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Journal of World's Poultry Science. 2025; 4(3): 63-69.

DOI: 10.58803/jwps.v4i3.73

http://jwps.rovedar.com/

Research Article

Growth Performance and Carcass Traits of Broiler Chicken Fed on Diets Containing Rumen Filtrate Fermented by Cassava Meal

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ARTICLE INFO

Article History:
Received: 02/07/2025
Revised: 10/08/2025
Accepted: 23/08/2025
Published: 03/09/2025

check for updates

Keywords:
Carcass quality
Fermented cassava
Growth parameter
Maize

ABSTRACT

Introduction: Maize serves as a primary energy source in poultry diets; however, rising human demands are reducing its sustainable usage, which has led to the search for more affordable alternatives such as cassava root meal. The present study evaluated key performance indicators, including feed intake, body weight gain (BWG), feed conversion ratio (FCR), dressing percentage, and carcass traits, in broiler chickens fed a diet of rumen filtrate-fermented cassava meal.

Materials and methods: A total of 96 Ross 306 one-day-old broiler chickens of mixed sex, and an average weight of 45 ± 5 g, were fed in a 42-day experimental trial at the Tatoon farm of Egerton University, Nakuru, Kenya. The chickens were fed four diets with different inclusion levels of rumen-filtrate-fermented cassava root meal (RFFCM) as a replacement for maize. The control diet contained 0% RFFCM (T1), T2 contained 15% RFFCM, T3 contained 30% RFFCM, and T4 contained 45% RFFCM. Data on daily feed intake and weekly BWG were recorded during the experimental duration. At the end of the study, during the growing phase, data on live weight, carcass weight, and weights of the breast, thigh, wing, and dorsum were determined.

Results: The current findings revealed that a high inclusion of RFFCM significantly reduced feed intake without substantially altering the FCR, BWG, and average daily weight gain of the chickens per treatment compared to the control group. The present findings indicated a similarity in nutrient utilization and performance among broilers fed on the four treatments. Broilers fed on diets with 45% RFFCM inclusion exhibited the highest mean live weight (2151.75 g) and carcass weight (1524.75 g), with higher thigh and breast weights compared to the control group.

Conclusion: These findings indicated that RFFCM can be included in broiler diets up to 45% without detrimental effects on BWG, FCR, dressing percentage, and quality of the chicken carcass.

1. Introduction

In most developing countries, the livestock sector supports millions of small-scale farmers through food security[1-3], and poverty alleviation[4]. In this regard, the poultry subsector can potentially transform Kenya's economy[5] since the industry contributes about 3% to the national GDP with a trade value of more than Kenya Shillings (KES) 12.1 billion from marketed products such as meat and eggs[6]. Successful broiler chicken farming is highly dependent on high-quality energy-feed ingredients, mainly maize. However, the use of maize as an energy source in poultry feeds has become unsustainable due to competing demands[7] and climate change that affects its yields[8] thus the need for sustainable and affordable alternatives[9] such as cassava. Cassava (*Manihot esculenta crantz*) is widely grown in tropical countries like Kenya due to its high yield, conducive environment, and favorable soil conditions[10,11]. In animal nutrition, it is the leaves and roots that are popular[12,13]. Several studies have suggested cassava root meal as a potential alternative basal ingredient to maize in chicken diets[3,14], but with different results and recommendations on optimum replacement values. In addition, the use of cassava products in poultry nutrition has been limited by the presence of antinutrient factors, such as hydrogen cyanide, high fiber content, and low crude protein

Cite this paper as: Kizito G, Macharia King'ori A, and Kemboi F. Growth Performance and Carcass Traits of Broiler Chicken Fed on Diets Containing Rumen Filtrate Fermented by Cassava Meal. Journal of World's Poultry Science. 2025; 4(3): 63-69. DOI: 10.58803/jwps.v4i3.73

(CP) levels[15,16]. Therefore, for its efficient utilization, it needs to be processed[16] which can be done through the use of biotechnology. Microbes can denature and destroy cyanide compounds in the cassava[17]. Rumen filtrate can be used as an inoculum during the fermentation of cassava root meal for feeding broilers. The filtrate is the liquid part of materials collected from a ruminant animal's rumen contents. This liquid contains large populations of microbes such as bacteria, protozoans, and fungi that digest plant materials[18,19]. Findings of Aladi et al.[20], Egbune et al.[21], and Ojo et al.[22] have shown that fermentation reduces the cyanide and fiber contents of cassava while increasing its CP content. However, there are inconsistent results regarding the growth performance of broiler chickens fed diets containing rumen filtrate fermented cassava root meal, a gap that this study aimed to address. Rumen filtrate fermented cassava meal is a cost-effective, nutrient-rich, and easily digestible feed for broiler chickens, offering a valuable alternative ingredient for broiler diets[23]. The present study aimed to evaluate the performance and carcass traits of broilers fed with rumen filtrate fermented cassava meal.

2. Materials and Methods

2.1. Ethical approval

The materials and procedures of this study were approved by the Egerton University Research and Ethics Committee, with approval number EUISERC/APP/377/2024, and the National Commission of Science and Technology of Kenya, under license number NACOSTI/P/25/414913.

2.2. Study area

The study was conducted at the Tatoon Agricultural Park (TAP) of Egerton University, Njoro, Nakuru County, Kenya, and located 1,800 m above sea level. The mean annual rainfall is about 1000mm, and the temperature ranges from 17 to 22°C. The university's coordinates are 0°22’11.0” S and 35°55’58.0” E (Longitude: -0.369734; longitude: 35.932779)[24].

2.3. Animals

The experimental design was a completely randomized design with four treatments, three replicates, with eight broiler chickens per replicate. A total of 96 one-day-old Ross 306 broiler chickens of both sexes, with an average weight of 45 ± 5 g, were sourced from a commercial poultry breeder, Kenchic® LTD, Kenya. The chickens were then brooded together for three days before being separated into four treatments. During this period, the chickens were provided with a 24-hour lighting system using infrared heat chicken bulbs, maintaining an average temperature of 33°C. The temperature was then lowered by 3°C every week until it reached 24°C, and lighting was reduced to 15 hours in the final days of the experiment[25]. A commercial multivitamin (Amintotal, Laprovet, France) was administered in clean water starting on day seven of the experiment at a rate of 1g per 10 liters of water, following the manufacturer’s instructions[26]. The chickens were housed in deep litter pens measuring 1 square meter, whose floors were thoroughly cleaned with liquid soap and disinfected using Omnicide® (Mirius Health Care, UK)[27] before being filled with a 10cm deep layer of wood shavings. The chickens were fed once a day at 07:00 hours and given clean water *ad libitum*[28].

2.4. Experimental duration

The feeding experiment was conducted over 42 days, encompassing the starter, grower, and finisher stages. For the first three days, the chickens were fed together *ad libitum* on the control starter diet. On day four, 96 broilers whose initial weight was close to the mean of 90g were weighed and selected for the study. The chickens were then fed on the four diets until day 42. Four chickens were selected per treatment, and on day 43, they were euthanized and slaughtered humanely for meat quality and carcass analysis according to the procedure by Browning et al.[29] and Govindaiah et al.[30] with slight modifications.

2.5. Experimental diet

The diets were formulated according to NRC [31] standards to meet the CP, metabolizable energy, and crude fiber requirements of the broilers. Table 1 shows the calculated composition of the experimental diets, while Table 2 shows the analyzed composition of the diets. The rumen filtrate fermented cassava root meal (RFFCM) was included in the diets at 0% (T1), RFFCM at 15% (T2), RFFCM at 30% (T3), and RFFCM at 45% (T4) on a weight-for-weight basis to meet the nutrient demands outlined in the NRC[31].

Table 1. Starter (0 – 14 days) and grower (15 – 42 days) diets for Ross 306 broiler chicken

Ingredients	Starter diets				Finisher diets			
	Inclusion levels of RFFCM							
	T1	T2	T3	T4	T1	T2	T3	T4
	0%	15%	30%	45%	0%	15%	30%	45%
Maize meal	52.00	35.00	15.00	3.50	50.50	36.50	23.50	9.50
RFFCM	0.00	15.00	30.00	45.00	0.00	15.00	30.00	45.00
Soya bean meal	30.00	26.00	35.00	36.00	19.00	18.50	20.50	27.00
Fish meal (crushed omena)	4.50	6.00	6.00	7.00	5.50	6.00	6.00	6.50
Wheat bran	10.50	15.00	11.00	5.50	19.00	18.00	14.00	6.00
Di Calcium Phosphate	0.65	0.65	0.65	0.65	0.90	0.90	0.90	0.90
Vitamin and mineral premix	0.50	0.50	0.50	0.50	1.0	1.0	1.0	1.0
Methionine	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50

Lysine	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50
Limestone	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Toxin binder	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00
Meat booster	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Total parts	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ME (MJ/kg DM)	14.66	14.64	14.86	15.02	14.07	14.15	13.98	14.68
CP	23.39	22.74	23.26	22.63	17.86	17.72	17.78	18.04
CF	5.07	4.54	4.02	3.08	5.85	4.91	3.95	3.93

RFFCM: Dry cassava tubers fermented by adding rumen filtrate at a rate of 1ml of rumen filtrate to 10 g of fresh cassava tubers, ME: Metabolized energy (MJ/kg DM), DM: Dry matter, CP: Crude protein, CF: Crude fiber, Booster: Grower booster. T1: 0% of RFFCM, T2: 15% of RFFCM, T3: 30% of RFFCM, and T4: 45% of RFFCM.

Table 2. Chemical composition and *in vitro* dry matter digestibility of rumen filtrate fermented cassava meal starter and finisher diets for feeding the Ross 306 broiler chickens during the 42 days of the experiment

Parameters	Starter diets				Finisher diets			
	T1	T 2	T3	T4	T1	T2	T3	T4
DM (%)	93.91	93.20	93.31	93.6	93.58	93.54	93.61	93.61
ME (MJ/Kg DM)	15.13	14.92	15.01	15.18	15.11	14.10	14.89	15.63
CP (%)	23.38	24.16	22.88	24.18	20.01	18.12	18.29	19.03
CF (%)	4.84	5.19	4.89	4.55	5.23	6.62	5.31	3.87
EE (%)	5.66	5.67	5.53	5.52	4.34	4.51	5.23	4.66
ASH (%)	5.24	5.67	5.63	5.40	2.72	5.82	5.06	3.07
IVDMD	83.94	82.03	76.33	81.75	79.08	66.50	85.52	81.33

RFFCM: Dry cassava tubers fermented by adding rumen filtrate at a rate of 1ml of rumen filtrate to 10 g of Fresh cassava tubers, DM: Dry matter, ME: Metabolized energy (MJ/kg DM), CP: Crude protein, CF: Crude fiber, EE: Ether extract, IVDMD: *In vitro* dry matter digestibility. T1: 0% of RFFCM, T2: 15% of RFFCM, T3: 30% of RFFCM, and T4: 45% of RFFCM.

2.6. Data collection

Data were collected on feed intake, body weight gain (BWG), feed conversion ratio (FCR), dressing percentage, and carcass indices for each pen during the study.

2.6.1. Feed intake

Data on feed intake for each pen were collected daily. The feed for each pen was weighed with a scale and distributed into the feeding trough daily, then fed *ad libitum*. The broiler chickens were fed once a day. Before the next feeding, any remaining feed in the troughs was transferred into plastic buckets and weighed with a digital scale (Kern HCB 200K200, China). This was done during the starter and finisher stages. The feed intake was determined by subtracting the amount of feed left after each feeding from the amount provided. The average daily feed intake (ADFI) was calculated using the formula[32].

$$\mathrm{FI} = \text{feed offered (g)} - \text{remaining Feed (g)}$$

$$ADFI = \frac{Cumulative\ feed\ intake\ (g)}{Number\ of\ chicken\ \times\ Number\ of\ days}$$

2.6.2. Body weight gain

The chickens were weighed in a plastic bag once a week using a digital weighing scale. The data was used to calculate the average daily gain (ADG) and BWG per broiler chicken during the starter stage, up to day 21, and finisher stage, from day 22 to day 42, for each group using the formula below[33]. The BWG was calculated as the weight gain of a chicken by subtracting its initial weight from its final weight.

$$\mathrm{ADG} = \frac{\text{final body weight (g)} - \text{initial body weight (g)}}{\text{Number of days}}$$

2.6.3. Feed conversion ratio

This ratio was calculated by dividing the total feed intake during the 42 days by the final total BWG per chicken per replica, per pen[33].

$$\mathrm{FCR} = \frac{\text{Cumulative feed intake per pen (g)}}{\text{Total weight gain per pen (g)}}$$

2.6.4. Dressing percentage

On day 43 of the study, a random sample comprising four broilers from each treatment group was selected. These chickens were subjected to an overnight fasting period, although they were allowed free access to water. The broilers were weighed and decapitated humanely by severing the jugular vein as described by Njoga et al.[34]. The slaughtered chickens were then hanged upside down for blood to drain out, scalded in hot water, and de-feathered. The carcasses were scalded in hot water at approximately 80°C for one minute and then manually plucked off. The head, neck, internal organs, and shanks were then removed, and their weight was determined using a weighing scale to calculate the dressing percentage[35].

2.6.5. Carcass indices

On day 43, the carcasses of the selected chickens from each replicate were weighed individually after slaughter. The weight of the drumstick, breast, wing, thigh, dorsum, and abdominal fat was measured with a digital scale.

2.7. Statistical analysis

The data obtained were analyzed using the statistical analysis software, version 9.4 M8, 2023. Using the General Linear Model of Analysis of Variance (GLM-ANOVA) to determine differences between treatments at the significant level of the p-value less than 0.05 ($p < 0.05$). The mean separation was done using multi-comparison Tukey's test using the following model;

$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$. Y_{ij} is the J^{th} observation of the i^{th} treatment, μ is the overall mean, τ_i is the treatment effect, and ε_{ij} is the random error.

All data were presented as mean ± standard deviation (SD). The SD was calculated as a measure of variability among replicate observations within each treatment group. For each parameter, the SD indicates the dispersion of individual values around the mean of the respective treatment.

3. Results and discussion

3.1. Feed intake and efficiency

These parameters measure the quantity of feed an animal consumes and describe how well an animal converts the consumed feed into BWG. The present results indicated that treatments recorded significant differences in ADFI ($p < 0.05$), as shown in Table 3.

Table 3. Feed intake and efficiency of Ross 306 broiler chicken fed on diets with varying inclusion of rumen filtrate fermented cassava meal for 42 days of their grower stage

Parameters	Treatments				SD	p-value
	T1	T2	T3	T4		
Feed intake (g/chicken)	3281.89^{a}	2910.89^{b}	3062.28^{ab}	3223.33^{ab}	82.21	0.0096
Average daily feed intake (g/day)	58.56^{a}	52.06^{b}	54.61^{ab}	57.56^{a}	1.461	0.0105
Feed conversion ratio	0.469	0.438	0.432	0.418	0.232	0.4778

T1: 0% of RFFCM, T2: 15% of RFFCM, T3: 30% of RFFCM, and T4: 45% of RFFCM, SD: Standard deviation. ^{a,b} Means in the same row with different superscript letters are significantly different ($p < 0.05$).

Chickens fed on diet 1 (0% of RFFCM) recorded the highest feed intake (3281.89 g/chicken), while those fed on diet 2 (15% of RFFCM) recorded the lowest feed intake (2910.89g/chicken). A slight increase was recorded in diets 3 (30% RFFCM inclusion) and 4 (45% RFFCM inclusion), suggesting that the chickens had adapted to the fermented cassava meal.

The feed intake in T1 (3281.89 g) differed significantly from that of T2 (2910.89 g, $p < 0.05$). The current results indicated that the chickens had difficulties in consuming and effectively utilizing diets containing RFFCM. The lower intake in RFFCM-containing diets was possibly due to their dustier, marshy form compared to the control diet. The dusty marsh was dry and less appealing, causing irritation in the mouth and leading to selective consumption, as the coarse particles are separated from the fine ones; hence, more time was needed to peck and chew the mash. The current findings were contrary to those of Ogbuewu and Mbajiorgu[36], who stated that the marshy form of cassava-based diets had a moderately significant impact on the feed intake of broilers which is because the marshy form of the cassava root meal is difficult to peck, causing xerostomia (Dry mouth) as the dry meal absorbs the little saliva in the mouth of the broiler chicken. The caking of the dry cassava meal in the upper part of the gut slows down feed passage through the throat, resulting in decreased feed intake. The present findings agree with the results of decreased feed intake associated with higher inclusion levels of fermented cassava meal in broiler diets from a study by Animashahun et al.[37]. Additionally, the low palatability of fermented feeds could be attributed to the high levels of bioactive amines and volatile organic acids in the fermented feeds. The lower intake of RFFCM-based diets may be due to the high energy density of fermented diets. This enabled the chicken to meet their nutrient requirements at a lower intake, resulting in a lower total intake in diets containing RFFCM. In contrast, findings of Ogbuewu and Mbajiorgu[3] reported that feeding broiler chickens diets with up to 20% inclusion rate of fermented cassava meal resulted in higher feed intake compared to those fed control diets. The feed intake in T4 was slightly higher ($p < 0.05$) than that in T2 and T3 because T4 had a lower crude fiber (CF). The low CF in the fermented RFFCM may have reduced nutrient densities, leading to increased digesta flow in the guts of broilers fed with T4, which resulted in higher feed intake ($p < 0.05$) compared to T2 and T3, which had slightly higher CF.

There was no significant variation across treatments in FCR, despite differences in feed intake ($p > 0.05$), indicating relatively similar feed utilization across diets. The current findings are in contrast with those of Mwangi[38], who reported significant variation in FCR between broilers fed cassava-based meals and control diets ($p < 0.05$). This was due to the low conversion efficiency, low digestibility, and poor nutrient balance in the feed, resulting in low BWG despite high feed intake.

3.2. Growth performance

The results indicated no significant differences in BWG and ADG across all treatments ($p > 0.05$; Table 4).

Table 4. Growth performance of Ross 306 broiler chicken fed on diets with different inclusion levels of rumen filtrate fermented cassava meal for 42 days of their grower stage

Parameters	Treatments				SD	p-value
	T1	T2	T3	T4		
Body weight gain (g)	2820.50	2348.22	2882.83	2989.72	191.37	0.0975
Average Daily Weight gain (g/day)	352.61	293.50	360.33	373.67	44.22	0.5906
Live weight (g/chicken)	1935.00^{b}	1638.00^{c}	1856.25^{b}	2151.75^{a}	27.14	0.0001

T1: 0% of RFFCM, T2: 15% of RFFCM, T3: 30% of RFFCM, and T4: 45% of RFFCM, SD: Standard deviation. $^{a,b,\text{ and } c}$ Means in the same row with different superscript letters are significantly different ($p < 0.05$).

The BWG and average daily weight suggested that the different levels of RFFCM had no adverse effects on growth performance ($p > 0.05$). Nonetheless, broilers fed diet 4 (45% RFFCM inclusion) recorded a higher mean live weight (2151.75 g), indicating enhanced nutrient assimilation and overall weight gain. The present study conflicts with the findings of Boukhers et al.[39] regarding fermented cassava as an alternative feed ingredient for poultry. According to Boukhers et al.[39], an unprocessed cassava diet resulted in lower weight gain due to its low protein and high fiber content. The present findings align with the results of Ogbuewu and Mbajiorgu[3], who demonstrated that fermented cassava improves poultry protein digestibility and energy utilization. Boukhers et al.[39] reported a positive correlation between fermentation and average daily weight gain (ADWG), attributed to increased CP and reduced CF in the fermented cassava root meal. This growth performance suggested enhanced biological utilization of the fermented cassava root meal in broiler chickens. In contrast, Abu et al.[40] reported inferior growth performance in terms of BWG and ADWG in broilers fed fermented cassava-based diets.

Additionally, Sugiharto et al.[41] reported higher growth performance in broilers fed enhanced weight gain with higher inclusion of RFFCM cassava meals compared to those fed conventional maize meals. These results demonstrated that fermenting cassava root meal improved the growth performance of broiler chickens, further supporting fermentation as a biotechnology to enhance the nutrient content of cassava-based poultry diets.

The enhanced live weight observed in T4, with a higher inclusion of RFFCM, could be due to the increased bioavailability of essential amino acids, such as lysine and methionine, which are lowly available in unprocessed cassava diets but are improved through fermentation ($p < 0.05$). However, Ogbuewu and Mbajiorgu[3] reported contradictory results, showing an adverse effect on BWG and ADWG. This reduced growth rate of -1.26% for broilers fed diets containing up to 50% inclusion of solid-state fermented cassava was attributed to the low CP and methionine content of fermented cassava-based meals was attributed to the presence of significant concentrations of fermentation byproducts, such as bioactive amines and organic acids, which lower the rate of digestion and nutrient absorption in broiler chickens.

3.3. Carcass traits

Table 5 presents the carcass traits of the broiler chicken.

Table 5. Carcass traits of Ross 306 broiler chicken fed on diets with varying inclusion levels of Rumen filtrate fermented cassava meal for 42 days of their grower stage

Parameters	Treatments				SD	p-value
	T1	T2	T3	T4		
Carcass weight (g)	1333.75^{bc}	1245.75^{c}	1418.25^{ab}	1524.75^{a}	40.21	0.0024
Thigh weight (g)	158.875^{b}	179^{ab}	190^{ab}	212.875^{a}	8.3146	0.0047
Breast weight (g)	378.5^{b}	396.0^{ab}	470.75^{ab}	472.75^{a}	22.338	0.0193
Wing weight (g)	80.625^{bc}	79.825^{c}	92.5^{ab}	97.125^{a}	2.9423	0.0026
Dorsum weight (g)	343.5^{a}	236.0^{b}	299.5^{a}	330.5^{a}	12.6565	0.003

T1: 0% of RFFCM, T2: 15% of RFFCM, T3: 30% of RFFCM, and T4: 45% of RFFCM, SD: Standard deviation. $^{a,b,\text{ and } c}$ Means in the same row with different superscript letters are significantly different ($p < 0.05$).

All treatments had significant effects on carcass, thigh, breast, wing, and dorsum weight ($p < 0.05$). Broiler chickens fed diet 4 had the highest carcass weight (1524.75 g), which was significantly higher ($p < 0.05$) than those fed on diet 2 (1245.75g). Therefore, higher RFFCM inclusion increased meat yield, mainly due to muscle deposition and protein retention. Similar results were seen in breast and thigh weights, with diet 4 having the highest values (212.88 g and 472.75 g, respectively).

Similar findings were reported by Boukhers et al.[39] who observed enhanced muscle mass growth in broilers when fed on fermented cassava diet. Additionally, Ikusika et al.[42] reported that carcass weight was improved by feeding fermented diets due to enhanced muscle development and protein metabolism resulting from reduced cyanide content through fermentation. Diet 2 recorded a decreased dorsum weight compared to diet 4 ($p < 0.05$), indicating that moderate RFFCM inclusion may impact fat deposition. The current findings align with those of Chukwukaelo et al.[43], who demonstrated that fermented cassava meal proportionally reduced abdominal fat deposition while increasing lean muscle formation, attributed to enhanced amino acid and CP digestibility, resulting in improved muscle protein synthesis and reduced fat accumulation.

In contrast, the findings of Animashahun et al.[44] and Khempaka et al.[45] indicated that using *Aspergillus niger* to ferment cassava stump in broiler chicken diets had no significant differences in the weights of prime cuts and carcass weight up to a 40% inclusion level, similar to other studies by Akter et al.[46] ($p > 0.05$).

The mean live weight significantly differs among treatments, with T4 being the highest (2151g) and T3 the lowest (1386.25 g; $p < 0.05$). The high live weight in T4 could be attributed to the low-fat-forming potential of the fermented diet and the high CP content that was readily bioavailable in the fermented RFFCM. This is responsible for the high muscle development, which results in a higher mean live weight ($p < 0.05$).

However, the current findings, as well as studies by Ogbuewu and Mbajiorgu[36] and Ikusika et al.[42], reported reduced carcass yield in broiler chickens fed on fermented cassava-based meals as a substitute for maize. The reduced carcass yield was attributed to the low levels of cysteine and methionine in cassava-based diets, which are essential for muscle protein synthesis, resulting in less muscle development in the broiler chickens.

4. Conclusion

The present study demonstrated that applying RFFCM up to 45% in broiler diets can be used as a substitute for maize. Although feed intake was significantly reduced at the 45% inclusion level, RFFCM supplementation had no significant effect on body weight gain, while carcass traits were significantly improved. The current findings demonstrated that feeding broiler chickens diets containing RFFCM boosts weight gain, carcass weight, and breast meat gain when added at a 45% inclusion level, indicating enhanced digestibility, nutrient retention, and muscle deposition. Further investigations into the effects of RFFCM on the hematological properties, internal organ functioning, and meat quality of broiler chickens are required. Such studies are essential for a comprehensive understanding of the potential applications of RFFCM in broiler diets.

Declarations

Competing interests

The authors declared no competing interests that influence the objectivity or integrity of the present study.

Funding

The study did not receive any extra funding.

Availability of data and materials

All data supporting the present study are available upon request. Interested readers may contact the corresponding author via email to access the data.

Acknowledgments

The authors sincerely thank and appreciate Egerton University, Tatton Agricultural Park, the Department of Animal Science, and the Department of Dairy and Food Science Technology in Kenya for the technical support provided during the period of this study.

Authors' contributions

The conception and design of the study were done by Gerald Kizito. Data collection, analysis, interpretation, and manuscript preparation were done by Gerald Kizito, Antony Macharia Kingori, and Fred Kemboi. All authors have read and confirmed the last edition of the manuscript for publication.

Ethical considerations

The authors confirmed that the present study was being submitted for the first time and that they had checked all the ethical criteria and plagiarism for publication.

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