

Research Article

Advance Research on Nutraceutical Composition of Mature Jute Leaves

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Abstract: This study investigated the effect of plant age on the nutrients of jute leaves [*Corchorus capsularis* (CVL-1)]. Jute seeds were sown on Jute Seed Production and Research Centre, Bangladesh Jute Research Institute (BJRI), Nashipur, Dinajpur, Bangladesh, an experimental field and the leaves were harvested on three day basis interval from the 15th day to 33th day after seed sowing (DASS) when senescence has started setting in. The moisture, protein, fat, crude fibre and ash of the plant leaves were determined using AOAC standard methods. The results obtained showed high moisture content which decreased from the 15th day after seed sowing (DASS) till the 33th DASS (82.46%-48.58%), the minimum value for ash (7.84%) was observed at 18th DASS while the maximum value 14.35% was observed at the 33th DASS. The crude protein content increased from 15th DASS (19.01%) till 24th DASS (26.46%) and reduced till final harvesting at 33th DASS (16.65%), fat content ranges from 1.54%-2.95%, fibre content increased from the 15th DASS till 33th DASS. On the other hand, the energy value of mature (DASS) 100 g dried leaf was 111 KJ. The study indicated that as the leaf matures the nutritional quality increases and the optimum value for crude protein was observed at 24th DASS. It also contain relatively high levels of phytochemical components, the processing and preparation methods prior to consumption reduce their final consumed nutraceutical amount.

Keywords: *Corchorus capsularis*, leaf maturity, nutraceutical, energy value.

Introduction

Jute plant (*Corchorus sp.*) is an erect woody herb growing up to 2.5 meters high. It belongs to the family *Tiliaceae* and is originally from Asia although Africa is currently the primary centre of its diversity. Jute is cultivated to provide bark for the production of fibres. Its mucilaginous leaves are used in food as a vegetable. It is grown for both fibre and culinary purposes [1]. It is a popular vegetable in West Africa and usually recommended for pregnant women and nursing mothers because they are believed to be rich in iron [2].

The two species used as a vegetable are *Corchorus capsularis* and *C. olitorius*. *Corchorus olitorius* is the most frequently cultivated [3] and is widely consumed by various communities.

The leaves are believed to be rich in vitamins and micronutrients. The plant exhibits antioxidant activity with a significant α -tocopherol equivalent Vitamin E.

The stems are harvested when the plant is in flower and are then retted (allowed to begin to rot) so that the fiber can be extracted. While perhaps better known as a fiber crop, jute is also a medicinal vegetable. Its bark and root have medicinal properties. In folk medicine, it is reported to be demulcent, deobstruent, diuretic, lactagogue, purgative, and tonic. It is a folk remedy for aches and pains, dysentery, enteritis, fever, dysentery, pectoral pains and tumors [4].

The nutritional chemicals of each 100g of the fresh leaves contained 43-58 calories, 4.5-5.6g protein, 0.3g fat, 7.6-12.4g total carbohydrate, 80.4-84.1g water, 1.7-2.0g fibre, 2.4g ash, 266-366mg Ca, 97-122mg P, 7.2-7.7mg Fe, 12mg Na, 444mg K, 6,410-7,850 µg beta carotene equivalent, 0.13-0.15mg thiamine (Vitamin B₁), 0.26-0.53 mg riboflavin (Vitamin B₂), 1.1-1.2 mg niacin and 53-80 mg ascorbic acid (Vitamin C) [1, 5, 6]. Folic acid (folate, B vitamin) substantially higher (0.03mg/L) than that of other folacin rich vegetables and iron 72 µg/g [7].

Plants have been major sources of medicines throughout human history [8] being used for traditional relief from numerous human diseases [9]. Their medicinal value lies in some chemical substances that produce definite physiological actions on the human body [10]. In developing countries, pharmaceutical drugs are not often affordable and approximately 60–80% of the world's population relies on traditional medicines as remedies for common illnesses [11]. A blend between traditional knowledge in medicinal plants, modern pharmacology and natural product chemistry has led to the discovery of very novel and efficacious forms of medication [12]. They recommend a daily intake of more than 400 g of vegetables and fruits per person to protect against diet related chronic diseases [13]. Therefore, the jute leaves consumption could play an important role in the WHO global initiative on increased consumption of vegetables [14].

Processing is mainly the transformation of food from perishable produce into stable foods with long shelf lives. This is to maintain a supply of wholesome, nutritious food during the year and preservation for the time of scarcity [15]. Nutrients are the building blocks of the human body and may be affected by food processing and cooking [16]. Nutrient losses occur during harvesting and distribution, household and industrial handling, storage as well as catering [17].

While food processing still has the main objective of providing a safe nutritious diet in order to maintain health, other aspects, particularly the generation of wealth for the producer and seller, have become increasingly important. Most people in the rural areas still rely on traditional foods for their basic diet, while those in urban and cosmopolitan centers tend to purchase processed and packaged foods for convenience [15]. However, vegetables are highly perishable food items thus require special processing treatments to prevent post-harvest losses [18]. Though drying has been used as a method of processing, it may increase the shelf life as well as alter the nutrient quality [19]. Owing to the lack of and/or inadequacy of processing methods, large quantities of perishable food spoil. Therefore, processing and preservation is one of the central problems facing developing countries. In Bangladesh, this problem exists with many fruit and vegetable varieties resulting in wastage during the in-season and limited supply during the off-season. This is accompanied by high prices [15] because most locally available vegetables are seasonal and not available year-long [20]. Therefore, there is need for data on special processing treatments of locally consumed cooked preparations to prevent post harvest losses and promote nutrient retention [18]. Leaves of two cultivated jute species, *C. olitorius* L. and *C. capsularis* are used as vegetables [21]. Green leafy vegetables constitute an indispensable constituent of human diet.

Therefore, they form a significant part of the traditional diets of households and agricultural communities both in urban and the rural areas [22]. Leafy vegetables are important items of diet in many Bangladeshi homes and they are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, mineral, vitamins, fiber and other nutrients which are usually in short supply in daily diets. Optimum utilization of vegetable jute leaves will also have significant influence on the income of farmers and traders, especially women, and thereby results on the

economic growth of the communities and the nation as a whole. Efforts to encourage the utilization of jute leaves require information on its proximate composition and the relationship between its stages of maturity, processing and nutritional behavior.

The present study was there by aimed at examining the best harvesting time and preserved for the leaves of *Corchorus capsularis* for optimal derived nutraceutical benefit to the consumer.

Materials and Methods

Place of study and study period

The cultivated variety of jute seed was used *Corchrus capsularis* (Deshi pat, CVL 1). Their seeds were collected from Jute seed production and research centre, Bangladesh Jute Research Institute (BJRI), Nashipur, Dinajpur and seed sowing at the experimental field in 17 May, 2017. Land was cleared, ploughed, harrowed. The experiment was established using a randomized complete block design (RCBD) with three replicates. The seeds were sown in broadcasting. Normal agronomic practices were observed on the field. The seeds were cleaned, sorted to remove damaged seeds and sown on the land. The study was conducted in the Department of Biochemistry and Molecular Biology, Hajee Mohammad Danesh Science and Technology University, Dinajpur; Department of Pharmacology, Bangladesh University of Health Science, Mirpur-1, Dhaka, Bangladesh and BCSIR, Dhaka, Bangladesh. The study was done during the period of March 2017 to November 2019.

Harvesting and processing of the plant

The jute leaves of each of the above vegetables were harvested between desired time (2 to 7) weeks after seed sowing. They were then washed properly with tap water, rinsed with sterile distilled water and subjected to post harvest processing.

Selection, Sampling, Harvesting and Sample Preparation

In the experiment, dates of shoot emergence from the seeds were noted and only shoots that emerged within the first 2-7 days after the first emergence were tagged. This was done to ensure some measure of uniformity in age of sampled plants. Plants were randomly sampled at 3 day interval from the 15th day after sowing till the leaves become very narrow and unappealing. Final harvesting was done at 33th day after seed sowing, when the leaves were broad and the stem woody. The whole plants were harvested by uprooting only from tagged plants and used for subsequent samplings and evaluation. The whole plants were washed with water and drained. Some leaves were shade-dried at room temperature to constant weight over a period of 2-3 days, while others were solar-dried using a sunlight 1 or 2 days. The leaves of the dried samples were plucked, milled to flour using blender, packaged in polyethylene bag and sealed for further analyses as described by Junaid et al. [23].

Biochemical parameter determination

Moisture, protein, fat, ash, fibre of the jute leaves was determined using the AOAC methods [24] as described by Indrayan et al. [25]. Carbohydrate was determined by subtracting the total ash content, crude fat, crude protein and crude fiber from the total dry matter content. The crude fat was converted into fatty acid by multiplying with a conversion factor 0.80 [26]. The calorific values were obtained by multiplying the carbohydrate, protein and crude fat by the Atwater factors of 17, 16 and 37 respectively [27]. The amino acid content was determined using the method of [28] with minor modifications. The amount of vitamin C and beta carotene in a sample was determined by redox titration method according to AOAC methods (2000) as described by [29]. Qualitative phytochemical test for alkaloids, saponins, flavonoids, tannin, phenols, steroids, terpenoids and anthraquinones adopting the procedures described by [30-31].

Preparation of Biochemical composition behavior of jute leaves

Cooking of jute leaves

The fresh jute leaf samples were sorted and weighed. One hundred grams was washed properly with tap water then rinsed with distilled water and finally boiled in 1L distilled water for 15 minutes. The

mixture was then macerated in a Warring blender for 10 minutes and then centrifuged at 4000g for 30 min. The supernatant was then filtered through Whatman No.1 filter paper and the extract was finally preserved aseptically in an airtight bottle at 5°C for later use.

Aqueous extraction of jute leaves

Aqueous extraction was carried out for fresh leaves, where 40gm of the jute leaves was macerated in 100ml sterile distilled water in a Warring blender for 10 minutes. The macerate was first filtered through double layered muslin cloth and then centrifuged at 4000gm for 30 min. The supernatant was then filtered through Whatman No.1 filter paper and sterilized at 120°C for 30 minutes. The extract was finally preserved aseptically in an airtight bottle at 5°C for later use [32].

Solvent extraction of dried jute leaves

Initial methanol 80% extraction was applied for the solar and shade dried samples. 50 grams of the powdered plant material in a flask was covered with 500 mL methanol and allowed to stand for 72 hours with regular interval of stirring. After 72 hours, the aqueous suspension was filtered with thin and clean cloth; and by filter paper. The suspension was filtered with thin and clean cloth; finally by filter paper. The suspension was dried using rotary evaporator (BUCHI rota vapor R-114) at 45°C until methanol free and dried by a freeze drier (HETOSICC, Heto Lab Equipment, Denmark) at -55°C solid powder was obtained. The resulting extracts were then subsequently labeled as methanol extracts and preserved at 5°C in airtight bottles until further use [33].

Statistical Analysis

Each experiment was done in triplicate. Data from the experiments were analyzed using the Statistical Package for Social Science (SPSS) software for windows version 16. Analysis of variance (ANOVA) was used to determine the mean. Fisher test was used in determining the least significant difference (LSD) of the mean. Test of significant was done at 5% probability level.

Results and Discussion

Effect of leaf maturity on the nutritional composition

The seeds were germinated within 2–3 days after seed sowing. They responded well with organic fertilizers land and they had a short growth period with most of them being ready for harvesting within 5 to 6 weeks. The nutritional composition of jute plant depends on plant leaves maturity.

Moisture content of fresh leaves

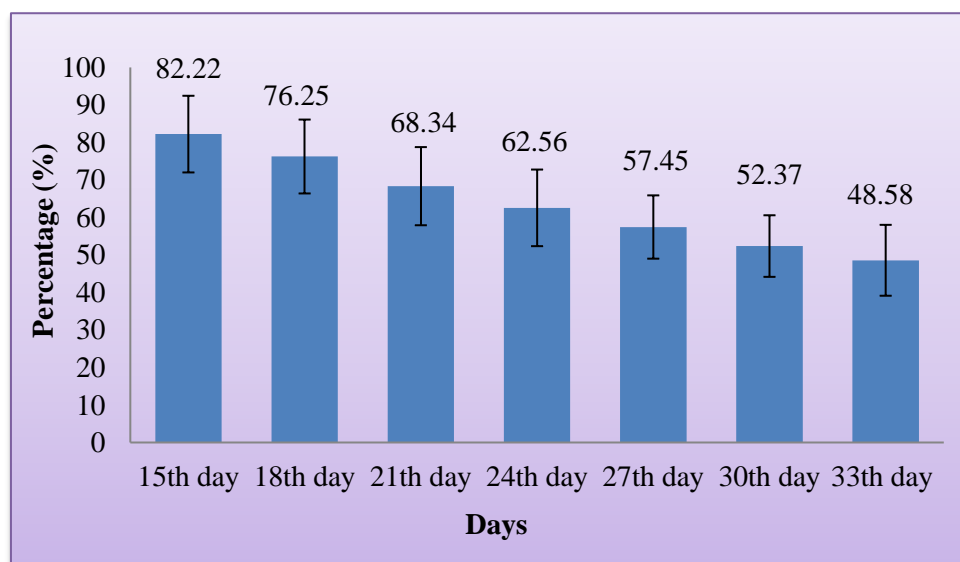


Figure 1. Moisture content (%) of fresh leaves with increase in age of plant.

Figure 1 shows that the fresh leaves have high moisture content which decreased from 15th DASS (82.22%) to 33th DASS (48.58%). Stage of maturity had significant ($p < 0.05$) effect on the moisture content of the plant. Moisture content is a widely used parameter in the processing and testing of food. It is an index of water activity of many foods.

The observed value implies that the leaf may have a short shelf life since microorganisms that cause spoilage thrive in foods having high moisture content and also indicate low total solids [34]. The possibility of spoilage however reduces with maturity of the leaves as indicated by the decrease in moisture content.

Ash content on dry leaves

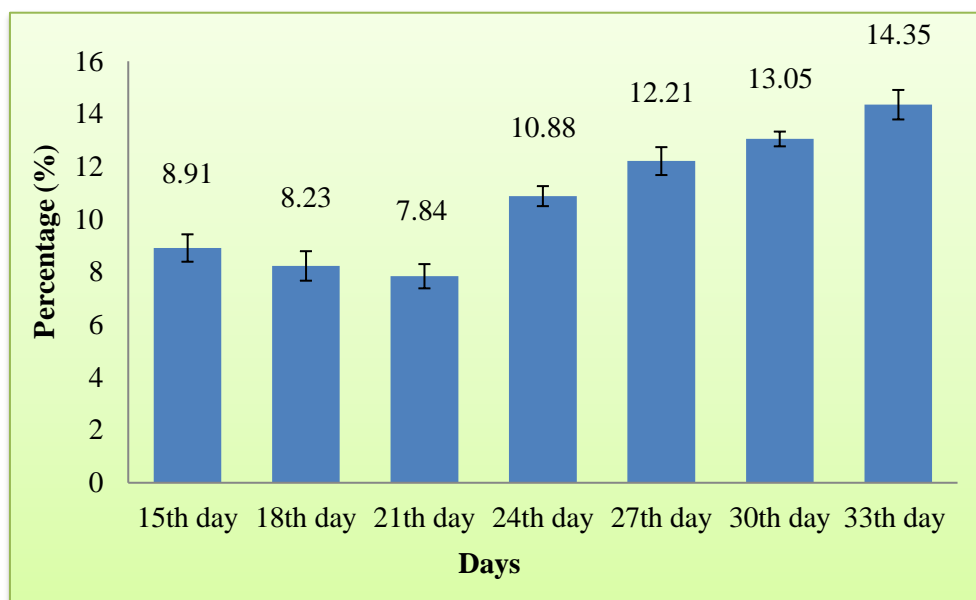


Figure 2. Ash content (%) of leaves with increase in age of plant

Figure 2 shows the ash content of the leaves with maturity. It decreased from 15th DASS (8.91%) to 21th DASS (7.84%) subsequently increased till 33th DASS (14.35) when maximum value was obtained. There was significant difference in the ash content between 15th DASS and 33th DASS.

Ash content, which is an index of mineral contents in biota, is relatively high in jute leaf when compared to the values reported in leaves of *Hibiscus esculentus* (8.00% DW) [35]. The ash content, however, is within the range of values (16.30%-17.31%) reported for some vegetables by Dairo and Adanlawo [36].

Protein content on dry leaves

The crude protein content increased from 15th DASS (19.86 %) till 24th DASS (26.46%) and reduced till final harvesting was done at 33th DASS when least value of 16.65% was obtained Figure 3.

The protein value observed in this study was between 19.86% and 26.46%, which is higher than 3.3% recorded by the USDA Nutrient Database for Standard Reference [37]. This makes the plant advantageous as a rich source of vegetable protein over some vegetables such as raw cocoyam leaf (3.4%), cooked cocoyam leaf (2.1%), *Amaranthus* (6.1%) and *Moringa oleifera* (4.2%) as reported by Adepoju et al. [34]. There was no significant difference in the values of the protein content with the maturity of the plant.

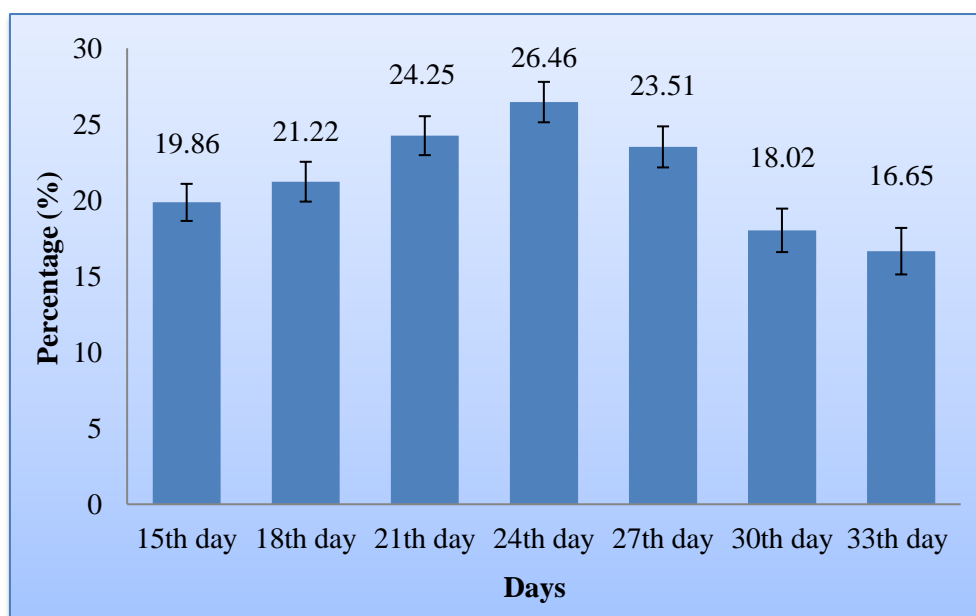


Figure 3. Protein content (%) of leaves with increase in age of plant

Fat content of dry leaves

The fat content of jute leaves does not follow any definite trend which means that the stage of maturity does not affect it. It ranged from 1.54% to 2.95% as shown in Figure 4.

The values revealed that the plant is lower in fat content like *Crassocephalum crepidioides* (12.45%) and *Senecio biafrae* (14.21%) [36], but higher than value reported for *Brassica oleracea* (0.26%) [38].

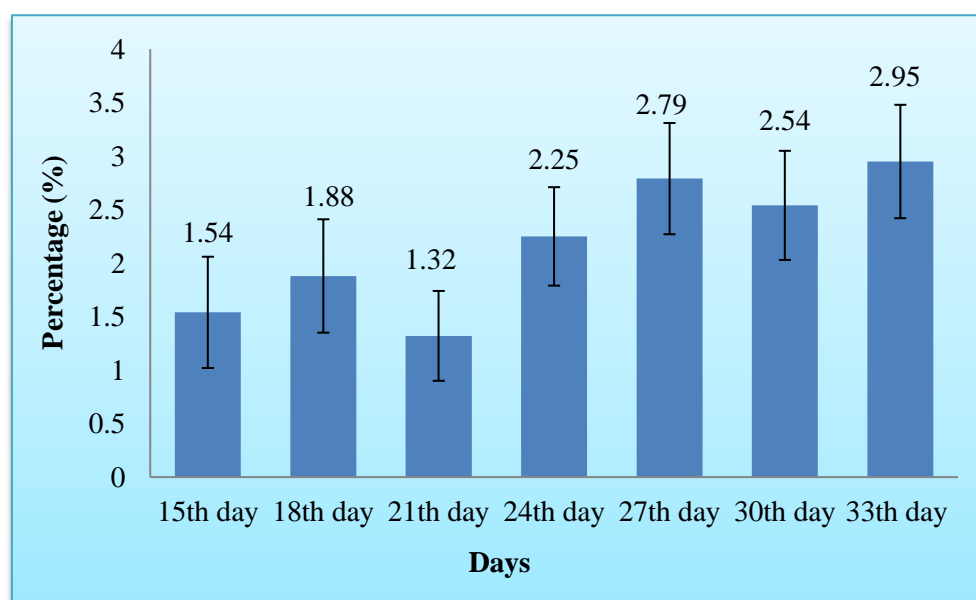


Figure 4. Fat content (%) of leaves with increase in age of plant

Fibre content of dry leaves

The Fiber content of the leaves was lowest at 15th DASS (5.24 %) and increased till the 33th DASS (12.04 %) as shown in Figure 5. This shows that as the plant matures, it becomes more fibrous hence the increase in the fiber content.

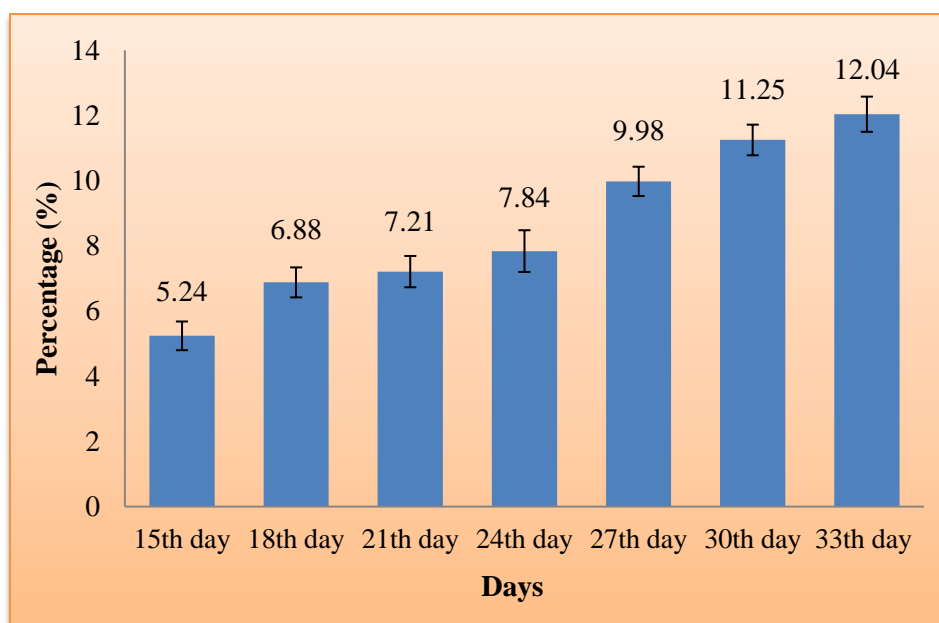


Figure 5. Fibre content (%) of leaves with increase in age of plant

There was significant difference in the fibre content at the 15th DASS and other days after seed sowing (DASS) while no significant difference was observed from 18th DASS through to the 24th DASS. However, the fibre content is higher than that of *Amaranthus hybridus* (8.61) reported by Akubugwo et al. [39]. Fiber in food cleanses the digestive tract by removing potential carcinogens from the body and prevents the absorption of excess cholesterol [40]. Fibre also adds bulk to the food and prevents the intake of excess starchy food and may therefore guard against metabolic conditions such as hypercholesterolemia and diabetes mellitus [41].

Energy value of mature (24th DASS) jute leaves

The nutrients in food reside in the dry matter portion, which is the material remaining after removal of water/moisture. During drying most of the water in the leaf were vapourized so the moisture content was drastically reduced and consequently solid content increase. This increased solid content results due to increased protein, mineral, fat and carbohydrate content of jute leaf. But in dry basis we find, the protein, mineral and carbohydrate content of fresh and dried jute leaves are same. So oxidation did not occurred change of proximate composition in the drying jute leaves. The proximate composition of tea is shown in Table 1. The following parameters were high (g/100 g) in the sample: crude protein (26.16), available carbohydrate (52.52), total ash (10.74) and crude fibre (6.80). The total energy due to total fatty acid was low at 111 KJ /100 g whereas total energy from carbohydrate, crude fat and protein was 1450 KJ /100 g sample whose total individual energy ranged from 139–892 KJ /100 g or percentage range of 9.58–61.51%. The sample had low moisture content (6.55 g /100g), this is an indication that it would not be liable to microbial spoilage easily. The ash content (10.74 g/100g) was moderately high suggesting that the jute leaf could probably provide essential, valuable and useful minerals needed for good body development.

The high content of crude protein (26.16 g/100g) was an indication that the leaves were good sources of protein for humans and could also be utilized as feed stocks. The value here was found to be higher than the one reported for *Anisopus mannii* (8.4%) by Aliyu and Co-workers [42]. The leaves were also high in carbohydrate (52.52 g/100g) which is a quick source of energy and also needed in the diet to ensure efficient oxidation of fats [43]. The value for crude fibre was 6.80 g/100g and since it has been found to possess hypocholesterolemic properties [44]. Jute leaves might be exploited for this purpose. The proximate results in the jute leaves were highly comparable with the proximate results in the leaves of *Aerva lanata* L. (another medicinal plant) with values as: ash (31.2%), moisture (6.38%), crude protein (22.6%), crude fat (6.43%) and carbohydrate (26.6%) [45].

The energy content of the proximate fractions (fat, protein, carbohydrate) ranged as 139–892 KJ/100g (or 1.27 MJ, mega Joule) showing the leaves to be good sources of concentrated energy, due to their high protein, carbohydrate but slightly low fat contents. Energy from cereals range from 1.3–1.6 MJ /100g [46]. Column 4 of Table 1 shows the various energy values as contributed by fat, protein and carbohydrate (in percentage levels). Whilst the fat had the least contribution (9.58%), carbohydrate had the highest contribution (61.51%). The fat contribution of 9.58% of total energy was about half of 30% recommended energy from fat particularly for adults [47]; this is useful for people wishing to adopt the guidelines for a healthy diet. In column 5 Table 1, we have the utilizable energy due to protein (UEDP%) for the jute leaf (assuming 60% utilization) with a value of 17.29. This value is higher than the recommended safe level of 8% for an adult man who requires about 55g protein per day with 60% utilization; this means the protein energy contribution would be more than enough to prevent protein energy malnutrition (PEM) in an adult fed solely on jute leaf as a main source of protein.

Table 1. Proximate composition of jute leaves (g/100 g dry weight of sample)

Parameter	Value	Energy value ⁺	Percentage energy	UEDP%
Crude fat	3.76	139	9.58	-
Crude protein	26.16	418	28.82	17.29
Carbohydrate	52.52	892	61.51	
Mineral	10.76	-	-	-
Crude fibre	6.80	-	-	-
Moisture	6.55	-	-	-
Organic mater	91.26	-	-	-
Total energy	-	1450	-	-
Total fatty acid ⁺⁺	3.00	111	-	-

⁺Energy value in KJ/100 g sample, ⁺⁺ Crude fat x 0.80, UEDP% = Utilizable energy due to protein percent.

These values are almost similar to those reported by Akindahunsi and Salawu [35]. The variation in the composition of jute leaf might be due to difference in variety, soil property, growing condition and agronomical practices.

Amino acid profile of jute leaves

The contain of protein in jute leaves is 19.86% at 15th day after seed sowing (DASS). Fourteen amino acid was found in jute leaves in Figure 6. The glutamic acid was found higher 2.20% and the lowest value of mithionine amino acid in 0.28% at 15th day after seed sowing.

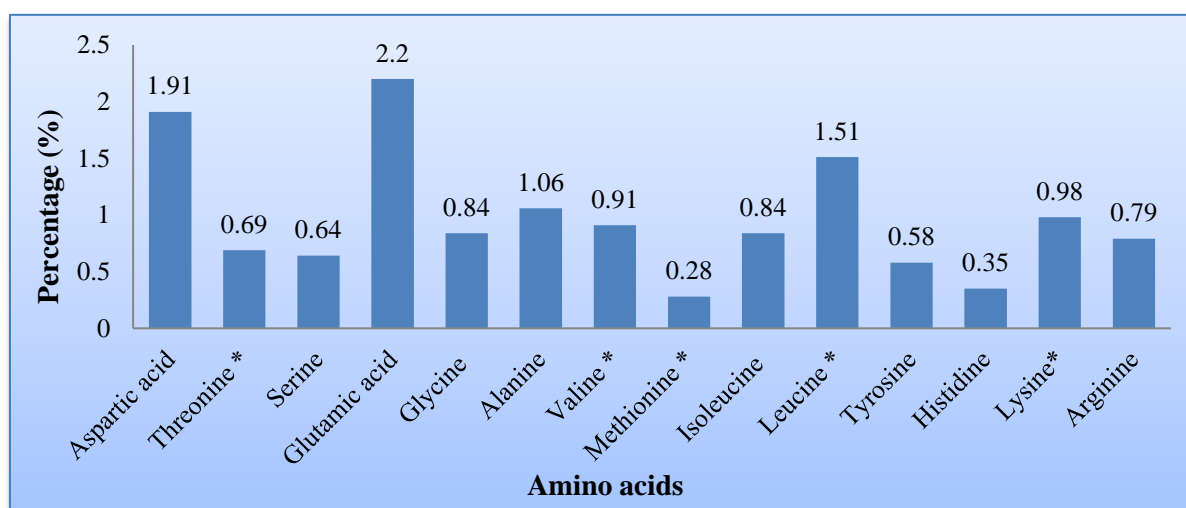


Figure 6. Amino acid profile of jute leaves

***Essential amino acid**

The fourteen amino acids were aspartic acid, threonine, serine, glutamic acid, glycine, alanine, valine, methionine, isoleucine, tyrosine, histidine, lysine and arginine. There are some essential amino acid such as threonine, valine, methionine, leucine and lysine. Free amino acids are regarded as important taste components in terms of tea quality, especially for green tea [48]. Theanine is primarily responsible for umami taste of green tea, similar to that of sodium glutamate [49-50]. It has been shown that the concentration of free amino acid undergo appreciable changes during the various stages of conversion of raw material to the food products commerce. The over-all changes which occurs in the level of free amino acids during food processing included tea products suggests that they are being converted to other substances [51-52]. Many study results show that the amino acids are being converted, at least in part, to volatile compounds likely to be important constituents of food aroma [53]. Amino acids and volatile compounds play an important role in determining the character of tea [50, 54]. However, amino acid levels in tea vary during each manufacturing stage. Production of leucine and phenylalanine in the withered leaf are responsible for the development of aroma in tea. Theanine, closely related to the protein forming amino acid glutamine, it has a calming effect on the brain without sedation, unlike drugs used to induce almsness, which also produce sedative action resulting in drowsiness.

Biochemical behavior of jute leaves**Vitamin C and Beta carotene contents of different treatment of jute leaves**

Vitamin C content in fresh jute was significantly higher than that of dried samples in Table 2. However, solar drying led to significantly high loss in vitamin C content compared to shade drying or cooking. The fresh sample showed the highest amount of vitamin C content (135.60 mg/100g DWB). The loss in vitamin C on drying and cooking was between 82-92%.

Table 2. Vitamin C and beta carotene content of jute leaves (mg/100 g DWB)

Component	Treatment			
	Fresh	Shade dried	Solar dried	Cooked
Vitamin C	135.60±8.75	16.82±0.45	11.55±0.24	24.45±0.95
Beta carotene	7.82±0.16	4.65±0.32	4.42±0.28	3.81±0.42

Values are given as means of two replicates ± standard deviation.

On the other hand, fresh jute leaves had significantly higher β -carotene contents compared to the dried and cooked in Table 5. The β -carotene of jute leaves 7.82, 4.65, 4.42, and 3.81 mg/ 100 g DWB in fresh jute leaf, shade dried, and solar dried and cooked sample, respectively. Solar drying also reported a significantly higher loss of vitamin C content as compared to shade drying. This might be due to high temperatures as it has been reported for other vegetables [55]. The results therefore, agree with the findings of Chaney and co-workers [56], which indicated that the most significant determinant of vitamin C content in foods is how the food is stored and prepared. The β -carotene (pro-vitamin A), the results also indicated that fresh jute leaf had a significantly higher β -carotene than the cooked and dried samples ($P<0.05$). This therefore implies that cooking and drying of jute leaves significantly reduces appreciable amount of β -carotene. However, the destruction was relatively lower when initial drying temperature was low especially when dried in the shade. This agrees with the report that at high temperatures, the long chain polyunsaturated carbons undergo isomerization from the *trans*-to the *cis*-form, leading to loss of the vitamin activity [57]. It has also been reported that light and oxidants catalyze the oxidation of β -carotene in stored dehydrated vegetables causing great losses [58]. Therefore the loss of β -carotene in the dried leaf was due to oxidation mainly by the oxygen retained in the environment and catalyzed by light. The vitamin C contents of fresh jute leaves obtained in this study were all higher than literature values reported for cabbage, 42.3 mg/100g fresh material, or spinach, 62.0 mg/100g fresh leaves [59]. Similarly, the β -carotene content of the fresh jute leaves were all higher than literature values reported for kales, 3.8–4.53 mg/100g fresh leaves [60].

Qualitative phytochemical analysis of different treated sample

The present study revealed the presence of a wide array of phytochemicals including alkaloids, flavonoids, tannins, saponins, steroids and phenols (Table 3). Flavonoids, alkaloids, saponins and phenols were most common. Anthraquinone and steroids in shade sample in doubtful, but fresh sample was present but solar and cooked sample were absent. On the other hand, terpenoid all sample was absent.

Table 3. Qualitative presentation of phytochemicals detected in the jute leaves

Treatment	Phytochemical compounds							
	Flav	Alka	Sap	Tan	Phe	Ant	Ster	Ter
Fresh	+	+	+	+	+	+	+	-
Shade	+	+	+	+	+	±	±	-
Solar	+	+	+	+	+	-	-	-
Cooked	+	+	+	+	+	-	-	-
+ Present, – Absent, ± Doubtful								
Alka-alkaloid, Flav-flavonoid, Sap-saponin, Tan-tannin, Phe-phenol, Anth-anthraquinone, Ster-steroids, Terp-terpenoids.								

Qualitative evaluation of phytochemicals were aimed simply to identify the presence of individual groups of phytochemical compounds. The jute leaves was found to contain a wide array of phytochemicals. On the other hand, the phytochemical components of fresh jute leaves samples were significantly higher ($P < 0.05$) than those of the dried and cooked samples. This might perhaps be due to the inter-conversion of these compounds into other derivatives, owing to the prolonged period of drying and cooking. However, there was no significant difference ($P > 0.05$) between the phytochemical compounds in solar and shade dried sample. The findings from this study are in agreement with those of work carried out in Bangladesh which indicated that the presence of some of these anti-nutrients is reduced by various processing techniques [61]. The risk of losing these plant chemicals as a result of cooking are therefore well founded and hence, the vegetables should be cooked in minimal heat and within a short time.

Phytochemicals act as antioxidants, suppressors of tumor growth, anti-mutagens, enzyme modulators, chemical inactivators and free radical scavengers. Flavonoids, tannins and saponins have been reported to have medicinal properties such as antimicrobial and antioxidant properties [62]. Alkaloids on the other hand, are heterocyclic indole compounds which have proved to have pharmacological properties such as hypotensive activity, anticonvulsant activity, antiprotozoal, antimicrobial and antimalarial activities [63]. They also have pronounced physiological effects particularly on the nervous system [62]. Plants have the limitless ability to synthesize phenols or their derivatives. These phenolic compounds give the vegetable an astringent taste. They also bind proteins and may lower protein digestibility and quality as well as reducing the risk of heart disease and certain types of cancers. The presence of phytochemicals in jute leaves justifies their potential pharmacological and medicinal value. Therefore, their constant consumption is beneficial and should be encouraged. In conclusion, the effect of plant leaf maturity or age indicated that the nutritional quality increase and the optimum value for crude protein and carbohydrate were observed at 24th day after seed sowing (DASS). The 100 g dry jute leaves contain 111 KJ energy. On the other hand, jute leaf contents the importance dietary potential phytochemicals as well as nutraceutical, like alkaloid, flavonoid, phenol and tannin. Though the leaf contain relatively high levels of some nutrients, the processing and preparation methods prior to consumption reduce their final consumed amount. This is through losing and oxidation due to cooking and drying. The drying of jute leaf in dark and dry place under low temperature and also cooking should be within a short time for best retention of nutrients. Finally, the data generated from this study provides an important insight on the value of jute leaves. It is clear that, jute leaf contain different bioactive compounds and nutritional qualities which when combined could be tremendous benefit to the body.

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Conflicts of interest: None declared.

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