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Standardised Ileal Amino Acid Digestibility of Processed Senna Seed (*Senna occidentalis* L.) in Broiler Chickens

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Abstract

Senna seed is an underutilised tropical legume with potential as an alternative protein source in poultry nutrition. However, its utilisation in broiler diets is constrained by anti-nutritional factors that reduce amino acid availability and utilisation. Processing methods have been reported to improve nutrient availability through the reduction of these antinutrients. This study evaluated the standardised ileal amino acid digestibility of processed senna seed meal in broiler chickens. One hundred and sixty 17-day-old Ross 308 broiler chicks were randomly assigned to four dietary treatments with five replicates of eight birds each in a completely randomised design. Diet 1 was a highly digestible protein (HDP); a control and diets 2, 3 and 4 contained Raw Senna Seed Meal (RSSM), Fermented Senna Seed Meal (FSSM), and Boiled Senna Seed Meal (BSSM) supplemented diets. Amino acid composition of the test ingredients was determined using standard analytical procedures, and ileal digesta were collected on day 21 for digestibility assay. Data were analysed using ANOVA at $p = 0.05$. Results showed that processing significantly affected ($p < 0.05$) the amino acid composition and standardised ileal amino acid digestibility of *Senna occidentalis* seed meal. Among the senna seed meals, RSSM generally contained higher amino acid concentrations. However, standardised ileal amino acid digestibility was highest in birds fed HDP followed by FSSM and BSSM diets. In FSSM, leucine (74.53%), lysine (70.52%), threonine (66.25%) and tryptophan (79.58%) showed superior digestibility compared to the RSSM diet (57.70%, 53.06% and 66.68%), respectively. This indicates that fermentation enhanced amino acid bio-availability through microbial degradation of anti-nutritional factors. In conclusion, fermentation effectively improved the nutritive value of Senna seeds by reducing anti-nutritional factors and enhancing amino acid digestibility and utilisation. Therefore, properly processed senna seed meal at 10% inclusion level can serve as a promising alternative protein source for broiler chickens.

Keywords: *Senna occidentalis, Amino acid digestibility, Processing methods, Non-conventional protein source, Broiler chickens.*

Introduction

Soyabean meal is the major protein source in poultry diets because of its favourable amino acid profile and high digestibility (Babatunde *et al*., 2021). However, rising costs have increased interest in alternative protein sources such as *Senna occidentalis*, a leguminous seed with appreciable protein and essential amino acid contents (Rabiu, 2019).

The utilisation of *Senna occidentalis* seed meal in broiler diets is limited by antinutritional factors, including tannins, phytates, oxalates and saponins, which can impair protein digestion and amino acid absorption (Diarra, 2021). Processing methods such as boiling and fermentation have been reported to reduce these compounds and improve nutrient availability (Diarra, 2021). However, information on the standardised ileal amino acid digestibility (SIAAD) of processed *Senna occidentalis* seed meal remains scarce.

Standardised ileal amino acid digestibility is considered a reliable measure of amino acid availability because it corrects for endogenous amino acid losses and provides accurate values for feed formulation (Doyin and Akinfala, 2023). Therefore, this study evaluated the SIAAD of raw, boiled and fermented *Senna occidentalis* seed meal in broiler chickens to determine its potential as an alternative protein source for poultry diets.

Materials And Methods

Experimental Site

The study was conducted at the Poultry Unit of the Teaching and Research Farm, University of Ibadan, Nigeria.

Seed procurement and processing

Mature seeds of *Senna occidentalis* were procured, cleaned, and processed by boiling or fermentation. For boiling, seeds were boiled in water (1:4 w/v) at 100°C for 1 h, drained, sun-dried, and milled (Doma *et al*., 2016). For fermentation, seeds were soaked in water for 1 h and fermented anaerobically for 5 days before drying and milling (Augustine *et al*., 2017). Processed meals were stored in airtight containers until use.

Experimental Birds and Diets

A total of 160 one-day-old Ross 308 broiler chicks were used for the study. Birds were randomly allotted to four dietary treatments in a completely randomised design comprising five replicates of eight birds each. Commercial starter feed was provided from day 1 to 16, while experimental diets were fed from day 17 to 21. Diets were formulated to meet NRC (1994) nutrient requirements for poultry. The diets contained approximately 21.5–21.7% crude protein and 2,804–2,823 kcal ME/kg. Titanium dioxide (0.5%) was included as an indigestible dietary marker. Birds had free access to feed and water throughout the study.

Experimental diet layout

Treatment I (Control): Highly digestible protein (whey protein) with 0% Senna Seed Meal (SSM).
Treatment II: Basal diet containing 90% SBM + 10% Raw Senna Seed Meal (RSSM).
Treatment III: Basal diet containing 90% SBM + 10% Fermented Senna Seed Meal (FSSM).
Treatment IV: Basal diet containing 90% SBM + 10% Boiled Senna Seed Meal (BSSM).

Amino Acid Analysis

The amino acid composition of the seed meals was determined according to AOAC (2006) procedures using an Applied Biosystems PTH Amino Acid Analyser.

Digesta collection

On day 21, birds were euthanised and ileal digesta samples were collected from the distal two-thirds of the ileum following the procedure of Agboola *et al*. (2021). Samples were pooled by replicate and oven-dried at 55°C prior to analysis.

Digestibility calculations

Apparent ileal amino acid digestibility (AIAAD)

$AIAAD\ (\%) = [1 - (TiO_2 diet/TiO_2 digesta \times AAdigesta/AAdiet)] \times 100$

Standardised ileal amino acid digestibility (SIAAD)

$SIAAD\ (\%) = AIAAD + [(IEAA\ flow) / (AA\ content\ of\ feedstuff)] \times 100$

where IEAA = ileal endogenous amino acid flow.

Titanium dioxide analysis

Titanium dioxide concentrations in diets and digesta were determined using the spectrophotometric method described by Morgan *et al*. (2014).

Statistical Analysis

Data were subjected to one-way analysis of variance (ANOVA) using SAS (2012). Treatment means were separated using Tukey's HSD test at a significance level of $P = 0.05$.

Results

Amino acid profile of raw and processed senna seed meal

The amino acid profile of raw and processed *Senna occidentalis* seed meals differed significantly ($p < 0.05$) among treatments (Table 1). The highly digestible protein (HDP) diet recorded the highest concentrations of both essential and non-essential amino acids, including leucine (8.32 g/100 g CP) and glutamic acid (13.03 g/100 g CP). Among the senna seed meals, RSSM generally had higher amino acid concentrations than the processed meals, with histidine reaching 2.71 g/100 g CP. Fermented senna seed meal (FSSM) recorded the lowest values for most amino acids, while BSSM showed appreciable levels, particularly in histidine (2.63 g/100gCP).

Standardised ileal amino acid digestibility of processed senna seed meal-based diet fed to broiler chickens

The SIAAD of the experimental diets fed to broiler chickens showed significant ($p < 0.05$) variations across treatments (Table 2). Across all, there is consistency with the Highly Digestible Protein (HDP) diet recording the highest digestibility values, while the RSSM diet had the least, except for methionine (82.36%), cystine (75.72%), and tyrosine (62.50%). The HDP diet showed superior digestibility in methionine (91.96%), glutamic acid (95.41%), cystine (91.42%), and proline (92.38%). FSSM diet maintained higher digestibility in leucine (74.53%), lysine (70.52%), phenylalanine (73.50%), and threonine (66.25%) compared to BSSM and RSSM while the boiled senna seed meal (BSSM) diet exhibited intermediate values across amino acids.

Discussion

Amino acid profile of raw and processed *Senna occidentalis* seed meal

The higher concentrations of essential and non-essential amino acids observed in the highly digestible protein (HDP) diet were expected because whey protein is recognised for its superior amino acid balance and protein quality (Minj and Anand, 2020). Compared with the values reported by Augustine *et al*. (2014), raw *Senna*

occidentalis seed meal in the present study contained lower concentrations of lysine, methionine and phenylalanine, although glutamic acid remained the predominant amino acid in both studies. Variations may be attributed to differences in seed source and processing conditions.

Table 1: Amino acid profile of raw and processed *Senna occidentalis* seed meal

AA PROFILE	*HDP*	*RSSM*	*FSSM*	*BSSM*	*SEM*	*P value*
Essential amino acid (g/100g CP)						
Arginine	7.83^{a}	5.33^{b}	3.58^{d}	4.10^{c}	0.38	0.001
Histidine	2.62^{c}	2.71^{a}	2.43^{d}	2.63^{b}	0.02	0.001
Isoleucine	4.53^{a}	4.03^{b}	3.61^{d}	3.81^{c}	0.08	0.001
Leucine	8.32^{a}	6.43^{b}	5.61^{d}	6.31^{c}	0.23	0.001
Lysine	6.27^{a}	3.74^{b}	3.23^{d}	3.53^{c}	0.28	0.001
Methionine	1.43^{a}	0.85^{b}	0.63^{d}	0.74^{c}	0.07	0.001
Phenylalanine	5.01^{a}	3.25^{b}	3.16^{c}	3.07^{d}	0.18	0.001
Threonine	3.76^{a}	3.62^{b}	3.08^{d}	3.31^{c}	0.00	0.001
Tryptophan	1.44^{a}	0.72^{b}	0.66^{c}	0.62^{d}	0.08	0.001
Valine	5.03^{a}	4.41^{b}	3.67^{d}	4.13^{c}	0.11	0.001
Non- essential amino acid (g/100g CP)						
Alanine	4.60^{a}	3.62^{b}	4.49^{a}	3.47^{b}	0.16	0.001
Aspartic acid	10.03^{a}	7.01^{b}	6.52^{d}	6.81^{c}	0.33	0.001
Cystine	2.01^{a}	0.62^{d}	0.67^{c}	0.77^{b}	0.13	0.001
Glutamic acid	13.03^{a}	9.62^{b}	8.03^{d}	9.05^{c}	0.43	0.001
Glycine	4.39^{a}	4.07^{b}	3.57^{d}	3.85^{c}	0.07	0.001
Proline	3.58^{a}	3.24^{b}	2.74^{d}	3.04^{c}	0.07	0.001
Serine	4.31^{a}	4.02^{b}	3.53^{d}	3.73^{c}	0.07	0.001
Tyrosine	3.76^{a}	2.69^{b}	2.23^{d}	2.42^{c}	0.14	0.001

^{abcd} Means on the same row with different superscripts are significantly ($p<0.05$) different. RSSM = Raw Senna seed meal, FSSM = Fermented Senna seed meal, BSSM = Boiled Senna seed meal, HDP = Highly digestible protein

Table 2: Standardised ileal amino acid digestibility of experimental diets fed to broiler chickens

AA PROFILE	*HDP*	*RSSM*	*FSSM*	*BSSM*	*SEM*	*P value*
Essential amino acid (%)						
Arginine	80.74^{a}	49.59^{d}	65.65^{b}	58.08^{c}	2.63	0.001
Histidine	84.08^{a}	63.26^{d}	76.84^{b}	65.60^{c}	1.94	0.001
Isoleucine	77.89^{a}	46.96^{d}	61.31^{b}	59.99^{c}	2.52	0.001
Leucine	82.78^{a}	57.70^{d}	74.53^{b}	69.46^{c}	2.08	0.001
Lysine	76.39^{a}	53.06^{d}	70.52^{b}	68.29^{c}	1.98	0.001
Methionine	91.96^{a}	82.36^{c}	89.57^{b}	79.75^{d}	1.15	0.001
Phenylalanine	84.44^{a}	58.38^{d}	73.50^{b}	60.27^{c}	2.43	0.001
Threonine	77.67^{a}	43.81^{d}	66.25^{b}	53.55^{c}	2.94	0.001
Tryptophan	90.70^{a}	66.78^{d}	79.58^{b}	73.34^{c}	2.02	0.001
Valine	81.27^{a}	49.76^{d}	59.61^{c}	66.49^{b}	2.65	0.001
Non- essential amino acid (%)						
Alanine	81.65^{a}	52.90^{d}	70.51^{b}	63.27^{c}	2.41	0.001
Aspartic acid	71.03^{a}	52.73^{d}	70.56^{b}	65.93^{c}	1.70	0.001
Cystine	91.42^{a}	75.72^{c}	83.00^{b}	61.78^{d}	2.50	0.001
Glutamic acid	95.41^{a}	69.05^{d}	80.02^{b}	69.35^{c}	2.46	0.001
Glycine	81.65^{a}	47.88^{d}	68.22^{b}	60.80^{c}	2.80	0.001
Proline	92.38^{a}	55.76^{d}	70.70^{c}	72.04^{b}	2.99	0.001
Serine	86.02^{a}	46.92^{d}	68.88^{b}	65.16^{c}	3.19	0.001
Tyrosine	82.92^{a}	62.50^{c}	76.09^{b}	61.83^{d}	2.07	0.001

^{abcd} Means on the same line row with different superscripts are significantly ($p<0.05$) not the same. RSSM - Raw Senna seed meal, FSSM =Fermented Senna seed meal, BSSM=Boiled senna seed meal, HDP = Highly digestible protein

The relatively low concentrations of lysine, methionine and cystine observed in the senna seed meals agree with the findings of Augustine *et al*. (2014), who reported deficiencies of sulphur-containing amino acids in *S. occidentalis*. Processing influenced the amino acid composition of the seed meal. Fermentation maintained or slightly improved some amino acids, which may be associated with microbial modification of seed proteins (Sun *et al*., 2022). In contrast, boiling reduced the concentrations of several amino acids, consistent with reports of heat-induced degradation and leaching during processing (Augustine, 2018).

Standardised ileal amino acid digestibility of processed Senna occidentalis seed meal

Standardised ileal amino acid digestibility (SIAAD) differed significantly among treatments, with the HDP diet recording the highest digestibility coefficients and the raw senna seed meal (RSSM) diet the lowest. The superior digestibility of the HDP diet was expected because highly digestible protein sources contain fewer structural barriers and antinutritional compounds that may limit amino acid utilisation.

The improved SIAAD values observed in the processed senna seed meals indicate that processing enhanced amino acid availability. This finding agrees with Diarra (2021), who reported that processing reduces antinutritional factors and improves nutrient utilisation in unconventional feed ingredients. Among the processed meals, fermented senna seed meal (FSSM) generally produced higher digestibility coefficients than boiled senna seed meal (BSSM). This may be attributed to microbial activity during fermentation, which can partially degrade complex proteins and antinutritional compounds, thereby increasing the accessibility of amino acids to digestive enzymes (Ohanenye *et al*., 2022).

The lower digestibility values observed in RSSM may be due to the presence of residual tannins, phytates and other antinutritional factors known to interfere with protein digestion and amino acid absorption (Augustine *et al*., 2017). Although boiling improved digestibility relative to RSSM, its effect was generally less pronounced than fermentation, suggesting that microbial modification of the seed matrix may be more effective than heat treatment alone in enhancing amino acid utilisation.

Conclusion

Processing improved the standardised ileal amino acid digestibility of *Senna occidentalis* seed meal in broiler chickens, with fermented seed meal generally exhibiting higher percentage digestibility than boiled and raw seed meals. The lower digestibility observed in the raw seed meal proves the negative influence of antinutritional factors on amino acid utilisation. These findings suggest that fermentation is an effective processing method for enhancing the nutritional value of *Senna occidentalis* seed meal and support its potential use as an alternative protein source in broiler diet formulation.

Declarations

Ethical Approval Certificate

The experimental procedures of this study were approved by the Local Animal Care and Ethics Committee of the University of Ibadan, with approval number UI-ACUREC/063-0125/09.

Author Contribution Statement

A. F., Adediji and O. V., Ojo,: Data collection, investigation, formal analysis, methodology, project administration and writing the original draft

O., Taiwo and K. A., Adekola: Data collection and Project administration

A. F. Agboola: Supervision, Conceptualization, Review and editing

Conflict of Interest

The authors declare no conflict of interest.

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