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Effect of Fermented Rice Bran and Cassava Waste on Growth Performance and Meat Quality of Crossbred Pigs

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Abstract Different levels of rice bran and cassava waste fermented with *Trichoderma longibrachiatum*, *Aspergillus niger*, *Pichia kudriavzevii* and *Lactobacillus buchneri* were used in diets for crossbred (Landrace x Yorkshire) pigs. Thirty-five pigs were randomly allocated to seven treatments: CO, control diet without fermented by-products; RBF1, RBF2 and RBF3 with 15, 20 and 25% fermented rice bran in the growing period and 30, 35 and 40% fermented rice bran in finishing period, respectively, and CWF1, CWF2 and CWF3 with 15, 20 and 25% fermented cassava waste in the growing period and 30, 35 and 40% fermented cassava waste in finishing period, respectively. The average daily feed intake (ADFI) was higher ($p<0.01$) on diets with RBF than with CWF in the growing and finishing periods and overall. There was no difference in average daily gain (ADG) between diets with fermented by-products in the growing period, while the ADG was higher ($p<0.01$) on diets with RBF than with CWF in the finishing period and overall. The feed conversion ratio was lower on diets with CWF than with RBF in the growing and finishing periods and overall ($p<0.01$). Inclusion of fermented by-products resulted in reduced ADFI ($p<0.01$) in the growing and finishing periods and overall, and lower ADG ($p<0.01$) in the finishing period and overall compared with the control diet. There were no differences ($p>0.05$) among treatments in carcass and meat quality traits. Inclusion of fermented rice bran and cassava waste reduced feed cost per kg ADG.

Keywords: *pigs, rice bran, cassava waste, fermented feed, performance*

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1. Introduction

One of the difficulties that the Vietnamese livestock industry has been faced is steadily increasing feed costs, which is partly due to the dependence on imported feed ingredients [1]. It was estimated that the feed costs in pig production accounts for 65-70% of the production costs, which makes the pork industry vulnerable to feed market price fluctuations. This calls for alternative feeding strategies involving more extensive use of cheap agricultural and industrial co-products as feed ingredients. Currently, there are two co-products from the agro-industry that are available in large quantities and at a low cost. One is cassava residue (CR) from cassava starch-processing factories and the other is rice bran (RB) from the rice industry.

There are around 60 industrial-scale cassava starch-processing factories in Vietnam with a total annual production capacity of more than 500,000 tons of cassava starch [2]. A small to medium size starch-processing factory with capacity of processing 250-300 tons per day, will produce 1.2 tons of peels and about 280 tons of fresh bagasse (85% moisture content) [3]. In nutritional terms, CR is low in protein (around 3% in DM) and high in fiber (around 60% NDF in DM) [4]. In addition, the cassava root and CR contain anti-nutritional substances such as HCN and tannins [5]. The high moisture content in CR, together with a warm climate, results in rapid deterioration if left un-preserved, and the disposal of the spoilt CR causes major environmental problems.

Rice bran (RB) is an agricultural waste by-product obtained after processing rice. Using rice bran as feed for mono-gastric animals has limitations because of high-fiber and low protein content, and the presence of phytate which affects the P and Ca availability [6]. Microbial fermentation is a technology that has a long history and that by tradition has been used worldwide for the preservation of various kinds of food. More recently, various microorganisms (bacteria, fungi and yeast) have been used to ferment industrial co-products such as CR and RB to increase their protein content, improve the digestibility of fiber and reduce the content of toxins [7,8,9]. There are several reports on an increase in protein content in CR after fermentation with these microorganisms [8,10,11]. [11] reported that when using *Trichoderma sp* to ferment cassava peels, protein content increased from

1.4 to 25.5%, while fermentation with *Aspergillus sp*. resulted in an increase in protein content from 1.4 to 18.9%. Moreover, fermenting CR with a mixture of fungi (*Aspergillus*) and bacteria (Lactobacillus) helped to reduce the toxin levels in the product [5]. In addition, some strains of *Aspergillus sp*. have the ability to produce fiber degrading enzymes (such as cellulase) [12], which can improve the digestibility of fiber in mono-gastric animals and thereby increase the feeding value. [13] reported that protein content of rice bran fermented with Bacillus amyloliquefaciens increased from 12.1 to 22.6% when incubated with 2% urea, 0.0025% Zn and 0.2% sulfur. [9] reported higher hen-day production in a diet with 50% inclusion of fermented rice bran (*Trichoderma viride*) compared with the control diet.

The aim with this study was to evaluate the impact of fermenting cassava residue and rice bran with a mixture of fungi (*Trichoderma longibrachiatum* and *Aspergillus niger*), yeast (*Pichia kudriavzevii*) and bacteria (*Lactobacillus buchneri*) on growth performance and carcass traits of crossbred (Landrace x Yorkshire) pigs.

2. Materials and Methods

2.1. Animal and Experimental Design

In total 35 crossbred pigs (Landrace x Yorkshire) with an initial body weight (BW) of 19.2 kg (SD 0.96) were used. The experiment was structured according to a completely randomized 2x4 factorial design, with two fermented by-products (cassava waste and rice bran) and four levels of inclusion (0, 15, 20 and 25% in the growing period and 0, 30, 35 and 40% in the finishing period). The pigs were kept in individual pens and divided into 7 groups with 5 pigs per group balanced in sex (3 female and 2 castrated male pigs per group) and were randomly allocated to the seven experimental diets. Prior to the experiment, all pigs were vaccinated against pasteurellosis, parathyphoid, asthma and hog cholera. The pigs were kept in pens at the Experimental Farm of the Institute of Development Studies of Hue University of Agriculture and Forestry, Vietnam. The experiments in this study wa clarified and approved by the Ethical Committee of the Research Committee of Hue University of Agriculture and Forestry.

2.2. Feeds and Feeding

2.2.1. Preparation of Microbial Inoculum

The fungi (*Trichoderma longibrachiatum* and *Aspergillus niger*), yeast (*Pichia kudriavzevii*) and lactic acid bacteria (*Lactobacillus buchneri*) used in this experiment for fermentation of cassava waste and rice bran were isolated from natural sources and cultured at the laboratory of Institute of Resource, Environment and Biotechnology of Hue University. The microbes used were selected based on high extra-cellular activity of cellulase, protease and amylase. All fungi, yeast and lactic acid bacteria were prepared in culture form and stored in a refrigerator at 4°C in separate bottles. The analyzed enzyme activities are shown in Table 1.

Table 1. Enzyme Activities of Fungi, Yeast and Lactic Acid Bacteria Used for Fermentation of By-Products (U/ml)

Microflora	Cellulase	Protease	Amylase
Trichoderma longibrachiatum	16.6	13.8	5.3
Aspergillus niger	19.1	0.6	29.0
Pichia kudriavzevii	94.5	3.3	10.1
Lactobacillus buchneri	-	-	61.9

2.2.2. Assay of Cellulase Activity

Cellulase assay was performed according to the method of [14] using carboxy-methyl cellulose as substrate. In brief, 250 µl of 1% CMC in 0.05 M citrate buffer (pH 4.8) was placed a test tubes and 250 µl of culture filtrate was added. The reaction mixture was incubated at 50°C for 30 minutes. The reaction was terminated by adding 500 µl 3,5-dimitrosalisylic acid (DNSA) reagent. The tubes were heated at 100°C in boiling water for 5 minutes, and then cooled at room temperature. The absorbance was read at 540 nm. Enzyme activity was defined as one µmol glucose released per min.

2.2.3. Assay of Protease Activity

The protease activity was assayed by the method of [15] using casein as substrate. In brief, 175 µl culture filtrate was added to 350 µl casein in 2% phosphate buffer (0.05 M, pH 7.0) and was shaked at 500 rpm/min during 10 minutes. The reaction was stopped by adding 875 µl of 5% trichloracetic (TCA) and incubated at room temperature. After 20 minutes, culture filtrate was centrifuged at 12,000 rpm/min at 4°C for 10 minutes to remove the precipitate of casein. The supernatant of 200 µl added with 800 µl 6% of Na_2CO_3, well shaking. Then 200 µl of 0.2 N Folin reagent was added. The absorbance of supernatant was read with spectrophotometer at 750 nm. Enzyme activity was defined as one µmol tyrosine released per min.

2.2.4. Assay of Amylase Activity

The assay mixture consisted of 250 µl of enzyme solution and 250 µl of 1% starch in 0.1 M phosphate buffer (pH 7.0) incubated at 50°C for 10 min. The reaction was stopped by adding 500 µl of 1% dinitrosalicylic acid. The tube containing enzyme solution was heated at 100°C in boiling water for 5 minutes, and then cooled at room temperature. Determine maltose released by spectrophotometer at 540 nm. Amylase activity was defined as the amount of enzyme that releases one µmol reducing sugar equivalent to maltose per min [16].

2.2.5. Preparation of Fermented By-Products

Fresh cassava waste was collected directly from a cassava starch processing factory in Hue. The cassava waste (CW) was sprayed directly on a clean concrete floor and turned occasionally to reduce moisture content. For preparation of fermented CW (CWF), the air-dried CW was thoroughly mixed with rice bran and maize (ratio 75: 15: 10), after which 2 mL per kg of each of *Trichoderma longibrachiatum* (1×10^7 spores per mL), *Aspergillus niger* (1×10^7 spores per mL), *Pichia kudriavzevii* (1×10^6 CFU per mL) and *Lactobacillus buchneri* (1×10^6 CFU per mL) were added together with 2.6 g urea/kg and once more thoroughly mixed as described by [17]. The cassava waste mixture was put into nylon bags for fermentation. The dry matter (DM) of the final product was around 35%.

For preparation of fermented rice bran (RBF), the rice bran (RB) was thoroughly mixed with maize (ratio 90: 10), after which 2 mL per kg of each of *Trichoderma longibrachiatum* (1 x 10^7 spores per mL), *Aspergillus niger* (1 x 10^7 spores per mL), *Pichia kudriavzevii* (1 x 10^6 CFU per mL) and *Lactobacillus buchneri* (1 x 10^6 CFU per mL) were added and once more thoroughly mixed. Then, water (40 L per 100 kg feed) containing 4.8 g urea/kg was added and thoroughly mixed with the rice bran mixture. The rice bran mixture was put into nylon bags for fermentation. The DM of the final product was around 64%.

The impacts of the fermentation treatments on the characteristic of the fermented by-products are presented in Table 2. In general, there were increases in the content of crude protein (CP) and decreases in NDF and ADF of fermented rice bran and cassava waste as compared with the un-fermented CW and RB. After 21 days of fermentation, HCN content had been reduced from 306 to 26 mg/kg DM.

Table 2. Dry Matter (DM) Content (%), Chemical Composition (% of DM) and Hydrogen Cyanide (HCN) Content (Mg/Kg Dm) of Un-Fermented and Fermented Rice Bran and Cassava Waste [1, 2]

	DM	CP	EE	CF	NDF	ADF	HCN
RB	86.4	15.2	12.0	13.6	39.3	14.6	-
RBF	64.0	17.8	20.5	10.3	33.4	13.7	-
CW	14.2	3.4	0.4	18.4	41.7	24.4	306
CWF	35.4	11.1	0.7	13.7	39.2	22.7	26

[1] CP= crude protein, EE=ether extract, CF=crude fiber, NDF=neural detergent fiber, ADF= acid detergent fiber

[2] RB=rice bran, RBF=rice bran fermented, CW=cassava waste, CWF=cassava waste fermented.

2.2.6. Experimental Diets and Feeding

The seven experimental diets comprised: CO, control diet without fermented by-products; RBF1, diet with 15% and 30% fermented rice bran in the growing and finishing period, respectively; RBF2, diet with 20% and 35% fermented rice bran in the growing and finishing period, respectively; RBF3, diet with 25% and 40% fermented rice bran in the growing and finishing period, respectively; CWF1, diet with 15% and 30% fermented cassava waste in the growing and finishing period, respectively; CWF2, diet with 20% and 35% fermented cassava waste in the growing and finishing period, respectively; and CWF3, diet with 25% and 40% fermented cassava waste in the growing and finishing period, respectively. The ingredients and chemical composition of the experimental diets are presented in Table 3 and Table 4.

Table 3. Ingredient Composition of The Experimental Diets (g/kg DM)

Ingredients	Diets						
	CO	RBF1	RBF2	RBF3	CWF1	CWF2	CWF3
	Growing period						
Concentrate*	230	230	220	200	240	240	240
Maize	615	615	575	545	605	555	505
Rice bran	150	-	-	-	-	-	-
RBF	-	150	200	250	-	-	-
CWF	-	-	-	-	150	200	250
Mineral	5	5	5	5	5	5	5
	Finishing period						
Concentrate*	110	100	90	80	140	130	130
Maize	585	595	555	515	555	515	465
Rice bran	300	-	-	-	-	-	-
RBF	-	300	350	400	-	-	-
CWF	-	-	-	-	300	350	400
Mineral	5	5	5	5	5	5	5

* Chemical composition (per kg of DM) of 108 Best Hope Concentrate Feed include: DM 870 g, CP 480 g, CF 40 g, Ca (min-max) 30-40 g, P (min) 25 g, NaCl (min-max) 10-15 g, lysine (min) 36 g, methionine (min) 12 g. Calculated content (Kcal per kg DM) of metabolizable energy, 3000.

The pigs were fed ad libitum and were given new feed three times per day (06.00, 11.00 and 18.00 h). The daily feed allowance was based on feed offered and refused the previous day. The pigs had free access to drinking water via automatic drinking nipples.

2.2. Data Recording

Feed refusals were recorded daily and were used for correction of the feed intake data. Pigs were weighed every month.

2.3. Carcass Traits

For evaluation of carcass traits, three pigs (2 females and 1 male) from each treatment were randomly selected at the end of experiment, starved of feed overnight, weighed and slaughtered at a commercial slaughterhouse. The back-fat thickness was measured at P2. The loin area was determined at the thirteenth and fourteenth rib. After slaughter, pH of the longissimus dorsi muscle (at the middle of the thirteenth and fourteenth rib) was measured with a pH-meter (Hanna Instruments 99163) by putting a pH probe into the muscle at 45 minutes (pH45) and at 24 hours (pH24). The iodine index of carcass fat was analyzed according to Wijs (method 993.20, [18]). Water-holding capacity of meat was determined as described by [19] using samples from the longissimus dorsi muscle at the middle of the thirteenth and fourteenth rib. In brief, 24 h after slaughter a muscle sample was collected and weighed (approximately 0.5 g) and put in a centrifuge tube with a filter paper (pore size 90 µm) at the bottom of the tube. The muscle sample was weighed after centrifugation at 30 x g for 1 h at 4°C. The water-holding capacity was calculated from weight of samples before and after centrifugation. The muscle samples were analyzed for moisture, crude protein (CP), ether extracts (EE) and ash with standard [20] methods (for method number see below).

Table 4. Dry Matter (DM) Content (g/kg DM), Chemical Composition (g/kg DM) and Metabolizable Energy (ME) Value (kcal/kg DM) of Experimental Diets

Item	Diets						
	CO	RBF1	RBF2	RBF3	CWF1	CWF2	CWF3
	Growing period						
DM	859	791	784	769	669	623	586
CP	175	195	189	183	189	198	197
True protein	142	144	133	138	129	137	125
EE	40	53	62	71	23	22	20
CF	50	54	57	60	60	66	71
NDF	30	50	67	83	59	79	98
ADF	14	21	27	34	34	45	56
Ash	23	30	36	42	18	20	22
ME	2929	2955	2942	2939	2902	2865	2828
	Finishing period						
DM	857	756	748	731	575	564	552
CP	156	159	160	160	159	157	158
True protein	127	128	129	129	120	122	121
EE	58	83	92	100	23	22	20
CF	49	56	59	62	70	74	80
NDF	61	100	116	133	117	137	156
ADF	27	41	47	55	68	79	90
Ash	35	50	56	62	25	27	29
ME	2958	3018	3005	2992	2893	2866	2829

2.4. Chemical Analysis

The feed samples were analyzed for DM (method 930.15), ash (method 942.05), CP (method 984.13), EE (method 920.39), crude fibre (CF, method 978.10), acid detergent fiber (ADF, method 973.18) and neutral detergent fiber (NDF, method 4.6.03) according to standard AOAC methods [18,20](AOAC, 1990; AOAC, 1997). True protein content of feed mixtures was analyzed using precipitation with trichloroacetic acid (TCA) as described by [20,21]. The HCN content of cassava waste was analyzed by the method of [22].

2.5. Statistical Analyses

The data were analyzed as a 2x4 factorial completely randomized design with diet type, level of inclusion and interaction (diet type by level of inclusion) as factors using the GLM procedure of Minitab Software, version 13.31 [23]. Treatment means which showed significant differences at the probability level of $p<0.05$ were compared using Tukey's pairwise comparison procedure.

3. Results

3.1. Performance

In the growing period, the average daily feed intake (ADFI) and feed conversion ratio (FCR) differed between the fermented feeds with lower ADFI and better FCR ($p<0.01$) on diet CWF than on diet RBF (Table 5). Inclusion of fermented feeds reduced the ADFI compared with the control diet ($p<0.01$). The FCR was improved with increasing inclusion of fermented feeds ($p<0.01$). There were no differences in average daily gain (ADG) between diet type or between inclusion levels of fermented feeds ($p=0.43$ and $p=0.30$, respectively).

In the finishing period, the ADFI, ADG and FCR differed between the fermented feeds with lower ADFI and ADG, and better FCR ($p<0.01$) on diet CWF than on diet RBF. Inclusion of fermented feeds reduced ADFI and ADG ($p<0.01$), while there was no clear effect of inclusion level on the FCR ($p=0.066$) compared with the control diet.

Overall, pigs fed diet CWF showed lower ADFI and ADG, and better FCR than pigs fed diet RBF ($p<0.01$). Inclusion of fermented feeds reduced ADFI and ADG ($p<0.01$), and improved FCR compared with the control diet ($p<0.01$).

3.2. Carcass Traits

Live weight at slaughter and hot carcass weight was lower on diet CWF than on diet RBF ($p<0.01$), while the dressing percentage was higher on diet RBF than on diet CWF ($p<0.03$) (Table 6). Carcass percentage, carcass length, loin muscle area and back fat thickness were unaffected by diet type. Increasing inclusion of fermented feeds resulted in lower live weight at slaughter, lower hot carcass weight and lower back fat thickness ($p<0.01$). The carcass percentage was affected by inclusion level of fermented feeds (p<0.01) but did not show any consistent pattern. The iodine index was lower on diet CWF than on diet RBF (p<0.01), but was unaffected (p>0.05) by inclusion level of fermented feeds. Dressing percentage, carcass length, loin muscle area and parameters measured on muscle samples (DM, CP, EE, ash, pH45, pH24 and water-holding capacity) were unaffected (p>0.05) by inclusion level of fermented feeds.

Table 5. Performance of Growing Pigs Fed Diets With Inclusion of Fermented Rice Bran (RBF) and Fermented Cassava Waste (CWF)

	By-products fermented (BPF)		Level (L)				SEM	P-value		
	RBF	CWF	CO	L1	L2	L3		BPF	L	BPF*L
Number of pigs	15	15	5	10	10	10				
The growing period										
Feed intake (g/day)	1102	1031	1136[a]	1063[b]	1044[b]	1024[b]	7.53	0.001	0.001	0.001
Weight gain (g/day)	475	464	453	485	460	480	13.61	0.432	0.304	0.872
FCR (kg/kg)	2.34	2.23	2.51[a]	2.21[bc]	2.28[b]	2.15[a]	0.01	0.001	0.001	0.001
The finishing period										
Feed intake (g/day)	2032	1774	2059[a]	1912[b]	1812[c]	1827[c]	14.09	0.001	0.001	0.001
Weight gain (g/day)	649	622	680[a]	648[b]	611[c]	603[d]	8.39	0.003	0.001	0.103
FCR (kg/kg)	3.14	2.85	3.03	2.96	2.96	3.03	0.02	0.001	0.066	0.001
Overall										
Feed intake (g/day)	1722	1526	1752[a]	1629[b]	1556[c]	1559[c]	16.66	0.001	0.001	0.001
Weight gain (g/day)	591	570	604[a]	594[a]	561[b]	562[b]	6.77	0.003	0.001	0.194
FCR (kg/kg)	2.92	2.68	2.90[a]	2.75[b]	2.77[b]	2.77[b]	0.02	0.001	0.001	0.001
Feed cost/kg gain (VND)	30371	25094	30333[a]	27283[b]	26905[b]	26409[b]	175.10	0.001	0.001	0.001

L1: 15 and 30% of RBF or CWF in growing and finishing period; L2: 20 and 35% of RBF or CWF in growing and finishing period; L3: 25 and 40% of RBF or CWF in growing and finishing period.

Table 6. Carcass Traits in Growing Pigs Fed Diets With Inclusion of Fermented Rice Bran (RBF) and Fermented Cassava Waste (CWF)

	By-products fermented (BPF)		Level (L)				SEM	P-value		
	RBF	CWF	CO	L1	L2	L3		BPF	L	BPF*L
Live weight at slaughter (kg)	73.6	71.1	74.7[a]	73.7[a]	70.5[b]	70.6[c]	0.40	0.001	0.001	0.07
Hot carcass weight (kg)	55.3	53.7	56.3[a]	55.5[a]	53.2[b]	53.1[b]	0.31	0.001	0.001	0.28
Dressing percentage (%)	75.1	75.6	75.4	75.2	75.4	75.3	0.14	0.03	0.83	0.01
Carcass percentage (%)	72.1	71.8	72.6[a]	71.4[ab]	71.7[a]	72.3[a]	0.16	0.17	0.001	0.09
Carcass length (cm)	97.8	97.3	97.9	97.9	97.1	97.2	0.22	0.13	0.13	0.36
Loin muscle area (cm^2)	42.5	42.7	43.0	42.3	42.6	42.3	0.19	0.68	0.31	0.73
Back fat thickness (cm)	2.13	2.03	2.40[a]	2.13[b]	1.85[c]	1.94[c]	0.02	0.03	0.001	0.001
Iod index	64.8	60.8	62.3	63.0	62.4	62.6	0.38	0.001	0.133	0.001

L1: 15 and 30% of RBF or CWF in growing and finishing period; L2: 20 and 35% of RBF or CWF in growing and finishing period; L3: 25 and 40% of RBF or CWF in growing and finishing period.

4. Discussion

4.1. Performance

The ADFI decreased with increasing inclusion of fermented rice bran and cassava waste in the growing and finishing period, and overall. However, the reduction in ADFI was more pronounced in the finishing than in the growing period. As a result, the ADG was unaffected in the growing period while it decreased linearly with increasing inclusion of fermented by-products in the growing period. The decreasing of ADG in the finishing period and overall can be explained by increased dietary fiber level [24]. The level of ADFI in diets with CWF inclusion was lower than that in diets with RBF inclusion, which can be explained by the higher water holding capacity (WHC) of CWF [25]. It was reported that the WHC (kg/kg DM) of rice bran was 2.5 and of cassava residue 5.5 [25]. It has been shown that the bulk of the feed will increase with increasing WHC and this will results in reduced feed intake [26]. [27] reported that the growth of rats and pigs was unaffected by inclusion of the rice bran at a level of 300 g/kg in dry matter (DM). In the present study, the ADG decreased at inclusion levels of fermented rice bran and cassava waste above 150 g/kg DM in the growing period and 300 g/kg DM in the finishing period.

Interestingly, the FCR was improved in the growing period and overall with increasing inclusion of fermented by-product while it remained unchanged in the finishing period. The improved FCR could be due to the change in diet composition with inclusion of fermented by-product, resulting in a higher intake of CP in the grower period. Moreover, the fermentation of rice bran and cassava waste with microbes with high activities of digestive enzymes may have improved the availability of nutrients, which would be reflected in an improved FCR. In addition, it is also possible that the fermented by-products had probiotic effects, which may have contributed to the improved FCR. [28] reported that dietary supplementation of a lactic acid bacteria complex together with Bacillus and Saccharomyces to growing-finishing pigs improved FCR while the ADFI was unaffected. This effect was most apparent during the growing period.

Feed cost per kilogram of live weight gained was highest on the CO diet (30,333 VND) and was gradually reduced with increasing inclusion level of RBF and CWF in the diet. The feed cost was reduced with 10% at the lowest inclusion level and with 13% at the highest inclusion level.

4.2. Carcass traits

Fermented cassava pulp has been used as alternative feed sources for many livestock species with cost-reducing benefits [9,29]. However, there is little information on the effects of the use of microbial fermented cassava by-product on meat quality and carcass characteristics of pigs. The current study showed that increasing level of RBF and CWF in the diets negatively affected live weight at slaughter, hot carcass weight and back-fat thickness. In contrast, the dressing percentage, loin muscle area and iodine index were unaffected by increasing inclusion of RBF and CWF in the diet. The lower live weight at slaughter, hot carcass weight and back-fat thickness can be explained by the reduction in feed intake with increasing inclusion of RBF and CWF in the diet. [30] showed that dietary inclusion of up to 40% of microbially enhanced cassava peels improved dressing percentage and improved protein and dry matter content of pig meat. [31] reported that there were no significant differences in composition of pork meat when using 10 to 20% fermented rice bran in the diet, but the fermented rice bran treated groups had a tendency for higher moisture content and a lower fat content. Overall, inclusion of fermented rice bran to the feed improved the quality of pork [31].

5. Conclusions

Crossbred (Landrace x Yorkshire) pigs can be fed fermented by-products of cassava waste and rice bran at an inclusion level of 15% in the growing period and 30% in the finishing period without negative effects on growth performance and carcass traits. The results suggest that, at this level of inclusion, the feed conversion ratio will be improved and the feed costs reduced when compared with a conventional maize-rice bran diet.

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