%) than tubers (3.34%), with significant variability (CV%: 35.36%), making them a superior source of this essential amino acid. Lysine is crucial for collagen formation, immune function, and calcium absorption. These findings align with Temesgen *et al.* [33], who reported higher lysine concentrations in taro leaves (4.54–7.64 g/100g), reinforcing the nutritional advantage of leafy parts. Given that lysine is often a limiting amino acid in plant-based diets [37], cocoyam leaves may help improve protein quality and address amino acid deficiencies in such diets. Cocoyam tubers contained higher isoleucine levels (4.49%) than leaves (3.93%), with a mean of 4.21% and low variability (CV%: 9.41%). This trend aligns with Temesgen *et al.* [33], who found that taro leaves generally had lower isoleucine levels than tubers. Isoleucine is essential for muscle metabolism, immune function, and energy regulation [38]. The higher isoleucine content in tubers enhances their dietary value, particularly for individuals seeking to increase essential amino acid intake through plant-based diets, reinforcing the nutritional significance of cocoyam and taro. Cocoyam leaves contained higher phenylalanine levels (5.23%) than tubers (3.99%), with a mean of 4.61% and moderate variability (CV%: 19.02%). Phenylalanine is essential for protein synthesis and serves as a precursor for tyrosine [39]. The elevated phenylalanine levels in leaves highlight their nutritional value, particularly in plant-based diets where essential amino acids may be limited. These findings align with Temesgen *et al.* [33], who reported higher essential amino acid concentrations in taro leaves than in corms. The results emphasize the importance of selecting plant parts for optimal nutritional benefits. The analysis of tryptophan content in our cocoyam samples indicates a mean concentration of 1.09 g, with specific values of 1.21 g in tubers and 0.97 g in leaves, resulting in a standard deviation of 0.17 and a coefficient of variation (CV%) of 15.57%. This variability suggests that while tubers contain a slightly higher concentration of tryptophan compared to leaves, both plant parts contribute valuable amounts of this essential amino acid. Tryptophan is particularly important as it serves as a precursor for serotonin, a neurotransmitter that plays a crucial role in mood regulation, sleep, and appetite [40]. While the tubers show a higher concentration, the presence of tryptophan in leaves still contributes to the overall amino acid profile, suggesting that both parts of the plant can be utilized to enhance dietary intake of this important nutrient.The analysis of valine content in our cocoyam samples reveals a mean concentration of 4.40 g, with specific values of 3.89 g in tubers and 4.91 g in leaves, resulting in a standard deviation of 0.72 and a coefficient of variation (CV%) of 16.39%. This variability indicates that while both plant parts provide valine, the leaves contain a higher concentration compared to the tubers. Valine is an essential branched-chain amino acid (BCAA) that plays a critical role in muscle metabolism, tissue repair, and energy production. The findings align with the results reported by Temesgen *et al.* [33], who also observed higher levels of essential amino acids in taro leaves compared to corm samples. The higher concentration of valine in cocoyam leaves emphasizes their nutritional value, particularly for individuals seeking to enhance their protein intake through plant-based sources.

The analysis of methionine content in our cocoyam samples reveals a mean concentration of 1.25 g, with specific values of 1.26 g in tubers and 1.23 g in leaves, resulting in a low standard deviation of 0.02 and a coefficient of variation (CV%) of 1.70%. This minimal variability indicates that the methionine content is relatively consistent across both plant parts, suggesting that both cocoyam tubers and leaves provide a stable source of this essential amino acid. Methionine is critical for various biological functions, including protein synthesis, methylation reactions, and as a precursor for other important biomolecules such as cysteine and taurine. In comparison, Temesgen *et al.* [33] reported lower methionine concentrations in taro samples, emphasizing the nutritional advantage of cocoyam as a source of this amino acid. The analysis of proline content in our cocoyam samples indicates a mean concentration of 3.55 g, with specific values of 3.45 g in tubers and 3.65 g in leaves, resulting in a standard deviation of 0.14 and a coefficient of variation (CV%) of 3.98%. This low CV% suggests that the proline content is relatively consistent across both plant parts, indicating that both cocoyam tubers and leaves provide a stable source of this amino acid. Proline is classified as a non-essential amino acid that plays a crucial role in protein synthesis, cellular hydration, and as a precursor for other amino acids, contributing to overall metabolic health [41]. The mean concentration of arginine was found to be 5.72 g, with tubers containing 4.99 g and leaves showing a higher concentration of 6.45 g. This results in a standard deviation of 1.03 and a CV% of 18.05%, indicating notable variability between the two plant parts. Arginine plays a vital role in protein synthesis and is essential for various metabolic processes. The mean tyrosine concentration was measured at 3.36 g, with tubers at 3.10 g and leaves at 3.61 g. The standard deviation of 0.36 and CV% of 10.75% suggest moderate variability, with leaves providing a slightly higher content. Tyrosine is crucial for the synthesis of neurotransmitters and hormones. Higher tyrosine levels in cocoyam leaves could support better cognitive function and stress resilience, as suggested by Fernstrom [42]. The mean concentration for histidine was recorded at 2.73 g, with tubers at 2.30 g and leaves at 3.16 g, resulting in a standard deviation of 0.61 and a CV% of 22.28%. This variability underscores the importance of selecting the appropriate plant part for optimal histidine intake, which is essential for growth and tissue repair. Histidine is important for the synthesis of red and white blood cells. It is a precursor for histamine which is good for sexual arousal and improved blood flow [43-44]. High dosage of histidine however increases stress and anxiety [45]. Cystine levels averaged 1.33 g across samples, with tubers at 1.21 g and leaves at 1.45 g, leading to a standard deviation of 0.17 and a CV% of 12.76%. Cystine is important for maintaining protein structure through disulfide bonds. Cystine, a sulfur-containing amino acid, is important for antioxidant function. Both samples provide adequate cystine levels for supporting antioxidant defenses [47]. The mean alanine concentration was found to be 4.52 g, with tubers at 5.01 g and leaves at 4.02 g, resulting in a standard deviation of 0.70 and a CV% of 15.50%. The higher alanine content in tubers suggests their potential as a source of this amino acid. %. Alanine is involved in glucose metabolism and energy production. Both samples offer sufficient levels of alanine to support metabolic health. Glutamic acid, with an average concentration of 10.29 g (8.93 g in tubers and 11.65 g in leaves), is the most abundant non-essential amino acid in cocoyam, showing notable variability (CV% = 18.69%). It plays a crucial role in neurotransmission and metabolism, aligning with findings by Aremu *et al.* [36]. While the body typically synthesizes non-essential amino acids, certain conditions may render them 'conditionally essential,' necessitating dietary intake. This underscores the importance of a varied diet rich in plant-based amino acids to support overall metabolic health [35-36].

The analysis of glycine content in cocoyam reveals a mean value of 3.71 g, with tubers containing 3.37 g and leaves containing 4.04 g (SD = 0.47; CV% = 12.75%). This amino acid plays a crucial role in various physiological processes, including collagen synthesis, metabolic regulation, anti-oxidative reactions, neurological function, and detoxification [47-48]. The presence of glycine in cocoyam suggests potential health benefits, such as tissue injury prevention, enhanced anti-oxidative capacity, promotion of protein synthesis and wound healing, improved immunity, and possible therapeutic applications in conditions like obesity, diabetes, cardiovascular disease, and inflammatory disorders [48]. These findings highlight the nutritional value of cocoyam, particularly its leaves serving as the highest source of glycine. Threonine levels were consistent across samples with a mean of 3.35 g (tubers = 3.36 g; leaves = 3.33 g), resulting in a very low standard deviation of 0.02 and CV% of only 0.63%. This consistency indicates reliable threonine content across both plant parts. Threonine is essential for protein synthesis, particularly in the formation of elastin and collagen [49]. Both samples offer adequate levels to support overall protein synthesis. The average concentration for serine was found to be 3.79 g (tubers = 3.76 g; leaves = 3.81 g), with a low standard deviation of 0.04 and CV% of 0.93%, indicating minimal variability. Serine is important for cell membrane formation and cognitive function [50]. The consistency between the samples suggests that both provide similar nutritional value in terms of serine. Aspartic acid showed an average concentration of 8.87 g (tubers = 7.72 g; leaves = 10.01 g), with a standard deviation of 1.62 and CV% of 18.28% (Table 3). This variability highlights the importance of plant part selection for maximizing aspartic acid intake. Aspartic acid, involved in hormone production and neural function, may offer better support for these functions [51].

Table 3: Amino acid profile of cocoyam tuber and leaves

Parameter (%)	Sample I	Sample J	Mean	SD	CV%
Leucine[e]	6.36	7.61	6.99	0.88	12.65
Lysine[e]	3.34	5.57	4.46	1.58	35.39
Isoleucine[e]	4.49	3.93	4.21	0.4	9.41
Phenylalanine[e]	3.99	5.23	4.61	0.88	19.02
Trytophan[e]	1.21	0.97	1.09	0.17	15.57
Valine[e]	3.89	4.91	4.40	0.72	16.39
Methionine[e]	1.26	1.23	1.25	0.02	1.70
Proline	3.45	3.65	3.55	0.14	3.98
Arginine	4.99	6.45	5.72	1.03	18.05
Tryosine	3.10	3.61	3.36	0.36	10.75
Histidine[e]	2.30	3.16	2.73	0.61	22.28
Cystine	1.21	1.45	1.33	0.17	12.76
Alanine	5.01	4.02	4.52	0.7	15.50
Glutamic Acid	8.93	11.65	10.29	1.92	18.69
Glycine	3.37	4.04	3.71	0.47	12.75
Threonine[e]	3.36	3.33	3.35	0.02	0.63
Serine	3.76	3.81	3.79	0.04	0.93
Aspartic Acid	7.72	10.01	8.87	1.62	18.28

e = Essential Amino Acids

Table 4: Concentrations of essential, non-essential, acidic, neutral, sulphur, aromatic etc. of cocoyam and leaves

Parameter (%)	Sample I	Sample J	Mean	SD	CV%
TAA	74.85	54.84	64.85	14.15	21.82
TNEAA	45.53	28.37	36.95	12.13	32.84
% TNEAA	60.83	51.73	56.28	6.43	11.43
TEAA					
*With His	29.32	26.47	27.90	2.02	7.22
*Without His	27.02	23.31	25.17	2.62	10.42
% TEAA					
*With His	39.17	48.27	43.72	6.43	14.72
Without His	36.10	42.51	39.31	4.53	11.53
EAAA	16.46	14.93	15.70	1.08	6.89
EarAA	4.17	3.37	3.77	0.57	15.00
TNAA	62.28	42.81	52.55	13.77	26.20
% TNAA	83.21	78.06	80.64	3.64	4.52
TAAA	19.34	11.10	15.22	5.83	38.28
% TAAA	25.84	20.24	23.04	3.96	17.19
TBAA	12.57	9.42	11.00	2.23	20.26
TSAA	2.58	2.01	2.30	0.4	17.56
% Cystine in TSAA	49.22	60.20	54.71	7.76	14.19

TAA = Total Amino Acid, TNEAA = Total Non-Essential Amino Acid, TEAA = Total Essential Amino Acid, EAAA = Essential Aliphatic Amino Acid, EarAA = Essential Aromatic Amino Acid, TNAA = Total Neutral Amino Acid, TAAA = Total Acidic Amino Acid, TBAA = Total Basic Amino Acid, TSAA = Total Sulphur Amino Acid, Sample I: Cocoyam tubers, Sample J: Cocoyam Leaves

Table 4 shows the Concentrations of Essential, Non-essential, Acidic, Neutral, Sulphur, Aromatic Etc. of cocoyam and leaves.Cocoyam tubers have a higher Total Amino Acid (TAA) content (74.85%) than leaves (54.84%) and contain more Total Non-Essential (TNEAA) and Essential Amino Acids (TEAA), with low variability [52]. Total Neutral (TNAA) and Acidic Amino Acids (TAAA) are significantly higher in tubers, aiding protein digestibility and energy metabolism [51- 53]. While sulfur amino acids (TSAA) are slightly higher in tubers, cystine–important for antioxidant defense–is more abundant in leaves. Overall, tubers provide higher amino acid content, whereas leaves may offer better antioxidant benefits.

Table 5: Amino acids scores of cocoyam tubers and leaves

EAA	PAAESP (g/100 g protein)	SAMPLE I		SAMPLE J	
		EAAC	EAAS	EAAC	EAAS
Isoleucine	4.0	4.49	1.12	3.93	0.98
Leucine	7.0	6.36	0.91	7.61	1.09
Lysine	5.5	3.34	0.61	5.57	1.01
Methionine + Cystine (TSAA)	3.5	2.47	0.71	2.68	0.77
Phenylalanine + Tyrosine	6.0	7.09	1.18	8.84	1.47
Threonine	4.0	3.36	0.84	3.33	0.83
Tryptophan	1.0	1.21	1.21	0.97	0.97
Valine	5.0	3.89	0.78	4.91	0.98
Total	**36.0**	**32.21**	**7.36**	**37.84**	**8.1**

PAAESP = Provisional Amino Acid (Egg) Scoring Pattern, EAAC = Essential Amino Acids Composition, EAAs = Essential Amino Acid Score

The essential amino acid (EAA) content in cocoyam is generally lower than FAO/WHO [14] recommendations, except for the EAAC of both tubers and leaves, which meet the required levels for leucine and phenylalanine + tyrosine. This suggests cocoyam can supplement diets lacking essential amino acids [50]. Tryptophan is the limiting amino acid in both tubers and leaves, which may restrict protein synthesis in plant-based diets. Understanding amino acid requirements across life stages is crucial for optimizing plant-based nutrition [54]. However, phenylalanine and leucine in cocoyam have a high essential amino acid score, indicating good biological value [55].

Conclusion

In conclusion, this study on the proximate, phytochemical, and amino acid compositions of *C. esculenta* tuber and leaves has revealed its significant nutritional value and potential as an important food source. The research highlights cocoyam's rich content of carbohydrates, proteins, fiber, vitamins, and minerals, positioning it as a valuable crop for addressing malnutrition and promoting health. The findings emphasize the importance of encouraging cocoyam production and consumption nationally, not only to diversify dietary options but also to provide additional income sources for farmers and vendors. Furthermore, proper cultivation practices, such as using balanced fertilizers and organic manure, to enhance the crop's nutritional quality are needed. This research provides valuable data for nutritionists, healthcare providers, and policymakers, potentially influencing future dietary recommendations and agricultural strategies aimed at improving public health and food security.

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