



EFFECT OF DIETARY SOYBEAN CHEESE WASTE ON GROWTH PERFORMANCE, NUTRIENT RETENTION, AMINO ACID PROFILE AND MEAT QUALITY OF RABBITS

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ABSTRACT

The increasing cost of conventional feed ingredients has necessitated the exploration of alternative, sustainable, and cost-effective feed resources in rabbit production. Soybean cheese waste (SCW), a by-product of soy milk and cheese processing, is a nutrient-rich feed resource with high protein and appreciable levels of essential amino acids. This study evaluates the role of Soybean cheese waste in improving rabbit growth performance and meat quality, focusing on amino acid composition, pH, water holding capacity (WHC), drip loss, and cooking loss of rabbit meat. The study was conducted using 60 weaned rabbits with initial body weights of 678 ± 15 g, fed over 9090 days and randomly distributed to one of these treatments (T) (T1 = 0%, T2 = 25%, T3 = 35% and T4 = 45% SCW inclusion). Results showed rabbits fed SCW 35% had better FCR than the control, and rabbits with SCW inclusion had better carbohydrate, crude fat and ash digestibility and compared favourably with the control in crude protein digestibility and retention. Furthermore, Rabbits fed SCW diets had better ($P < 0.05$) WHC and pH with a favourable ($P > 0.05$) amino acid profile compared to the control. These results indicate that Soybean cheese waste inclusion enhances muscle protein deposition, stabilizes post-mortem pH, and increases WHC while reducing drip and cooking losses. These improvements contribute to better meat texture, juiciness, and overall consumer acceptability. The findings thus support that soybean cheese waste could serve as an alternative to a conventional feedstuff for rabbit meat production.

Keywords: Amino acid profile, Growth performance, Meat quality, Soybean cheese waste

INTRODUCTION

Rabbit production is gaining global attention due to its efficiency in converting low-cost feed into high-quality animal protein. Rabbit meat is characterized by high protein content, low fat, a favorable amino acid profile, and excellent digestibility (Dalle Zotte and Szendrő, 2011), making it suitable for human consumption. However, its overall quality, defined by parameters such as tenderness, juiciness, pH, water holding capacity (WHC), drip loss, and cooking loss, is largely influenced by nutrition (Wani *et al.*, 2021). These meat quality traits significantly influence consumer acceptance and market value.

In recent years, attention has shifted toward the use of agro-industrial by-products as alternative feed resources to reduce feed cost, improve product quality, and maintain the principles of circular agriculture, sustainability, and waste minimization (Omoikhoje *et al.*, 2008). One such by-product is okara (soybean cheese chaff), which is abundantly available in regions where soy products are processed, including Nigeria.

Soybean cheese waste contains substantial amounts of crude protein (17.85%), fibre (13.38%) and essential amino acids such as lysine and leucine. These nutrients are critical for muscle development and post-mortem biochemical processes affecting meat quality; according to Kong *et al.* (2022), dietary protein sources significantly influence carcass characteristics and meat physicochemical properties in rabbits. High-quality dietary protein sources improve carcass composition and amino acid balance in rabbit meat (Kong *et al.*, 2022) by increasing nitrogen retention and muscle protein accretion.

In rabbits, increased dietary protein improves digestible crude protein intake and efficiency of utilization for growth. Dietary protein influences the protein concentration of rabbit meat by improving amino acid deposition in muscle tissues (Xiccato, 2010), thus enhancing the nutritional value of rabbit meat for human consumption. Meat pH is a critical determinant of meat quality, influencing shelf life, colour and water retention (Wang *et al.*, 2018). Optimal ultimate pH values for rabbit meat range from 5.5-5.8 (Kindossi, 2021), indicating good quality meat.

Water-holding Capacity (WHC) is the ability of meat to retain water during processing and storage. It is a major determinant of meat texture and overall quality. Protein structure stability enhances moisture retention, and protein functionality is strongly linked to water retention in muscle tissues (Wani *et al.*, 2021). This is due to the presence of hydrophilic

amino acids like lysine, arginine, histidine, glutamine, and glutamic acid, which improve water binding. The nutrient composition of Soybean cheese waste contributes to stronger protein networks, enhancing water retention and reducing drip loss during storage, thus improving juiciness.

Drip loss refers to fluid loss during storage. It affects meat appearance and weight. A stronger protein matrix retains intracellular water; improved WHC minimizes exudate formation, thus lowering drip loss percentages, reducing nutrient loss, and improving the visual appeal of meat. Cooking loss represents the total loss of water and fat during cooking. It is inversely related to WHC and protein quality (Wang *et al.*, 2018). Protein denaturation influences water expulsion, and Soybean cheese waste improves fat binding and protein stability, thus reducing cooking loss, maintaining higher cooking yield, and improving sensory qualities like tenderness and palatability.

Soybean cheese waste is an abundant and readily available by-product of soybean processing industries, generated during the production of soybean cheese and soymilk. The increasing global demand for soy-based foods has resulted in the continuous production of large quantities of soybean cheese waste, much of which remains underutilised despite its valuable nutrient content. Its widespread availability, low cost and year-round production make it a promising alternative feed resource for livestock and rabbit production systems (Singh and Krishnaswamy, 2022; Malencia *et al.*, 2023)

This study examines its role in improving amino acid composition and meat quality parameters.

MATERIALS AND METHODS

The experiment was conducted at the Rabbitry Unit of Highbreed Model School Farm along Kwara Poly Road, Eleko Area, Ilorin, Kwara State. The farm lies at approximately latitude 8.3429 0N and longitude 4.4796 0E. A total of 60 healthy, weaned rabbits, aged 4 weeks, with an average initial body weight of 690 g, were used for the experiment. Before the commencement of the experiment, rabbits were acclimatized for 14 days, during which they were fed a standard grower rabbit diet and provided clean drinking water *ad libitum*. Routine management practices, including cage sanitation and proper health monitoring, were strictly observed throughout the experimental period.

The experiment was laid out in a Completely Randomized Design (CRD). Rabbits were randomly allocated to four dietary treatments with 3 replicates per treatment and 5 rabbits per replicate. The dietary treatments consisted of graded levels of soybean cheese waste (SCW) supplementation as follows:

T₁ (Control): 0% Soybean Cheese Waste; T₂: 25% Soybean Cheese Waste; T₃: 35% Soybean Cheese Waste; T₄: 45% Soybean Cheese Waste

Table 1: Experimental Diet Formulation

Ingredients	T1 (0%)	T2 (25%)	T3 (35%)	T4 (45%)
Maize	35.40	35.40	35.40	35.40
Soybean Meal (SBM)	26.00	19.500	16.90	14.30
Soybean Cheese Waste (SCW)	0.00	6.50	9.10	11.70
Wheat bran	27.00	27.00	27.00	27.00
PKC	8.00	8.00	8.00	8.00
Bone Meal	2.00	2.00	2.00	2.00
Vitamin	0.80	0.80	0.80	0.80
Salt	0.80	0.80	0.80	0.80
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
Crude Protein (%)	19.95	18.85	18.42	17.98
ME Kcal/kg	2501.00	2485.00	2478.00	2472.00
Crude Fibre (%)	6.82	6.92	6.96	7.00
Ether Extract (%)	3.53	4.08	4.30	4.52
Calcium (%)	0.72	0.72	0.72	0.73
Phosphorus (%)	0.71	0.70	0.70	0.69

No forage supplement was used because diets were formulated to meet the nutrient requirements of growing rabbits.

Data Collection

Soybean cheese waste is a fibrous residue rich in protein and bioactive compounds. From proximate analysis conducted using the AOAC (1999) method, the moisture, crude protein, crude fat, total ash and crude fibre contents were determined, and carbohydrate content calculated.

Data were collected on initial body weight, final body weight, feed intake, and feed conversion ratio. The initial body weight of the Rabbits was the weight of the rabbits measured at the beginning of the experiment. The final body weight was the weight of the rabbits taken at the end of the twelfth week of the experiment. Feed intake was evaluated as the difference between the feed given and the leftover after 24 hours. Weight gain was calculated as the difference between the final body weight and the initial body weight of the rabbits. The feed conversion ratio was determined by dividing feed intake by body weight gain.

Nutrient digestibility was determined during the 12th week of the feeding trial. Three rabbits were randomly selected from each dietary treatment and housed individually for fecal collection. Rabbits were offered 150 g of feed daily, and feed intake was recorded. Faecal samples were collected quantitatively for 72 hours, weighed fresh, and subsequently oven-dried at 60 °C for 72 hours to obtain constant weight. The dried faecal samples were re-weighed, ground and analysed for proximate composition. Feed samples were similarly analysed. Proximate analyses of both feed and faecal samples were conducted according to the methods of the Association of Official Analytical Chemists (AOAC, 2005). Apparent nutrient digestibility coefficients were calculated from the differences between nutrient intake and nutrient excretion in the faeces.

To determine pH, 5 g of muscle from the loin (*Longissimus lumborum*) was cut and placed in a clean porcelain mortar; 10 mL of distilled, deionized water was added and ground to form a slurry. The slurry was transferred to a 25 ml beaker, and a calibrated pH electrode, which had been standardized with a known pH, was inserted into it, allowed to stabilize for 5 minutes and then the pH was read.

The drip loss was determined using the bag method (Honikel, 1987). Muscle from the loin (*Longissimus lumborum*) weighing 50 g was cut and all subcutaneous fat trimmed off. It was suspended in an airtight, inflated nylon bag using twine to ensure it didn't touch the sides or

bottom of the bag. The sample was stored in a refrigerator at 4 °C for 48 hours. It was then taken out carefully and gently dabbed with serviette paper to remove all surface water and weighed again.

The cooking loss was determined using the boiling method. Muscle from the hind leg weighing 10 g was cut and dipped into boiling water for 10 minutes. It was then cooled to room temperature and weighed again.

The water holding capacity was determined using the Filter Paper Press Method (Grau and Hamm Method). At the end of the twelve-week feeding trial, 5 g of muscle was cut from the loin (*Longissimus lumborum*) and stored for 24 hours, after which it was dabbed gently with a serviette paper to remove surface moisture. It was then placed on a dry, weighed filter paper, which was then placed between two glass plates and compressed with a load of 2.5 kg for 5 minutes. The muscle was then removed, and the filter paper was rapidly weighed to calculate the weight of water released from the meat.

The Amino Acid profile in the samples was determined using the AOAC (2006) method; however, the method was slightly modified. The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer, which separated the amino acids. The separated amino acids from the column reacted with combined tetrahydrofuran and acetonitrile to form phenylthiohydantoin (PTH) amino acids. The detector measured the absorbance of each (PTH) amino acid proportional to their concentration.

Data Analysis

Data obtained from all determined and calculated parameters were subjected to ANOVA using the PROC UNIVARIATE procedure of the SAS package (2014). Means were separated using the Turkey HSD test at a $P < 0.05$ significance level

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RESULTS

Table 2: Proximate Composition

Parameters	Value (%)
Moisture content	8.51
Crude Protein	17.85
Total Ash	2.67
Crude Fibre	13.38
Crude Fat	5.54
Carbohydrate	52.05

Growth Performance

The results of dietary graded levels of SCW on growth performance of the Rabbits are presented in Table 3. Regardless of the Rabbits on dietary treatments SCW (0%), SCW (25%), SCW (35%) and SCW (45%), there were significant differences ($P<0.05$) in the final body weight (FBW), weight gain (WG), feed intake (FI), water intake (WI) and feed conversion ratio (FCR). There were no significant differences ($P>0.05$) in the initial body weight (IBW) of the Rabbits across the treatments. Rabbits on dietary SCW (35%) treatment had a higher ($P<0.05$) FBW and WG values than Rabbits on other treatments while maintaining similarity ($P>0.05$) with those on SCW (0%). Rabbits on SCW (45%) treatment had significantly higher ($P<0.05$) FBW and WG than rabbits on SCW (25%) treatment, which had the lowest ($P<0.05$) FBW and WG values. Rabbits on dietary SCW (0%) treatment had a higher ($P<0.05$) FI value than Rabbits on other treatments. Rabbits on SCW (45%) treatment had a significantly higher ($P<0.05$) FI value than rabbits on SCW (35%) treatment and similar to those on SCW (25%) treatment, which were in turn also similar to those on SCW (35%) treatment, which had the lowest ($P<0.05$) FI value. There were similarities ($P<0.05$) in the FCR of the Rabbits on SCW (0 and 45%) treatments but were significantly higher ($P<0.05$) in FCR than those Rabbits on SCW (35%) treatment and lower than those on SCW (25%) treatment.

The result of the effect of SCW inclusion on residual nutrient retention of weaner Rabbits is presented in Table 4. Regardless of the dietary treatments fed to the experimental Rabbits, there were significant differences ($P<0.05$) in the crude protein (CP), ash (AS), crude fibre (CF) and carbohydrate (CHO) of the retained nutrients. Rabbits on SCW (45%) had the highest CP value, followed by those fed SCW (35%), then those fed SCW (25%) and those fed SCW (0%), with the lowest CP value. Rabbits fed SCW (35% and 45%) had similar ($P>0.05$) ash values, while rabbits on SCW (25%) had the highest value, which was significantly higher ($P<0.05$) than those fed SCW (0%). Rabbits on SCW (25%) treatment had the highest CF value, which was significantly higher ($P<0.05$) than those in treatments (0, 35 and 45%), all of which are also significantly different ($P<0.05$), with the values decreasing in order. Rabbits on SCW (0 and 25%) treatments had similar CF ($P>0.05$) values but were significantly lower ($P>0.05$) compared with those Rabbits on SCW (35 and 45%) treatment, with SCW (45%) having the highest CF value and being significantly different ($P<0.05$) from SCW (35%). Similarly, there was a significant difference ($P<0.05$) in CHO values in the Rabbits along the row. Rabbits on SCW (45%) treatment had the lowest value, while those on SCW (0%) treatment had the highest value. Rabbits on SCW (25 and 35%) treatments were also significantly different ($P<0.05$)

Table 3: Effect of Dietary Soybean Cheese Waste on Growth Performance of Grower Rabbits

Parameters	Treatments				SEM	P-value
	SCW (0%)	SCW (25%)	SCW (35%)	SCW (45%)		
IBW (g/r)	667.00	688.00	667.00	693.00	12.67	0.06
FBW (g/r)	2900.00 ^a	2300.00 ^c	2992.00 ^a	2700.00 ^b	34.80	<0.0001
WG (g/r/w)	26.58 ^a	19.24 ^c	27.85 ^a	23.96 ^b	0.45	<0.0001
FI (g/r/w)	35.67 ^a	31.67 ^{bc}	29.56 ^c	33.11 ^b	0.55	0.0003
FCR (%)	1.30 ^b	1.64 ^a	1.05 ^c	1.37 ^b	0.03	<0.0001

^{a, b, c} means having different superscripts along the same row are significantly different ($P<0.05$). IBW- initial body weight, FBW- final body weight, WG- weight gain, FI- feed intake, FCR- feed conversion ratio, g-gram, r- rabbit, w-week, SCW- soybean cheese waste.

Table 4: Effect of Dietary Soybean Cheese Waste on Nutrient Retention of Grower Rabbits

Parameters		Treatments					
		SCW (0%)	SCW (25%)	SCW (35%)	SCW (45%)	SEM	P-value
Crude Protein (%)		10.27 ^d	10.68 ^c	11.10 ^b	11.54 ^a	0.01	<0.0001
Ash (%)		14.50 ^b	14.59 ^a	14.37 ^c	14.40 ^c	0.01	<0.0001
Crude Fiber (%)		19.25 ^b	19.53 ^a	18.56 ^c	17.95 ^d	0.02	<0.0001
Crude Fat (%)		2.52 ^c	2.48 ^c	2.87 ^b	3.02 ^a	0.01	<0.0001
CHO (%)		46.12 ^a	45.39 ^b	45.32 ^c	45.17 ^d	0.01	<0.0001

a, b, c means having different superscripts along the same row are significantly different ($P < 0.05$). SCW- soybean cheese waste, CHO – carbohydrate, SEM – sum of error means, % - percentage

From the results of dietary graded levels of SCW on meat qualities of the Rabbits as presented in Table 5, there was a significant difference ($P < 0.05$) along the rows in all treatments for the pH, drip and cooking losses. Drip and cooking losses were highest ($P < 0.05$) in Rabbits fed SCW (0%) diets and lowest in those fed SCW (45%) diets. Rabbits on SCW (25%) were also significantly different ($P < 0.05$) from those on SCW (35%), having a higher value. pH and water holding capacity values were also significantly different ($P < 0.05$) along the rows, with the highest values at SCW (45%) treatment and the lowest value at SCW (0%) treatment. Rabbits on SCW (35%) treatment have higher WHC values and are significantly different ($P < 0.05$) from those fed SCW (25%) diets.

Table 6 shows the results of the effects of graded levels of dietary SCW on fed SCW (0 and 25%) treatments had similar ($P > 0.05$) Leucine (LEU), Proline (PRO), Tyrosine (TYR) and Serine (SER) values and were significantly different ($P < 0.05$) from Rabbits fed SCW (35 and 45%) amino acid profile of the Rabbit meat. There were significant differences ($P < 0.05$) in the amino acid profile of the carcass of rabbits regardless of their different dietary

Table 5: Effect of Dietary Soybean Cheese Waste on Meat Quality (Physicochemical Properties) of Grower Rabbits

Parameters	Treatments				SEM	P-value
	SCW (0%)	SCW (25%)	SCW (35%)	SCW (45%)		
pH	5.00 ^d	5.50 ^c	5.80 ^b	6.20 ^a	0.10	<0.0001
Drip Loss	6.50 ^a	5.67 ^b	5.06 ^c	3.53 ^d	0.11	<0.0001
Cook Loss	4.91 ^a	3.95 ^b	3.10 ^c	2.70 ^d	0.065	<0.0001
WHC	21.13 ^d	26.80 ^c	28.60 ^b	53.21 ^a	0.35	<0.0001

^{a, b, c} means having different superscripts along the same row are significantly different ($P < 0.05$). WHC – water holding capacity, SCW- soybean cheese waste.

treatments. Rabbits treated with SCW (35%) had higher values. There were significant differences ($P < 0.05$) along the rows for Isoleucine (ISO), Phenylalanine (PHENYL), Valine (VAL), Alanine (ALA), Glutamic acid (GLU), Arginine (ARG), Cysteine (CYS) and Glycine (GLY) values in all treatments, where rabbits on SCW (0%) diets had the highest values and those on SCW (45%) diet had the lowest values. Rabbits on SCW (25 and 35%) treatments showed no significant differences ($P > 0.05$) in TRY, METH, THRE and ASP. Also, there was similarity ($P > 0.05$) in TRY values in rabbits on SCW (35% and 45%) treatments.

DISCUSSIONS

Growth Performance

The growth performance of Rabbits on SCW 0 and 35% treatments exhibited higher values of weight gain and ultimately body weight than the other treatments, probably due to greater digestion, absorption, and utilization of nutrients. This result supports findings by Osho *et al.* (2020) that moderate levels of fibre improve live weight gain and feed utilization compared with low-fibre diets, which results in poor growth performance and unfavourable feed conversion ratios. The feed conversion ratio of rabbits on SCW 35 % was best compared with other dietary treatments. This indicates that rabbits on SCW 35 % utilized their feed more

efficiently than rabbits on other dietary treatments. This supports findings by Trocino *et al.* (2015) and Martignon *et al.* (2017) who reported that diets with balanced neutral detergent fibre (NDF) levels supported optimal nutrient digestibility while maintaining gut health. Furthermore, this agrees with the observation that fibre improves gut motility and limits the proliferation of pathogenic bacteria by maintaining an appropriate rate of digesta passage (Gidenne *et al.*, 2020), while also improving live weight gain and feed utilization due to favourable feed conversion ratios (Osho *et al.*, 2020).

Table 6: Effect of Dietary Soybean Cheese Waste on Amino Acid Profile of Grower Rabbits

Parameters	Treatments				SEM	P-value
	SCW (0%)	SCW (25%)	SCW (35%)	SCW (45%)		
LEU	7.70 ^a	7.53 ^a	7.12 ^b	5.56 ^c	0.08	<0.0001
LYS	7.86 ^a	7.51 ^{ab}	7.20 ^b	5.54 ^c	0.10	<0.0001
ISO	4.47 ^a	4.20 ^b	3.88 ^c	3.13 ^d	0.05	<0.0001
PHENYL	4.18 ^a	3.80 ^b	3.56 ^c	3.20 ^d	0.04	<0.0001
TRY	1.49 ^a	1.30 ^b	1.21 ^{bc}	1.12 ^c	0.03	<0.0001
VAL	4.95 ^a	4.46 ^b	4.00 ^c	3.02 ^d	0.09	<0.0001
METH	2.65 ^a	2.44 ^b	2.36 ^b	2.13 ^c	0.05	0.0003
PRO	3.71 ^a	3.44 ^a	3.03 ^b	2.63 ^c	0.07	<0.0001
ARG	6.33 ^a	5.66 ^b	5.02 ^c	4.11 ^d	0.05	<0.0001
TYR	3.41 ^a	3.30 ^a	2.77 ^b	2.11 ^c	0.07	<0.0001
HIS	3.80 ^a	3.65 ^a	3.37 ^b	2.40 ^c	0.06	<0.0001
CYS	1.23 ^a	1.12 ^b	0.88 ^c	0.74 ^d	0.02	<0.0001
ALA	6.62 ^a	5.80 ^b	5.31 ^c	3.66 ^d	0.09	<0.0001
GLU	16.21 ^a	14.08 ^b	12.44 ^c	10.00 ^d	0.04	<0.0001
GLY	4.55 ^a	4.16 ^b	3.33 ^c	2.36 ^d	0.17	<0.0001
THRE	4.20 ^a	3.60 ^b	3.47 ^b	2.61 ^c	0.05	<0.0001
SER	4.31 ^a	3.98 ^a	3.60 ^b	2.93 ^c	0.08	<0.0001
ASP	8.77 ^a	7.85 ^b	7.55 ^b	5.06 ^c	0.07	<0.0001

a, b, c means having different superscripts along the same row are significantly different (P< 0.05). LEU – leucine, LYS – lysine, ISO – isoleucine, PHENYL – phenylalanine, TRY – tryptophan, VAL – valine, METH – methionine, PRO – proline, ARG – arginine, TYR – tyrosine, HIS – histidine, CYS – cysteine, ALA – alanine, GLU – glutamic acid, GLY – glycine, THRE – threonine, SER – serine, ASP – aspartic acid.

Nutrient Digestibility

The superior digestibility and availability of more protein and fat in the SCW 45% diet prevented excessive excretion of nutrient constituents in the digested feed, leading to substantial retention (g/rabbit) and improved retention efficiency of protein in the form of

amino acids; low digestibility of CHO and CF resulted in excessive excretion of carbohydrate and fibre in the digested feed. These findings from this study support conclusion that high levels of fibre generally reduce dry matter and energy digestibility due to increased rate of passage and reduced contact time with digestive enzymes (Gidenne *et al.*, 2020), while moderate inclusion of fermentable or soluble fibre improves nutrient digestibility (Trocino *et al.*, 2015), nitrogen utilization and caecal fermentation efficiency (Martignon *et al.*, 2017).

Meat Quality (Physicochemical Properties)

The pH is a key determinant of meat quality, as it directly affects water-holding capacity (Huff-Lonergan, 2009) and invariably drip loss and cooking loss. Rabbits on SCW diets had better pH, water-holding capacity and lower drip and cook losses compared to the control, with rabbits on SCW (35%) showing desirable pH ranges, which, according to Kindossi (2021), are between 5.5 – 5.8; while rabbits on SCW (45%) diets showed the best WHC result. These results agree with Mancini and Hunt (2005), who reported that post-mortem muscle pH strongly affects the functional properties of meat, particularly moisture retention and protein; thus, Soybean cheese waste improved energy metabolism by increasing glycogen reserves in muscle and supporting controlled lactic acid production post-mortem. This reduced microbial growth, prevented conditions like PSE (pale, soft exudative) meat and protein denaturation while also enhancing meat stability.

Amino acid profiles

The amino acid profile of rabbit meat was significantly ($P < 0.05$) influenced by dietary soybean cheese waste (SCW) inclusion. The results showed a progressive reduction in the concentrations of both essential and non-essential amino acids as the level of SCW increased from 0 to 45%. This trend indicates that increasing the replacement of soybean meal with soybean cheese waste reduced amino acid deposition in the muscle tissue of grower rabbits rather than improving it. These findings agree with the principle that the amino acid composition of animal tissues largely reflects the quantity and digestibility of dietary amino acids supplied by the feed (Carabaño *et al.*, 2010).

Among the essential amino acids, leucine, lysine, isoleucine, phenylalanine, tryptophan, valine, methionine, arginine, histidine, threonine and cysteine decreased significantly with

increasing SCW inclusion. For example, leucine declined from 7.70% in rabbits fed the control diet to 5.56% in rabbits fed 45% SCW, while lysine decreased from 7.86% to 5.54%. Since leucine and lysine are indispensable amino acids involved in muscle protein synthesis and tissue accretion, their reduction suggests that increasing dietary SCW reduced the availability of digestible amino acids required for efficient muscle protein deposition (Carabaño *et al.*, 2010).

The observed reduction may be explained by the relatively lower biological value of soybean cheese waste compared with conventional soybean meal. During soybean processing for cheese production, a substantial proportion of soluble proteins and amino acids are extracted into the soy milk, leaving the residual cheese waste with reduced protein quality. This observation agrees with van den Berg *et al.* (2022), who concluded that processing conditions significantly influence soy protein quality and amino acid digestibility, thereby affecting the nutritional value of soy-derived products. Consequently, replacing soybean meal with increasing levels of SCW may dilute the dietary supply of digestible essential amino acids, resulting in lower amino acid deposition in rabbit muscle. The decline in amino acid concentrations observed at higher levels of soybean cheese waste inclusion suggests that the nutritional quality and digestibility of the residual soybean protein may have been reduced during soybean processing. Residual antinutritional factors may also have contributed to the decline in amino acid concentrations. Although heat processing considerably reduces trypsin inhibitors and phytate, residual quantities may remain and reduce protein digestibility and amino acid absorption. Furthermore, soybean cheese waste generally contains more fibre than soybean meal, and excessive dietary fibre may reduce nutrient digestibility by limiting enzyme access to nutrients or increasing digesta passage rate. Such reductions in protein utilization ultimately decrease amino acid availability for muscle protein synthesis (Carabaño *et al.*, 2010).

Although the amino acid concentrations declined with increasing dietary SCW, this finding should not be interpreted to mean that soybean cheese waste is unsuitable as a rabbit feed ingredient. Studies by Sudik (2020), Iyeghe-Erakpotobor and Esievo (2021), Abdullahi (2023), and Magaji *et al.* (2024) have demonstrated that soybean cheese waste can successfully replace part of conventional protein sources while maintaining acceptable growth performance, nutrient digestibility, and reducing feed cost, particularly at moderate inclusion levels. The present findings therefore suggest that while SCW is an economically

valuable alternative feed resource, excessive replacement of soybean meal may compromise the amino acid composition of rabbit meat. Consequently, moderate dietary inclusion levels or supplementation with limiting amino acids may be necessary to maintain meat nutritional quality while exploiting the economic advantages of soybean cheese waste.

CONCLUSION

Dietary soybean cheese waste significantly affected the amino acid profile of grower rabbits. The progressive decline observed in both essential and non-essential amino acids as the inclusion level increased indicates that high dietary replacement of soybean meal with SCW reduced amino acid deposition in rabbit muscle. This reduction is likely associated with the comparatively lower biological quality of residual soybean cheese waste protein, possible losses of soluble proteins during soybean processing, higher fibre content and reduced amino acid digestibility. These findings are consistent with established knowledge that dietary protein quality and amino acid digestibility are major determinants of muscle protein deposition in rabbits.

Nevertheless, considering the favourable growth performance, nutrient retention and physicochemical properties observed in this study, soybean cheese waste remains a promising unconventional feed ingredient when used at moderate dietary levels. Moderate inclusion rates may provide a balance between reducing feed costs and maintaining acceptable meat nutritional quality. Therefore, soybean cheese waste should be combined with high-quality protein sources like groundnut cake (GNC) or synthetic amino acids to improve the overall amino acid balance of rabbit diets.

RECOMMENDATIONS

Based on the results obtained from this study, dietary soybean cheese waste can be incorporated into diets of grower rabbits at up to a 35% replacement level, as it improved growth performance, feed conversion efficiency, nutrient retention, and meat quality characteristics without adverse effects on the rabbits. However, it should be properly sun-dried to prevent microbial spoilage and increase shelf-life. Further studies should investigate processing techniques capable of improving the protein quality and digestibility of soybean cheese waste before its use at higher dietary inclusion levels.

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