Amino Acid Profile of Leaf Protein Concentrates and Bagasse of Jute Plant (*Corchorus olitorius*) in Edo State Nigeria

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Abstract
Jute (*Corchorus olitorius*) is an abundant and underutilized leafy plant traditionally valued for its fiber and culinary uses in West Africa. Its leaves are rich in proteins and bioactive compounds, making them promising candidates for protein recovery. This study aimed to investigate the amino acid composition of jute leaf meal (JLM), jute leaf protein concentrate (JLPC), and jute leaf bagasse (JLB) to identify their potential as a nutritional supplement in human and animal nutrition. The research employed standard acid and alkaline hydrolysis followed by amino acid quantification using an automated amino acid analyzer (Sykam S 433 Amino Acid Analyzer). Results obtained revealed significant differences ($p<0.05$) in the amino acid profiles of the three sample types. JLPC consistently demonstrated the highest concentrations of both essential and non-essential amino acids, including leucine (4.51 g/100 g), glutamic acid (5.78 g/100 g), and aspartic acid (4.68 g/100 g), reflecting the efficacy of the protein concentration method. In contrast, JLM and JLB exhibited lower amino acid values, with JLB being notably lower, though still containing residual nutrients. The enrichment of branched-chain amino acids (BCAAs) such as leucine, isoleucine, and valine in JLPC underscores its potential in supporting muscle growth and recovery. Additionally, higher levels of lysine and methionine in JLPC enhance its nutritional value in plant-based diets, often limited in these amino acids. These findings support the nutritional viability of JLPC as a functional food ingredient or animal feed supplement. This study serves as a basis for optimization of processing techniques to improve amino acid retention and evaluate the application products in human and animal nutrition.
Keywords: Amino acid profile, jute leaf meal, leaf bagasse, leaf protein concentrates, *Corchorus olitorius* plant-based proteins

Introduction

In many developing regions, malnutrition and food insecurity continue to drive research into sustainable and affordable protein sources (WHO, 2024). Leaf protein concentrates (LPCs) have emerged as a promising solution due to their rich nutritional profile, particularly in their potential for incorporation into both human and animal diets (Nwokoro, 2015; Agbonghae and Nwokoro, 2023). One such underutilized plant resource is jute (*Corchorus olitorius*), which is traditionally known for its fiber production and culinary use in West Africa (Ahmed and Sarkar, 2022), yet remains understudied in terms of its leaf-based protein potential.

Jute leaves are abundant, fast-growing, and widely available across tropical climates, including Nigeria. They are rich in proteins, vitamins, and minerals, and have been used in traditional medicine to treat fever, constipation, and inflammation (Biswas *et al*., 2022). Despite these known benefits, comprehensive scientific evaluations of jute leaf derivatives such as leaf protein concentrates (JLPC) and bagasse (JLB) are still limited. Leaf protein concentrates are produced through mechanical disruption and heat coagulation, processes that isolate soluble proteins while discarding fibrous residues (Nwokoro *et al*., 2022; Agbonghae *et al*., 2024). The remaining fibrous fraction, or bagasse, although often regarded as waste, may still contain valuable nutrients, particularly dietary fiber and residual amino acids (Akaeze and Paul-Osagie, 2023; Agbonghae *et al*., 2024).

The amino acid composition of plant-based protein products is a critical indicator of their nutritional and functional value, particularly for animal feed and human food applications. Understanding the amino acid profile of jute leaf meal (JLM), JLPC, and JLB is essential to evaluating their dietary utility, especially in protein-deficient populations (Razak *et al*., 2017; Moe, 2025). Prior research has established that processing methods significantly influence the retention and concentration of amino acids, with thermal and mechanical treatments affecting both the availability and degradation of sensitive compounds like tryptophan and methionine (Xiao *et al*., 2024; Yang and Liao, 2019).

In this study, a comparative analysis of the amino acid profiles of JLM, JLPC, and JLB was performed to identify their potential as nutritional food and feed materials. By generating detailed quantitative data, the research seeks to inform future applications of jute leaf derivatives in functional foods and livestock nutrition strategies.

Materials and Methods

Study Area

The extraction of leaf protein concentrates was carried out at the Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The institution is located in the humid rainforest agroecological zone in southern Nigeria, around latitude 6°24′17″N and longitude 5°36′39″E**.** The region receives approximately 6.68 hours of sunlight per day, 2162 mm of rainfall annually, an average relative humidity of

72.5%, and an average annual temperature of 27.6°C (NAA, 2018; Google Earth, 2024).

Sample Collection and Preparation

Mature plants grown in many places around Edo State, Nigeria, were plucked for their fresh, healthy jute leaves to ensure proper representation of the State. Immediately after harvest, the leaves were sent to the processing lab in vented containers. To get rid of dirt particles and surface impurities, leaves were carefully washed in distilled water upon arrival. The leaves were spread on, perforated trays and allowed to air-dry for about three hours at room temperature (between 25 and 30 °C) in order to minimise surface moisture before being processed further.

Jute Leaf Meal (JLM)

For five to seven days, jute leaves were further air-dried at room temperature (25 to 30 °C) to a relatively constant weight. A laboratory-grade electric mill (Binatone BLG-450) was used to mill the dry biomass into a fine powder, and a 1 mm sieve was used to guarantee consistent particle size. The jute sample, known as jute leaf meal (JLM), was kept at room temperature in sealed, light-resistant plastic containers until analysis.

Jute Leaf Protein Concentrates (JLPC)

As seen in Figure 1, the heat coagulation technique was used for extraction of leaf protein concentrates. The fresh jute leaves were milled for five minutes at high speed in distilled water at a 1:5 (w/v) ratio. A second layer of muslin cloth was used to filter the resultant slurry in order to extract the juice from the fibrous residue. To thermally coagulate the soluble proteins, the filtrate (leaf juice) was heated till coagulation. The coagulated protein curd was collected via **sieving** and labeled jute leaf protein concentrates (J**LPC)**. It was oven dried at 40°C to a relatively constant weight, and the concentrate was ground and kept for later use.

Jute Leaf Bagasse (JLB)

Bagasse, the fibrous residue that remained after the juice was extracted during the JLPC preparation process, was gathered, dried at 40°C relatively constant weight and then milled to fine powder. This high-dietary-fiber by-product, known as jute leaf bagasse (JLB), was kept in sealed containers at room temperature for amino acid analysis.

Amino Acid Analysis

Hydrolysis of Samples

Amino acid profiling was carried out using the dried and ground samples of JLM, JLPC, and JLB. Each sample was weighed into hydrolysis tubes, sealed, and exposed to acid hydrolysis at a concentration of approximately 100 mg. In vacuum-sealed glass ampoules, samples were hydrolyzed with 6 M hydrochloric acid (HCl) under nitrogen gas to stop amino acids from oxidizing throughout the process. The tubes were incubated at 110°C for 24 hours. Following cooling, the hydrolysates were filtered and dried by evaporating them at 40°C under decreased pressure (approximately 100–200 mbar) for 30–60 min using a rotary evaporator (Büchi Rotavapor R-210).

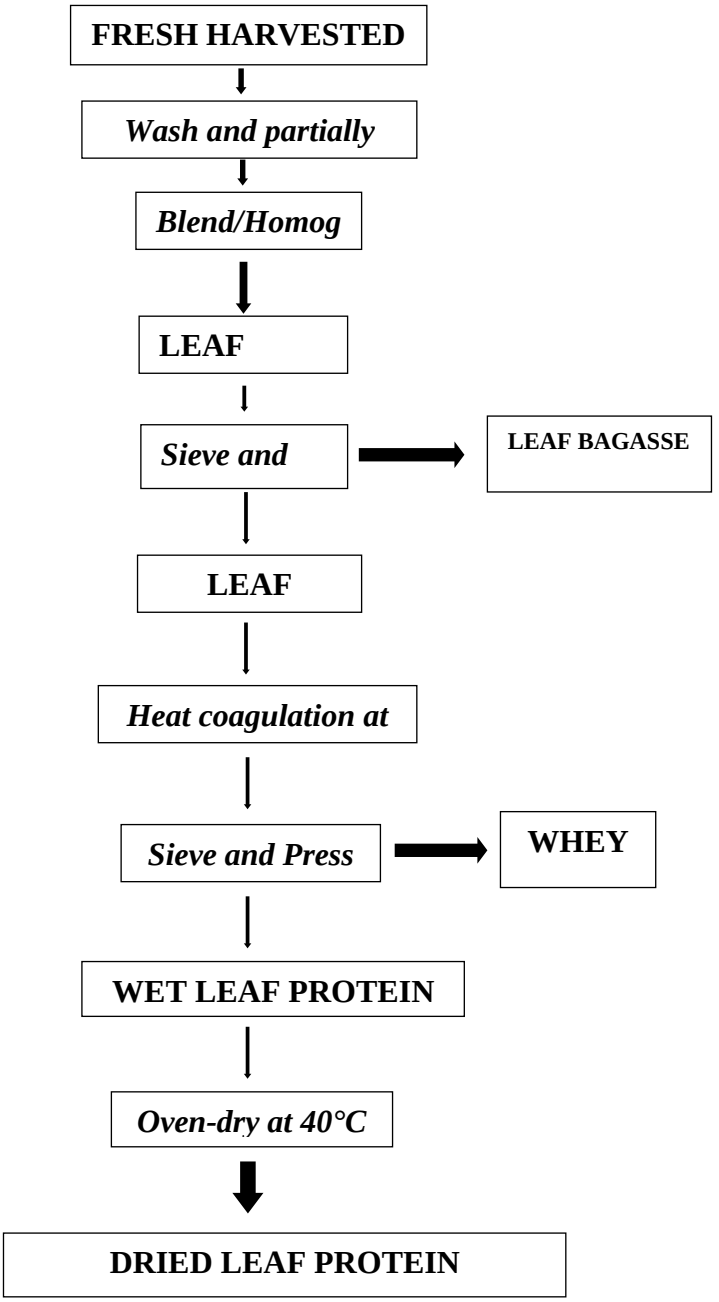

Figure 1: Flow chart of leaf protein concentrates production

For further examination, the residue was reconstituted in 0.02 M sodium citrate buffer (pH 2.2). Since tryptophan is damaged in very acidic environments, separate alkaline hydrolysis was performed using 4.2 M NaOH at 110°C for 16 hours to maintain its integrity for the analysis.

Amino Acid Quantification

An automated amino acid analyzer (Sykam S 433 Amino Acid Analyzer) with a cation exchange column and a post-column ninhydrin derivatization device was used to quantify the amino acids. Absorbance at 570 nm for the majority of amino acids and 440 nm for proline served as the basis for the detection. According to the manufacturer's recommendation, the elution was

performed using a stepwise gradient of sodium citrate buffers under carefully regulated pH and temperature settings.

The retention periods and peak areas of the amino acids were compared to those of recognized standards conducted under the same circumstances in order to identify and quantify the amino acids. A reference standard and a blank sample were included in every batch, and all analyses were carried out in triplicate to guarantee accuracy and precision. With a coefficient of variation (CV) of less than 5% between repetitions, analytical repeatability was confirmed. The technique was in compliance with AOAC Official Method 994.12 (2005), which is used to analyze amino acids in feed materials (AOAC, 2005; Xiao *et al*., 2024).

Statistical Analysis

Data from the study were subjected to one-way analysis of variance (ANOVA) in order to detect significant differences between the samples. At a significance level of $p<0.05$, means were separated using Duncan's Multiple Range Test. For statistical analysis, SPSS software version 25 was utilized.

Results and Discussions

The amino acid composition of jute leaf meal (JLM), jute leaf protein concentrates (JLPC), and jute leaf bagasse (JLB) is presented in Table 1. The results reveal significant differences in the concentrations of individual amino acids across the three sample types, reflecting the effects of protein concentration and residual nutrient content in the bagasse. In general, JLPC exhibited significantly ($p<0.05$) higher levels of most amino acids compared to JLM and JLB, indicating its enhanced nutritional profile.

Non-essential Amino Acid

Alanine and Arginine

Alanine levels were highest in JLPC (3.32±0.15 g/100 g), followed by JLM (2.16±0.11 g/100 g) and lowest in JLB (1.34±0.11 g/100 g). The significantly higher alanine concentration in JLPC suggests effective concentration and retention of this non-essential amino acid during the protein extraction process. Alanine plays a role in glucose-alanine cycling and energy metabolism. The enrichment in JLPC supports its functional use in energy-related metabolic pathways (Razak *et al*., 2017; Holeček, 2024). The increase is likely due to the removal of fibrous materials and concentration of soluble proteins during processing (Calderon-Chiu *et al*., 2024, González-Félix *et al*., 2023).

Arginine, a conditionally essential amino acid important in growth and immune function, was also most abundant in JLPC (2.93±0.25 g/100 g), showing a significant increase over JLM (1.87±0.19 g/100 g) and JLB (1.15±0.14 g/100 g). This again underscores the concentration efficiency of the JLPC preparation. Arginine is vital for nitric oxide synthesis and immune modulation. The significantly higher value in JLPC may enhance cardiovascular and immune-supporting functions (Lopez and Mohiuddin, 2024). Its presence in higher concentration may also make JLPC a favourable additive for animal feed, particularly for weaned livestock that require arginine supplementation (Yang and Liao, 2019).

Aspartic acid, Cysteine, and Glutamic acid

Aspartic acid, a precursor in amino acid synthesis and an important neurotransmitter, followed a similar trend as alanine and arginine with its highest value recorded in JLPC (4.68±0.29 g/100 g). This was significantly greater than in JLM (2.92±0.24 g/100 g) and JLB (1.94±0.19 g/100 g). The magnitude of increase suggests enhanced recovery of acidic amino acids during the concentration process. Aspartic acid contributes to urea cycle and nucleotide production for improve the flavor and nutritive value of plant protein products (Wu, 2013; Brosnan and Brosnan, 2006)

Cysteine, a sulfur-containing amino acid essential for protein structure and function, was highest in JLPC (1.75±0.12 g/100 g), which was significantly greater than the values in JLM (1.09±0.08 g/100 g) and JLB (0.93±0.05 g/100 g). The relatively high level of cysteine in JLPC may enhance its utility as a functional food ingredient due to its antioxidant properties. The high cysteine content in JLPC may increase its functional capacity as a dietary antioxidant, potentially improving immune health and reducing oxidative stress (Lu, 2013).

Glutamic acid, the most abundant amino acid detected, showed the highest concentration in JLPC (5.78±0.25 g/100 g), followed by JLM (3.23±0.21 g/100 g) and JLB (2.74±0.18 g/100 g). These differences were significant ($p<0.05$), indicating that JLPC could be a good source of glutamate, which contributes to flavor enhancement and metabolic functions. Glutamic acid not only contributes to umami flavor but also plays roles in neurotransmission and nitrogen metabolism (Lu, 2013; Zhou and Danbolt 2014).

Glycine, Proline, Serine, and Tyrosine

JLPC demonstrated superior glycine concentration (2.91±0.29 g/100 g), which was significantly higher than JLM (1.88±0.21 g/100 g) and JLB (1.14±0.19 g/100 g). Glycine is involved in collagen synthesis and detoxification, and its higher concentration in JLPC supports its nutritional value. Its enrichment in JLPC improves the bio-functional profile, suggesting potential for therapeutic applications (Razak *et al*., 2017; Holeček, 2024).

Proline and serine, both non-essential amino acids, followed similar trends, with the highest concentrations in JLPC (1.96±0.18 and 2.59±0.11 g/100 g respectively), further reflecting the successful concentration of amino acids in this fraction. Higher proline in JLPC may enhance its structural and healing properties in tissue repair and joint health (Vettore *et al*., 2021). JLPC contained the highest serine levels (2.59 g/100 g), reinforcing its role in cell proliferation and neurotransmission. The increase supports better bioavailability and functional properties in JLPC (Jennings *et al*., 2015; D'Connect, 2024; IHSM, 2024).

Tyrosine, a non-essential amino acid derived from phenylalanine and important for neurotransmitter synthesis, was significantly more concentrated in JLPC (3.13±0.26 g/100 g) than in JLM (1.59±0.18 g/100 g) and JLB (1.17±0.11 g/100 g), further supporting the functional potential of the concentrate. Tyrosine is crucial for neurotransmitter production and stress hormone synthesis. Its abundance in JLPC adds to its functional food potential (Jennings *et al*., 2015; D'Connect, 2024; IHSM, 2024).

Essential Amino Acid

Histidine, Isoleucine, and Leucine

Among the essential amino acids, notable differences were observed. Histidine content was significantly higher in JLPC (2.41±0.21 g/100 g) than in JLM (1.55±0.12 g/100 g) and JLB (1.07±0.11 g/100 g). This amino acid plays a critical role in growth and development, particularly in infants. Its increase may be valuable for tissue repair and immune response, particularly in growing children and individuals with increased physiological demand (Nie *et al*., 2018).

Isoleucine and leucine, which are branched-chain amino acids essential for muscle metabolism and repair, showed significantly higher levels in JLPC (3.07±0.18 and 4.51±0.29, g/100 g respectively) compared to JLM and JLB. These results emphasize the enhanced anabolic potential of the concentrated protein. The concentration of isoleucine in JLPC underscores its value in muscle protein synthesis and post-exercise recovery (Nie *et al*., 2018; Shimomura *et al*., 2006; Moe, 2025). This amino acid is key for anabolic signaling and has been shown to stimulate muscle growth and repair (Nie *et al*., 2018; Shimomura *et al*., 2006; Moe, 2025). Its presence in high amounts makes JLPC particularly suitable for formulating protein-rich foods or supplements.

Lysine, Methionine, and Phenylalanine

Lysine, vital for protein synthesis and calcium absorption, also showed its highest concentration in JLPC (2.67±0.19 g/100 g), significantly higher than JLM (1.99±0.21 g/100 g) and JLB (1.18±0.18 g/100 g). The elevated lysine content is particularly important given its limitation in most plant-based diets. This enhancement is critical as lysine is necessary for calcium absorption and protein biosynthesis (Lopez and Mohiuddin, 2024).

Similarly, methionine, another sulfur-containing essential amino acid involved in methylation and detoxification pathways, was significantly higher in JLPC (1.98±0.28 g/100 g) than in JLM (1.29±0.21 g/100 g), while its content in JLB (1.27±0.27 g/100 g) was comparable to that in JLM, indicating limited retention during fiber extraction. Methionine is essential for methyl group donation and antioxidant function. Its improved levels in JLPC further validate the nutritional benefits of protein concentration (Yang and Liao, 2019).

Phenylalanine, a precursor of neurotransmitters such as dopamine and epinephrine, was significantly enriched in JLPC (2.77±0.18 g/100 g) compared to JLM (1.21±0.17 g/100 g) and JLB (1.77±0.11 g/100 g). This enrichment has implications for cognitive and mood-related benefits. This amino acid contributes to mood regulation and cognitive function and supports the classification of JLPC as a functional protein source (Nie *et al*., 2018; Shimomura *et al*., 2006; Moe, 2025).

3.2.3 Threonine, Tryptophan, and Valine

Threonine and tryptophan, although essential, did not show a uniformly increasing trend across the samples. Threonine levels were comparable between JLPC (1.61±0.14 g/100 g) and JLM (1.79±0.28 g/100 g), with both significantly higher than JLB (0.77±0.09 g/100 g). Threonine supports mucin production and intestinal integrity, thus enhancing JLPC's utility in therapeutic diets (Yang and Liao, 2019).

For tryptophan, the JLPC value (1.89±0.37 g/100 g) was significantly higher than JLB (1.2±0.38 g/100 g), but comparable to JLM (1.22±0.28 g/100 g). This suggests that the extraction process may not equally enhance all amino acids, possibly due to differential solubility or degradation during processing. Its preservation in JLPC, despite potential oxidative degradation, highlights the efficiency of the concentration method (Yang and Liao, 2019). Valine, another BCAA, was highest in JLPC (2.43±0.71 g/100 g), emphasizing the enriched anabolic profile of the protein concentrate. Valine supports muscle recovery and energy production during exercise (Nie *et al*., 2018; Shimomura *et al*., 2006; Moe, 2025).

Total Amino Acid

The cumulative data on total essential amino acids (TEAA) and total amino acids (TAA) reinforced the superiority of JLPC in terms of overall amino acid content. JLPC recorded the highest TEAA content (23.34±1.62 g/100 g), which was significantly higher than in JLM (14.44±1.41 g/100 g) and JLB (11.5±1.38 g/100 g). The TAA content followed a similar trend, with JLPC at 69.85±4.07 g/100 g, significantly higher than JLM (47.85±2.59 g/100 g) and JLB (38.79±2.18 g/100 g). This improvement reflects the effectiveness of protein concentration methods in enriching protein quality by removing fibrous and non-protein components (González-Félix *et al*. 2023; Calderon-Chiu *et al*. 2024). These findings indicate that protein concentration significantly enhances the nutritional quality of jute leaves by enriching essential and total amino acids. Conversely, the fibrous by-product of this process, SLB, showed the lowest quantities of amino acids, supporting observations by Agbonghae *et al*. (2024) and Akaeze and Paul-Osagie (2023) for cassava and citrus leaf bagasse, respectively.

Conclusion and Recommendation

This study highlights the nutritional potential of jute leaves through the comparative analysis of their meal, protein concentrate, and bagasse. The significant improvement in essential amino acid concentrations observed in the protein concentrate underscores its value as a rich source of plant-based protein. The reduced protein content in the bagasse indicates it is more suitable as a fiber-rich residue rather than a primary protein source. Overall, the enhanced amino acid profile of the jute leaf protein concentrate suggests its suitability

for application in dietary supplementation, functional food development, and animal nutrition. This fractionation of jute leaves contributes not only to sustainable utilization of agricultural by-products but also to the advancement of affordable, nutrient-dense food ingredients for human and animal nutrition. As a way of recommendation, jute leaf protein concentrates and bagasse should be investigated for organoleptic properties in human diet. Additionally, animal nutrition studies should be performed for the utilization of these jute leaf derivatives.

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Conflict of Interest
No conflict of interest associated with this work

Contribution of Authors
We declare that this work was done by Osagie Wisdom Agbonghae (OWA) and Shalom Esther Idahosa (SEI) and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. OWA conceived and designed the study, SEI collected the data, OWA analyzed the data. SEI wrote the first draft of manuscript and OWA revised and wrote the final draft of the manuscript. All authors read and approved the manuscript for publication.

Availability of Data and Materials
Datasets used and/or analyzed during the current study are available from the corresponding author.

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Table 1: Amino acid profile of jute leaf meal, protein concentrates, and bagasse

	TREATMENTS			
Amino acid	**JLM (g/100 g)**	**JLPC (g/100 g)**	**JLB (g/100 g)**	**SEM**
Alanine	2.16±0.11^{b}	3.32±0.15^{a}	1.34±0.11^{b}	0.97
Arginine	1.87±0.19^{b}	2.93±0.25^{a}	1.15±0.14^{b}	0.17
Aspartic acid	2.92±0.24^{b}	4.68±0.29^{a}	1.94±0.19^{b}	1.23
Cysteine	1.09±0.08^{b}	1.75±0.12^{a}	0.93±0.05^{c}	0.07
Glutamic acid	3.23±0.21^{b}	5.78±0.25^{a}	2.74±0.18^{c}	0.64
Glycine	1.88±0.21^{b}	2.91±0.29^{a}	1.14±0.19^{c}	0.13
Histidine*	1.55±0.12^{b}	2.41±0.21^{a}	1.07±0.11^{c}	0.06
Isoleucine*	1.94±0.22^{b}	3.07±0.18^{a}	1.44±0.07^{c}	0.34
Leucine*	1.53±0.26^{b}	4.51±0.29^{a}	1.78±0.21^{b}	1.83
Lysine*	1.99±0.21^{b}	2.67±0.19^{a}	1.18±0.18^{c}	0.54
Methionine*	1.29±0.21^{b}	1.98±0.28^{a}	1.27±0.27^{b}	0.16
Phenylalanine*	1.21±0.17^{b}	2.77±0.18^{a}	1.77±0.11^{b}	1.71
Proline	1.09±0.15^{b}	1.96±0.18^{a}	0.94±0.11^{b}	0.12
Serine	1.66±0.06^{b}	2.59±0.11^{a}	1.01±0.08^{b}	0.34
Threonine*	1.79±0.28^{a}	1.61±0.14^{a}	0.77±0.09^{b}	0.21
Tryptophan*	1.22±0.28^{a}	1.89±0.37^{a}	1.2±0.38^{b}	1.32
Tyrosine	1.59±0.18^{b}	3.13±0.26^{a}	1.17±0.11^{b}	0.11
Valine*	1.92±0.91^{a}	2.43±0.71^{a}	1.02±0.45^{b}	0.81
Total essential amino acid	14.44±1.41^{b}	23.34±1.62^{a}	11.5±1.38^{c}	2.38
Total amino acid	47.85±2.59^{b}	69.85±4.07^{a}	38.79±2.18^{c}	4.53

JLM = Jute leaf meal; JLPC = Jute leaf protein concentrates; JLB = Jute leaf bagasse.

^{abc} = Means on the same row with different superscript are significantly different ($p<0.05$).

* = Essential amino acids. SEM = Standard error of mean