Research Article

Growth Performance, Meat Quality and Economic Efficiency of Chickens Fed Fermented Cassava Root by *Saccharomyces cerevisiae*

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Abstract | This study was carried out to examine the effect of different levels of fermented cassava root (FCSR) by *Saccharomyces cerevisiae* (SC) in diets on growth performance, carcass characteristics and economic efficiency of chickens. A total of 600 chickens, 28 days old with an average body weight of 427.33 ± 4.58 g, were randomly assigned in a completely randomized design to five treatment groups. Each group consisted of 120 chickens, which were further divided into four pens (four replicates, 30 birds per pen). Each group was fed one of five treatments: Control (CO, basal diet) and the 4 other treatments were replaced by different levels (10, 15, 20 and 25 %) of FCSR of the total rations (FCSR10, FCSR15, FCSR20 and FCSR25, respectively). The results showed that fermented cassava root by *Saccharomyces cerevisiae* increased CP, TP contents and reduced hydrocyanic acid (HCN) ($p<0.05$). Growth performance did not differ significantly between chickens fed diets containing 10–20% fermented cassava root (FCSR) and the control group ($p>0.05$). However, inclusion of 25% FCSR resulted in reduced growth performance. The different levels of FCSR had no significant effect on the carcass characteristics and overall meat quality of the chickens ($p>0.05$). On the other hand, FCSR inclusion significantly improved the amino acid (AA) profile of the chicken meat ($p<0.05$). Additionally, economic efficiency was highest in the group receiving 20% FCSR ($p< 0.05$). Based on these findings, fermentation of cassava root using *Saccharomyces cerevisiae* is an effective method for reducing hydrogen cyanide (HCN) content, and incorporating 20% FCSR in poultry diets can partially replace conventional feed ingredients. This substitution helps reduce feed costs and enhances economic efficiency for farmers.

Keywords | Amino acid, Economic efficiency, Fermented cassava root, Growth performance, Meat quality

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INTRODUCTION

Chicken production plays an important role in Vietnam. However, feed accounts for 70% of the total production cost of chicken (Sugiharto and Ranjitkar, 2019). Therefore, research has been conducted to reduce the production cost, improve performance and quality of the products (Bukola, 2013; Egoamaka and Tonukari, 2023). Cassava is widely recognized as one of the three main crops and an important source of income for farmers in rural areas, as it requires low investment and grows well in poor-quality soils. Thus, cassava is a potential feed source to reduce production cost in poultry diet (Bukola, 2013; Egoamaka and Tonukari, 2023). However, the cassava utilisation is limited by high hydrocyanic acid (HCN), high fibre (Ngiki *et al.*, 2014) and low protein concentration (Stupak *et al.*, 2006). Therefore, finding methods to utilize casava in chicken production is an essential.

Previous studies demonstrated that fermentation of cassava by yeast improved protein content and reduced the cyanide content (Oboh *et al.*, 2002, Oboh and Akindahunsi, 2003; 2005; Boonnop, *et al.* 2009; Polyorach *et al.*, 2013; Arzinnahar et al., 2021). Moreover, replacing maize with a fermented mixture of grated cassava roots and palm kernel cake, or with fermented cassava waste, did not affect the growth performance or meat quality of chickens (Tran, et al., 2017; Chukwukaelo *et al.*, 2018; Egoamaka and Tonukari, 2023; Ogbuewu *et al*, 2023). In addition, various researchers (Uchegbu *et al.*, 2011; Etalem, 2013, Elnour *et al.*, 2020) recommended that the casava roots, cassava roots meal or cassava chip can replace with based diets up to 25, 30 and 100%, respectively. Furthermore, it is well known that *Saccharomyces cerevisiae* (SC) is one of the type of probiotics. Its have been shown that supplement of fermented maize and rice bran by SC to the chicken diets improves digestibility of dry matter, protein, enhances the height of villus in duodenum (Hang *et al.*, 2020), and increases the aroma and taste of chicken meat (Hai *et al.*, 2024). However, it is unclear whether using fermented cassava root to the chicken diet effect on growth performance and meat quality. Therefore, the purpose of this study was to examine the effect of cassava root fermented by *S. cerevisiae* on chicken growth performance, meat quality, and economic efficiency.

MATERIALS AND METHODS

This study was carried in Center for Practice and Training on Animal Husbandry and Veterinary Medicine, Faculty of Animal Sciences and Veterinary Medicine (FAS), Hue University of Agriculture and Forestry (HUAF), Hue University, Viet Nam. This research was approved by Committee of Ethics at Faculty of Agriculture and Technology, South Bohemia University in České Budějovice after checked all activities relating to the care and use of animals including the acquisition, transport, housing, husbandry of animals and slaughter (protocol ID: 22036/2019-MZE-18134).

Animals and experimental design

A total of 600 28-day-old Ri chickens with an average body weight of 427.33 ± 4.58 g were randomly assigned to five groups in a completely randomized design, balanced for sex. Each group consisted of 120 chickens, which were randomly divided into four pens (four replicates of 30 birds per pen), and each group was fed one of five diets for 63 days. The treatments were as follows: a control diet (CO), consisting of a basal diet made of concentrate, maize, and rice bran (Table 1); and four treatment diets FCSR10, FCSR15, FCSR20, and FCSR25 where 10%, 15%, 20%, and 25% of the total ration, respectively, was replaced with fermented cassava root (FCSR) in place of the control diet. A 2-phase feeding program from 28-63 days and from 64-91 days was used in this experiment (Table 1). All chickens were vaccinated Newcastle, infectious bronchitis, Gumboro, and fowl pox disease before starting experiment and were housed on rice husk in floor mixed with beneficial microflora to reduce odor, absorb toxic gas.

Preparing starter and fermented cassava root

S. cerevisiae (SC) was purchased from ICFOOD Company, Ho Chi Minh City, Vietnam (2×10^{10} CFU/g). The starter

Table 1: The formulation and chemical composition of experimental diets.

Ingredients (g)	Period 28-63 days					Period 64-91 days				
	CO	FCSR10	FCSR15	FCSR20	FCSR25	CO	FCSR10	FCSR15	FCSR20	FCSR25
Concentrate	250	245	240	235	235	195	190	185	180	180
Maize	592	447	352	247	187	647	502	407	302	242
Rice bran	150	200	250	310	320	150	200	250	310	320
Fermented cassava root	0	100	150	200	250	0	100	150	200	250
Salt	3	3	3	3	3	3	3	3	3	3
Premix	5	5	5	5	5	5	5	5	5	5
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Chemical composition										
Crude protein (CP, %)*	19.89	20.99	20.67	20.48	20.28	17.89	18.78	18.69	18.51	18.19
True protein (TP, %)*	16.63	16.83	16.28	16.21	16.15	14.52	14.37	14.57	14.4	14.21
ME (kcal/kg)**	3142	2989	2897	2799	2732	3154	3101	3059	3011	2994
Feed cost (VND)***	13,260	10,498	9,960	9,393	9,038	10,673	9,810	9,273	8,705	8,350

*Chemical composition has been analysed at FAS laboratory, HUAF, Hue University. **Calculated composition. *** Calculated based on the ingredients price on the local market. CO (Control): Animals were fed a standard basal diet without any replacement. FCSR10: 10% of the total ration was replaced with fermented cassava root (FCSR). FCSR15: 15% of the total ration was replaced with FCSR. FCSR20: 20% of the total ration was replaced with FCSR. FCSR25: 25% of the total ration was replaced with FCSR.

culture for fermented cassava root (FCSR) was prepared as follows: (i) 1 g of SC was added to a solution containing 350 g molasses, 634 g water, and 15 g urea, then incubated aerobically at 30°C for 24 hours. (ii) This starter solution was then used to prepare FCSR by inoculating 1 kg of cassava root with 30 ml of the starter solution and 5 g urea, followed by aerobic fermentation at 30°C for 5 hours. (iii) The mixture was then placed in a polythene bag under anaerobic conditions at 30°C for 3 days. (iv) Finally, the FCSR was used in the feeding trial. Samples were collected on day 0 (preparation day) and day 3 after anaerobic fermentation to evaluate pH, hydrogen cyanide (HCN) content, and the chemical composition of FCSR.

Data recording

Chicken were free access to drinking water, fed *ad libitum*, and daily allowance was based on offered feed and refused previous day. Feed refusal was recorded daily and was used for detection of the feed intake data. Chicken were weighed every 14 days.

Sampling and laboratorial analysis

At the end of experiment, six chickens (three males, three females) with body weight closest to the mean were slaughtered for each of the replicates. The muscles of breast have been collected to evaluate quality of the meat and contents of amino acids. The pH of muscles was estimated by pH meter (model HI99163, Gemany) at 15 minutes, 24 hours postmortem. The muscle color was determined according to previous method (Wanner et al., 1997) using the Minola Chroma Meter (Model CR400, Japan) at 24h postmortem. The system of CIE was L* (lightness), a* (redness), b* (yellowness). The drip and loss cooking of the muscles were evaluated by using the previous method (Schilling et al., 2012). Drip loss was evaluated based on percentage loss of the muscle weight in 24h thawed at 4°C. To determine cooking loss, the breast muscles placed individually in plastic bags and cooked in water bath at 80°C for 15 minutes. Cooking loss was determined by measuring the weight of the uncooked and cooked samples.

Determination of dry matter (DM), crude protein, true protein, ash and lipid contents of the feed were analysed at the FAS laboratory, HUAF, Hue University according to AOAC (1990). The amino acid concentration in breast was analysed according to (AOAC, 2000, ID994.12).

Statistical analysis

Data were presented in the form of the mean (M), standard error of the mean (SEM). The data were statistically processed by analysis of variance (ANOVA) by General Linear Model in Minitab version 16.2 (2010). The difference between the mean values was determined by the Tukey method at a confidence level of 95%.

RESULTS AND DISCUSSION

Chemical composition of unfermented and fermented cassava root

The chemical composition of unfermented and FCSR by SC are presented in Table 2. Fermented cassava root by SC reduced significantly pH and DM but increased its CP and TP ($p<0.05$, Table 2). These results were similar that reported by Oboh et al. (2002); Oboh and Kindahunsi (2003), (2005); Boonnop *et al.* (2009); Polyorach *et al.* (2013); Arzinnahar et al. (2021). The increase of protein concentrations in FCSR may be that the SC produced some enzmes as cellulase, amylases and linamarase into cassava during fermentation processing, which caused of increasing in proliferation and growth of the fungi or bacterial complex (Antai and Mbongo, 1994; Oboh, 2002; Oboh and Akindahunsi, 2003; Egbune *et al.*, 2022a, b; Ezedom *et al.*, 2022). These findings are in agreement with previous evidences that using SC on rich sources of carbohydrate increase in CP concentrations (Anigboro *et al.*, 2022). However, the protein levels of FCSR (Table 2) were lower than in previous studies. Fermentation of cassava peels by pure culture of SC could increase its protein content from 2.4% in nonfermented cassava to 14.1% in fermented products (Antai and Mbongo, 1994). The fermented cassava flour with SC enhanced the protein level from 4.4% to 10.9% (Oboh and Kindahunsi, 2005). This may be affected by kind of microbial and fermentation time or the conditions of environment. In addition, this study was conducted in the summer, so it was difficult to control fermentation conditions (humidity, temperature), and the anaerobic fermentation time only 3 days may not have been enough for microorganisms to grow.

Table 2: Chemical composition of unfermented and fermented cassava root.

Parameter	pH	DM (%)	CP (%)	TP (%)	HCN (mg/kg DM)
Unfermented	4.64	41.99	2.45	0.78	205.68
Fermented	3.47	41.38	5.56	0.95	165.50
SEM	0.119	0.169	0.072	0.029	12.95
P	0.012	0.022	0.000	0.002	0.046

DM: Dry matter; CP: Crude protein; TP: Total protein; HCN: hydrogen cyanide.

In addition, the HCN content of FCSR has decreased significantly compared unfermented cassava root ($p<0.05$, Table 2). The above result is similar with Tran et al. (2017) who reported that HCN content of fermented cassava waste were reduced by using *Pichia kudriavzeii* yeast. These finding is also similar with previous studies that fermented cassava flour or peels by SC decreased HCN content (Oboh *et al.*, 2002; Oboh and Akindahunsi, 2003, 2005; Boonnop *et al.*, 2009). This mention that SC has the ability to utilize HCN, thus demonstrating why SC has been used in fermented cassava during processing for animal feeding (Tweyongyere and Katongole, 2002). Feed fermentation with SC is similar with previous study by Ren *et al.* (2024) that explores sustainable methods for contaminant removal and that microbial fermentation emerges as an effective biological strategy for reducing antinutrients in agricultural raw materials.

Growth performance

The growth performance of chicken fed with different levels of FCSR in diets are shown in Table 3. The final live weight, daily gain weight and feed intake did not differ significant difference between 10-20% of FCSR and control ($p>0.05$), but increasing level of FCSR up to 25% in the diet lead to reduce growth performance of chicken ($p<0.05$). However, there was not significant different in FCR among all treatment ($p>0.05$, Table 3).

In the present study, using FCSR by SC with 10-20% did not affect on body weight, feed intake and FCR compared to the control diet. These results agree with previous reported that replaced maize by fermented mixture of grated cassava roots and palm kernel cake did not affect on growth performance of broilers (Chukwukaelo *et al.*, 2018; Egoamaka and Tonukari, 2023). The current results are also similar with Tran et al. (2017) reported that no significant different in body weight, growth rate of Ri chicken among treatments containing different levels of fermented cassava waste. In addition, these findings agree with Ogbuewu *et al.* (2023) who suggested that the tolerated levels of fermented cassava in chicken diets are 10–20 %. However, using 25% FCSR in the diet was negative effect on growth performance of chicken. Similarly, previous studies reported that chicken fed of the levels of fermented cassava 21–30, 31–40, 41–50, and > 50 % affected on growth performance parameter, special effected on ADG (Ogbuewu and Mbajiorgu, 2022; Ogbuewu *et al.*, 2023). The lower growth performance in treatment using 25% of FCSR in the diets may be related to anti-nutritional factors in cassava roots such as HCN, tannin, protease inhibitors and non-starch polysaccharides (Reed *et al.*, 1982; Omede *et al.*, 2017; Ogbuewu and Mbajiorgu 2023a). Aboved results similarly with previous reported that common issues arise with animal health and welfare due to imbalances in the pathogen–host–environment triad. Therefore, using physicochemical variables and biomarkers has proven to be an effective and practical method for monitoring animal health via monitoring the safety of ingredients used in feed and to ensure the microbiological and chemical safety of fermented inputs for animal feed (Araújo *et al.*, 2024).

Carcass yield of chicken

The affect of different levels of FCSR in dietary on carcass yield of chicken are presented in Table 4. Except dressing percentage, the other parameters were not significant different among treatments ($p>0.05$, Table 4). The dressing percentage were significantly affected with dietary treatments ($p< 0.05$). Treatment was replaced by levels 10% FCSR revealed higher dressing percentage, followed by 15, 20% and lower in CO, FCSR25. These results agree with previous findings that the use of fermented cassava pulp did not have detrimental effects on carcass yield of chicken (Khempaka et al., 2014; Aladi *et al.*, 2017; Ogbuewu *et al.*, 2023). The carcass yield was not significantly different among treatments may be that the dietary treatments were formulated to nutrients balance and meet the requirements of chicken.

Table 3: Effect of fermented cassava root on performance of chicken.

	CO	FCSR10	FCSR 15	FCSR 20	FCSR 25	SEM	P
Initial live weight (g)	430	426	426	426	425	2.98	0.903
Final live weight (g)	1,376^{a}	1,400^{a}	1,353^{ab}	1,396^{a}	1,303^{b}	12.20	0.001
Daily weight gain, (g/day/bird)	15.02^{a}	15.46^{a}	14.71^{ab}	15.40^{a}	13.94^{b}	0.19	0.024
Feed intake, (g/day/bird)	48^{a}	50^{a}	47^{ab}	48^{a}	45^{b}	0.72	0.006
FCR	3.20	3.23	3.19	3.12	3.23	0.06	0.349

^{abc} Means values with different letter are significantly different at $P<0.05$.

Table 4: Effect of different levels of fermented cassava root on carcass yield of chicken.

Parameters	CO	FCSR10	FCSR 15	FCSR 20	FCSR 25	SEM	p
Live weight (g/bird)	1,339	1,390	1,309	1,358	1,259	97.8	0.35
Dressing percentage (%)	66.8^{a}	73.5^{b}	70.4^{ab}	70.0^{ab}	64.16^{a}	1.9	0.02
Breast meat (%)	17.8	17.5	17.9	16.6	15.4	0.7	0.22
Thigh meat (%)	24.3	24.5	23.6	24.2	21.3	0.7	0.56
Abdominal fat (%)	7.1	7.2	6.9	6.8	6.7	0.4	0.79
Organs (%)	2.2	3.1	2.2	2.1	2.2	0.9	0.76

^{abc} Means values with different letter are significantly different at $P<0.05$

Table 5: Effect of different levels of fermented cassava root on breast muscle quality of chicken.

Parameters	CO	FCSR10	FCSR 15	FCSR 20	FCSR 25	SEM	p
pH 15min	6.3[a]	6.8[b]	6.7[ab]	6.9[b]	6.7[ab]	0.1	0.01
pH 24h	5.8[ab]	5.7[ab]	5.7[a]	5.8[ab]	5.9[b]	0.1	0.03
Drip loss 24h (%)	2.3	1.8	2.5	1.7	1.4	0.8	0.64
Cooking loss 24h (%)	22.5	21.6	24.2	22.4	22.4	3.2	0.92
L* (lightness)	53.4	54.0	54.0	53.9	56.9	2.1	0.49
a* (red)	1.1	1.2	2.1	2.0	2.0	0.7	0.68
b* (yellow)	8.3	7.5	8.4	7.5	5.6	1.0	0.10

[abc] Means values with different letter are significantly different at P<0.05.

Table 6: Effect of different levels of fermented cassava root on Amino acid composition of chicken.

Amino acids (µg/g of meat)	CO	FCSR 10	FCSR 15	FCSR 20	FCSR 25	SEM	p
EAA[1]							
Arg	7.35[a]	8.11[a]	15.36[b]	54.17[c]	26.60[d]	4.65	0.000
His	6.97[a]	9.88[a]	10.16[a]	21.35[b]	11.80[a]	1.33	0.000
Ile	4.08[a]	8.14[b]	6.99[c]	7.13[c]	7.07[c]	0.38	0.000
Leu	1.60[a]	3.05[b]	2.83[b]	2.87[b]	7.24[c]	0.52	0.000
Lys	28.73[a]	53.20[b]	60.96[c]	80.84[d]	51.61[abc]	4.52	0.000
Meth	1.68[a]	3.41[b]	2.48[c]	5.30[d]	3.71[b]	0.34	0.000
Phe	4.26[a]	4.40[a]	4.43[a]	4.62[a]	5.67[b]	0.17	0.018
Thr	6.20[a]	13.20[b]	13.88[b]	14.30[b]	13.23[b]	0.82	0.000
Val	4.90[a]	8.70[b]	10.03[c]	10.45[c]	10.25[c]	0.57	0.000
NEAA[2]							
Ala	67.63[a]	99.11[b]	97.84[b]	95.12[b]	94.57[b]	3.45	0.001
Asp	17.67[a]	35.62[b]	46.19[c]	43.92[c]	33.29[b]	2.77	0.000
Cys	2.17[a]	3.25[b]	3.04[b]	3.41[b]	3.18[b]	0.13	0.004
Gly	4.65[a]	3.38[b]	4.28[a]	4.37[a]	5.83[c]	0.22	0.000
Glu	12.54[a]	14.10[b]	11.82[a]	16.43[c]	17.07[c]	0.57	0.000
Ser	4.74[a]	4.45[a]	3.49[b]	4.04[b]	6.91[c]	0.33	0.000
Pro	183.41[a]	292.80[b]	282.08[b]	335.07[c]	301.35[b]	13.86	0.000
Tyr	9.93[a]	17.12[b]	16.95[b]	15.92[bc]	15.18[c]	0.72	0.000
Total	368.52[a]	581.93[b]	592.80[cb]	719.32[d]	614.58[c]	30.70	0.000

[1]EAA: Essential amino acids, [2]NEAA: Non-essential amino acids, Arg: Arginine, His: Histidine, Ile: Isoleucine, Leu: Leucine, Lys: Lysine, Meth: Methionine, Phe: Phenylalanine, Thr: Threonine, Val: Valine.Ala: Alanine, Asp: Aspartic acid, Cys: Cysteic acid, Gly: Glycine, Glu: Glutamic acid, Ser: Serine, Tyr: Tyrosine, Pro: Proline. [abcd] Means values with different letter are significantly different at P<0.05

Breast muscle quality of chicken

The breast meat quality of the chickens fed different percentages of FCSR are presented in Table 5. Except of pH value, the other physic-chemical parameters such as drip loss, cooking loss, L* (lightness), a* (red), b* (yellow) were not influenced by different levels of FCSR in dietary (p>0.05, Table 5). The pH value effect on appearance of meat, texture and plays an important role for keeping quality meat and that directly relay on muscle energy metabolism balance (Li et al., 2017). In this study, the pH of meat significantly affected with dietary treatments (p<0.05). The breast meat was less acidic with using FCSR in the diets than control diet. This result disagreed with previous that increased the levels of fortified fermented cassava stump induced meat became acidic (Surgiharto *et al.* 2019; Animashahun *et al.*, 2022). However, the pH_{15} and pH_{24} values are in the acceptable range for chicken meat suggested by Doan et al. (2011). These findings mention that using FCSR in diets for chicken did not affect on meat quality (p>0.05). These results agree with previous reported that using fermented cassava waste in dietary of Ri chicken did not affect meat quality of Ri chicken (Tran et al., 2017). In current results also similar with previous study that supplementation of SC is not effect on the physic-chemical of chicken meat such as color, water holding capacity and cooking loss (Pelicano et al., 2005).

Table 7: Effect of different levels of fermented cassava root on economic benefit of chicken production.

No.	ITEM	UNIT*	CO	FCSR10	FCSR 15	FCSR 20	FCSR 25
I	Input	VND/bird	77,730	77,337	72,717	72,069	68,301
1.1	Breed	VND/bird	25,000	25,000	25,000	25,000	25,000
1.2	Veterinary	VND/bird	1,000	1,000	1,000	1,000	1,000
1.3	Feed cost	VND/bird	51,73	51,337	46,717	46,069	42,301
II.	Income	VND/bird	96,320	98,000	94,710	97,720	91,210
2.1	Final body weight	Kg/bird	1,376	1,400	1,353	1,396	1,303
2.2	Price per unit	VND/bird	70,000	70,000	70,000	70,000	70,000
III.	Profit (II-I)	VND/bird	18,590	20,663	21,993	25,651	22,909

*VND: Vietnamese dong (1 USD: 26135 VND).

Amino acid composition of chicken breast

Table 6 showed effected of different levels of FCSR on amino acid compositions of chicken breast. Results showed that all amino acid concentrations were significantly higher in the groups fed with FCSR compared to the control group ($p < 0.05$). The total AA in the FCSR groups were higher than in the control group ($p<0.05$) and the total AA in the treatment using 20% FCSR was highest. Previous researches demonstrated that AA plays an importance role for meat flavour (Bachmanov et al., 2016). Furthermore, using FCSR in diets increased the concentration of Glu, Asp, Arg, Lys, Meth, Ser which affected on the chicken meat taste (Ali et al., 2019; Huang et al., 2011). These results aggre with reported that probiotics supplement improved the AA content of muscle of chicken (Abdulwahab and Horniakova, 2013; Santoso et al., 2015; Podolian, 2017). In current findings mention that using FCSR improved the AA contents of chicken meat especially, AA consisted to meat flavor (aroma and tasty).

Economic evaluation of using fermented cassava root

The compounding cost of 1kg of the feed are presented in the Table 1. The results shown that using FCSR in diets reduced significantly the cost of 1 kg of feed compared to control groups (Table 1). These results agree with Egbune and Tonukari (2023). Furthermore, the benefit of the diets with FCSR from 10%-25% were higher than control diet (Table 7). Specially, the profit in the FCSR group at level 20% was highest. These results were in agreement with previous studies that using fermented mixture cassava root and palm kermnel cake, ensiled cassava peel meal or cassava wastes in diet reduced the feed cost for chicken and increased economic benefits (Obikaonu and Udedibie, 2008; Bukola, 2013; Thip-Uten *et al.*, 2022; Egbune and Tonukari, 2023). These evidences mentioned that using 20% FCSR in diet could help decrease the production cost and increase economic benefits.

CONCLUSION

Based on the above results, it is suggested that incorporating 20% FCSR in the diet can partially replace conventional feed in chicken production, enhancing the amino acid profile of the meat, reducing feed costs, and improving economic efficiency for farmers. Further research should focus not only on the amino acid content in the breast but also in the thigh.

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NOVELTY STATEMENT

Our study provides evidences that fermented casavaroot by Saccharomyces cerevisiae is an esstential method to reduce HCN and that it is possible to use a diet containing 20% FCSR to replace a part of the feed in chicken production, which reduce feed cost and improve economic efficiency to the farmers.

AUTHOR'S CONTRIBUTION

DTH, PTH, LDT, ZL: Conceptualization.
DTH, PTH: Methodology, formal analysis, investigation and writing original draft preparation.
DTH, LDT, ZL: Writing review and editing.
DTH: Project administration.
DTH, ZL: Funding acquisition.
All authors have read and agreed to the published version of the manuscript.

Generative AI and AI-assisted technology statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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