science, engineering and health studies

Research Article

Science, Engineering and Health Studies
https://li01.tci-thaijo.org/index.php/sehs
ISSN (Online): 2630-0087

Improvement of crude protein composition of cassava pulp by yeast fermentation with chicken manure

Simon Anthony Kayombo, Pattaraporn Poommarin and Panida Duangkaew*

Faculty of Animal Science and Agricultural Technology, Silpakorn University, Phetchaburi 76120, Thailand

***Corresponding author**:
Simon Anthony Kayombo
smnkayombo@gmail.com

***Received**: 15 February 2022*
***Revised**: 12 October 2022*
***Accepted**: 15 November 2022*
***Published**: 14 December 2022*

***Citation**:*
Kayombo, S. A., Poommarin, P., and Duangkaew, P. (2022). Improvement of crude protein composition of cassava pulp by yeast fermentation with chicken manure. Science, Engineering and Health Studies, 16, 22030009.

ABSTRACT

The aim of this study was to increase crude protein composition of cassava pulp by yeast fermentation with chicken manure. Two different fermentation experiments were conducted, the first with sugar activation under controlled temperature, and the second with sugar or molasses activation under uncontrolled temperature. The experiments were designed as a factorial arrangement in completely randomized design. Two factors, including treatment composition and fermentation time, were studied. The results revealed that the crude protein percentage of fermented cassava pulp increased in all treatments containing chicken manure. The highest level of crude protein composition was observe in cassava pulp fermented with yeast and chicken manure plus sugar activation for 20 days, which was higher than non-fermented cassava pulp. In conclusion, fermenting cassava pulp by yeast and chicken manure with sugar activation for 20 days could improve the crude protein content of cassava and may be used as an alternative ingredient for animal feeds.

Keywords: animal feeds; cassava pulp; chicken manure; *Saccharomyces cerevisiae*

1. INTRODUCTION

One of the constraints of monogastric animal production, especially in farms with poor resources, is high price and inaccessibility of feed. In commercial situations, feed cost accounts for 50 to 70% of the production cost (Spring, 2013). The biggest contributor to higher production costs is protein ingredients, which are more expensive compared to cereals (Manyelo et al., 2020). The increasing cost of conventional protein sources such as soybean, fish meal, sunflower seed cake, necessitates the need to find other alternative feeds to replace or decrease the crude protein content of conventional protein ingredients.

Cassava pulp is a solid moist fibrous material remaining after starch extraction from cassava roots. It is comparatively cheap, and its availability offers an opportunity for utilization by the livestock industry because it may reach up to 30% of the whole original cassava roots depending on the efficiency of cassava starch processing factories (Ghimire et al., 2015). However, the nutritional problem of cassava pulp is its low crude protein of less than 2.2%, and a high fiber content of up to 26.9%, as reported by Heuzé et al. (2016). In addition, the presence of starch and cellulose fiber in cassava pulp makes it a good medium for growing fungi through fermentation (Boonnop et al., 2009; Sugiharto et al., 2017).

Fermentation is one of the less expensive ways of increasing protein and quality of feed ingredients. It entails a metabolic process involving the chemical breakdown of organic materials through the action of enzymes from microorganisms. *Saccharomyces cerevisiae* yeast is of interest and widely used in the fermentation of feed ingredients. Yeast fermentation of cassava pulp (YFCP) can increase crude protein, true protein and lysine, but can also lower crude fiber and cyanide content (Kasprowicz-Potocka et al., 2016; Khampa et al., 2011). Also, the improvement may be more impressive if a source of nitrogen is used, such as urea, ammonium sulfate, diammonium sulfate, and peptone (Okrathok et al., 2018). Alternative nitrogen source from agricultural by-products can be further elucidated to explore the new materials and to reduce waste pollution.

Chicken manure has a crude protein content of 15.4% (Lanyasunya et al., 2006) to 31% (Trevino et al., 2002). It can possibly be a choice of organic nitrogen sources. It has been used directly as pig feed by some livestock producers in different countries. Nigerians use dried poultry manure to feed pigs. In Southeast Asia, farmers construct layer cages 1.5 meters above the pig pens, hence the excreta fall in pens and are consumed by the pigs (Flachowsky, 1997). The use of this waste at the recommended level does not show any negative effect (Adesehinwa et al., 2010). However, the chicken manure should be dried to remove harmful microbes (Trevino et al., 2002).

Therefore, this study intended to investigate the increase in cassava pulp crude protein composition by yeast fermentation with chicken manure as a nitrogen source under different conditions of temperature, moisture, and sugar activation.

2. MATERIALS AND METHODS

2.1 Materials

Cassava pulp was bought from EK Animal Feed Store (Tha Yang, Phetchaburi, Thailand). *Saccharomyces cerevisiae* yeast (Lesaffre Saf-Instant®, France), ammonium sulfate (Crown, Terragro, Thailand), and table sugar were bought at a nearby store. Chicken manure was collected from layer pens at university farm. The trash was removed, dried in a hot air oven (60°C) for 3 days, and then finely ground using a pestle, mortar, and electric blender.

2.2 Experimental design

This experiment was designed as 5(A) × 3(B) and 2(A) × 3(B) factorial arrangement in completely randomized design in Fermentation 1 and Fermentation 2, respectively, with three replications. Factor A was arranged into treatments and factor B was set at different fermentation times (0, 10, and 20 days). Details of treatments with calculated total nitrogen (N) and crude protein are shown in Table 1.

Table 1. Treatments group with their hypothetical percentage of nitrogen and crude protein

Treatment	Composition (%)				Contribution of N from each ingredient (%)				Total N	% CP
	CPu	Y	AS	CM	CPu	Y	AS	CM		
Fermentation 1										
T1	100				0.32	0.00	0.00	0.00	0.32	2.00
T2	99	1			0.32	0.06	0.00	0.00	0.38	2.36
T3	97	1	2		0.31	0.06	0.42	0.00	0.79	4.95
T4	70	1		29	0.22	0.06	0.00	0.46	0.83	5.21
T5	70	1		29	0.22	0.06	0.00	0.46	0.83	5.21
Fermentation 2										
TS	70	1		29	0.22	0.06	0.00	0.46	0.83	5.21
TM	70	1		29	0.22	0.06	0.00	0.46	0.83	5.21

Note: AS = ammonium sulfate, CM = chicken manure, CP = crude protein, CPu = cassava pulp, N = nitrogen, T = treatment, TS = treatment with sugar, TM = treatment with molasses, Y = yeast. Nitrogen content of each ingredient used in calculation: CPu =0.32, Y=6.11, AS=21.0, and CM= 1.6.

2.3 Preparation of cassava pulp fermentation

Cassava pulp fermentation was prepared by combining the methods of Huu and Khammeng (2014) and Nukreaw et al. (2019) with modification. In Fermentation 1, cassava pulp and chicken manure were weighted according to each percentage of treatment composition. Yeast solution (10% w/v) was prepared by mixing 12 g of yeast with 20% sterile sugar solution, stirring well for 30 min. Ammonium sulfate solution (20% w/v) was prepared in sterile water. Then, 10 mL of yeast solution were added into treatments T2, T3, T4, and T5 to obtain 1% yeast inoculation. Ammonium sulfate solution was added to T3 to get 2% of the treatment. All treatments were adjusted to 40% by the addition of sterile water, then thoroughly mixed. The treatments were each packed anaerobically in a plastic bag, and treatments T1 through T4 were stored in the incubator at 37°C, while T5 was stored at room temperature (28-33°C) for 0, 10, and 20 days. When reaching the specific fermentation time, the samples were placed in a freezer until analysis. Fermentation 2 (TS and TM) followed the same procedures of Fermentation 1 (T5). The difference between the two was that TM was activated with 20% a solution of molasses as 4% of treatment weight, but TS was activated with table sugar as in Fermentation 1. Then, the moisture was adjusted to 30% instead of 40% and stored at room temperature (28-33°C).

2.4 Data collection

The data collected were dry matter, crude protein, crude fiber, gross energy, and pH of cassava pulp, chicken manure, and YFCP, following the AOAC (2000). The pH value was determined by dissolved samples in distilled water (1:10 ratio) and measured by a pH meter (Adwa AD12, Hungary).

2.5 Statistical analysis

The mean ± standard deviation of dry matter, gross energy, crude protein, crude fiber, and pH were statistically analysed using analysis of variance (ANOVA) and compared by Duncan's new multiple range test (DMRT) in the R program (significance was defined as $p<0.05$).

3. RESULTS AND DISCUSSION

Prior to fermentation, the dry matter, crude protein, crude fiber, gross energy, and pH of ingredients, including cassava pulp and chicken manure used in the experiments, were analyzed (Table 2). Cassava pulp contained higher dry matter, crude fiber, and gross energy, compared to chicken manure, which had higher crude protein and pH. The pH of cassava pulp was lower because storage and room temperature seemed to reduce the pH due to the production of acid by the fermentative natural microorganisms in the sample (Souza et al., 2013)

Table 2. Crude protein, crude fiber and gross energy of cassava pulp and chicken manure (on a dry basis)

Parameters	Cassava pulp	Chicken manure A
Dry matter (%)	87.03 ± 0.25	25.39 ± 0.68*
Crude protein (%)	1.99 ± 0.19	13.93 ± 0.29
Crude fiber (%)	15.63 ± 0.73	13.32 ± 1.48
Gross energy (kcal/kg)	3,456.67 ± 50.38	2,386.47 ± 24.31
pH value	4.67 ± 0.11	7.89 ± 0.05

Note: Data are expressed as mean ± standard deviation (n = 3), *chicken manure dry matter is on a fresh basis.

Percentage of crude protein (%CP) of YFCP under a controlled temperature of 37°C, showed that %CP was affected by the interaction effect among both factors (p<0.1) and individual factors (p<0.001) (Table 3). The highest CP of 6.41% was observed in the treatment with chicken manure stored in the incubator (T4) at 20 days, followed by 6.38% and 6.29% in the treatment with chicken manure stored at room temperature (T5) at 10 and 20 days of fermentation, respectively. Higher CP was found in the treatment containing a source of nitrogen (T3, T4, and T5), compared to those with no source of nitrogen (T1 and T2). The mean results within treatments showed T4 had the highest %CP of 6.04%. Also, there was an increase in crude protein at different fermentation times. The mean result within fermentation days showed that day 20 had a higher amount of CP (Table 3).

Table 3. Crude protein results of first fermentation of 5 treatments in 3 fermentation times under controlled temperature

Treatment (A)	Fermentation times (days)			Mean (A)
	0	10	20	
T1	2.08 ± 0.18 ^{g}	2.10 ±0.16 ^{fg}	2.20 ±0.36 ^{fg}	2.13 ± 0.22 ^{e}
T2	2.56 ± 0.04 ^{e}	2.40 ±0.10 ^{ef}	2.54 ±0.10 ^{e}	2.50 ± 0.1 ^{d}
T3	5.10 ± 0.20 ^{d}	5.10± 0.20 ^{d}	5.61± 0.11 ^{c}	5.28 ± 0.31 ^{c}
T4	5.80 ± 0.10 ^{bc}	5.91± 0.07 ^{bc}	6.41 ± 0.26 ^{a}	6.04 ± 0.31 ^{a}
T5	5.10 ± 0.10 ^{d}	6.29± 0.08 ^{a}	6.38± 0.28 ^{a}	5.92 ± 0.2 ^{b}
Mean (B)	4.13 ± 1.74 ^{b}	4.36 ± 1.83 ^{b}	4.63 ± 1.94 ^{a}	
p value				
A	<0.001			
B	<0.001			
A : B	<0.1			
% CV	3.9			

Note: Results are on a dry matter basis and are expressed as mean ± standard deviation (n = 3). The different superscript letters are statistically different by Duncan's new multiple range test (p≤0.05)

The results of Fermentation 2, whereby cassava pulp, yeast, and chicken manure with molasses (TM) or sugar (TS) activation were fermented in an uncontrolled temperature are shown in Table 4. Before fermentation, the crude protein was observed to be higher than in Fermentation 1. This was caused by the different batches of chicken manure collected. TS at 10 and 20 days of fermentation and TM at day 10 showed the highest crude protein value. Considering the effects of sugar and molasses, the results showed that sugar gave a significantly higher level of crude protein. The higher effect of fermentation time was observed at 20 days of fermentation.

Protein ingredients are one of the most expensive components of feeds in animal production. In the present work, cassava pulp was fermented with yeast in the presence of chicken manure, with activation by table sugar or molasses. The high percentages of CP in T3, T4, T5, TS, and TM during the different fermentation times were due to the addition of ammonium sulfate and chicken manure as nitrogen sources.

In both fermentations, the crude protein of cassava pulp was increased. Interaction effects of both factors, time and treatment compositions, were observed in two fermentation batches. In Fermentation 1, the highest increase was 6.41% observed in the treatment containing chicken manure under a controlled temperature of 37°C (T4) and 6.38% in the treatment containing chicken manure (T5) stored at room temperature (Table 3). In Fermentation 2, both treatments (TS and TM) had comparable crude protein percentages at day 20 of fermentation; however, the percentage increase in TM was higher (2.15%), compared to 1.46% in TS (Table 4). The results suggested that fermentation with chicken manure seemed to produce a higher %CP and indicated that activation of soluble sugar was preferred. The effect of fermentation time was also observed. As fermentation time increased, the crude protein level increased. This result of a time effect on fermentation matched with those of Hang et al. (2019) and Iyayi (2001), whereby the best time for cassava pulp fermentation was between 14 and 21 days, respectively.

Table 4. Crude protein of second yeast fermented cassava pulp activated with sugar (TS) and molasses (TM) at room temperature

Treatment (A)	Fermentation times (days)			Mean (A)
	0	10	20	
TS	7.50 ± 0.90 ^{b}	8.65 ± 0.54 ^{a}	8.96 ± 0.72 ^{a}	8.70 ± 0.66 ^{a}
TM	6.17 ± 0.08 ^{b}	6.37 ± 0.35 ^{b}	8.32 ± 0.37 ^{a}	6.95 ±1.06 ^{b}
Mean (B)	6.84 ± 1.4 ^{b}	7.51 ± 1.31 ^{b}	8.64 ± 0.62 ^{a}	
p value				
A	<0.001			
B	<0.01			
A : B	<0.05			
% CV	7.15			

Note: Results are on a dry matter basis and are expressed as mean ± standard deviation (n = 3). The different superscript letters are statistically different by Duncan's new multiple range test ($p \leq 0.05$)

The percentage of crude protein in Fermentation 2 was higher than in Fermentation 1. The low percentage of crude protein in the first fermentation may be caused by a higher temperature of 37°C. AL-Sa'ady (2014) discovered the optimal temperature for *S. cerevisiae* incubation is 30°C. Lower and higher temperatures decrease the enzymatic reaction of microorganisms and reduce growth. Also, it may be caused by the lower moisture content of 30% in the inoculant solution in the second fermentation, compared to 40% in the first fermentation. Low moisture reduced the porosity of the substrate, which limits the oxygen transfer within a substrate and led to low production of enzymes and growth as previously reported (AL-Sa'ady, 2014; Camacho-Ruiz et al., 2003).

The CP increase in Fermentation 2 is related to 8.54% (Kayombo et al., 2022). Also, the highest CP reached in the first and second fermentations of the present work were quite low when compared to 12% (Sengxayalth and Preston, 2017). This may be caused by a higher percentage combination of initial nitrogen source of 4.05% urea and 1% diammonium phosphate, and a higher percentage of 2.02% yeast, compared to 1% yeast and low initial nitrogen sources in chicken manure, which equated to 2% of ammonium sulfate in the present work. Likewise, the higher pH of chicken manure interferes with the fermentation process, which needs an acidic environment, as reported by Flachowsky (1997) and Serrano et al. (2004). However, the increase in the first fermentation (0.61%) was higher than the 0.04% increase, as revealed by Sugiharto et al. (2017), whereby *Rhizopus oryzae* fungi were used without a source of nitrogen. Additionally, the increase in the second fermentation was related to 2.05% (Hang et al., 2019), which used a combination of 2% urea and 1.5% diammonium phosphate as a nitrogen source. As well, related to 1.98% as reported by Kayombo et al. (2021), who used a related condition, the differences were 20% inoculant activator solution, a batch of chicken manure, and sugar activator solution, instead of the molasses activator of the present work. Moreover, the increase in percentage of crude protein in both fermentations was lower than 4.31% (Iyayi, 2001), whereby 2% of peptone was used as a nitrogen source for the yeast.

The increase in %CP may be caused by the action of yeast to utilize the carbohydrates of cassava pulp as an energy to produce some proteins using nitrogen from chicken manure. The *S. cerevisiae* cells have invertase and maltase enzymes, which can easily utilize simple carbohydrates (Batista et al., 2004; Parapouli et al., 2020). Also, yeast can use organic and inorganic nitrogen, because of the presence of three permease enzymes (MEP 1, MEP 2, and MEP 3), which facilitate the entrance of ammonia into the cell and linked with glutamate dehydrogenase, then combine with glutamine through glutamine synthetase (Jiranek et al., 1995; Magasanik and Kaiser, 2002). Besides the action of yeast, it was observed that treatments without chicken manure showed no difference in crude protein, compared to treatments with chicken manure, when increasing the fermentation time. Therefore, the increase of crude protein might be contributed by some associated microorganisms in chicken manure (Li et al., 2020). Incorporation of organic and/or inorganic nitrogen to amino acids and proteins could occur by the action of any microorganism presence in the fermentation batch. Hydrolysis of the carbohydrate portion of cassava to small sugar molecules and oxidation to energy by cellular respiration process could be sources of energy. The energy produced is used for synthesis of cell components, including nitrogen containing biomolecules such as proteins. For further clarification of this phenomena, the true protein should be directly examined from this fermentation. Also, the study of beneficial microorganisms in chicken manure might provide more information and further advantages.

4. CONCLUSION

Based on this study, fermentation of cassava pulp by yeast with chicken manure plus sugar or molasses activation could increase crude protein from 1.99% pure cassava pulp to 8.96% at 20 days. The higher initial crude protein source in fermentation contributed higher final crude protein. Both table sugar and molasses can be used as initial energy sources during the fermentation process of cassava pulp.

It should be noted that proximate analysis was used in this work to evaluate the increase in protein content in fermented cassava.

REFERENCES

Adesehinwa, A. O. K., Obi, O. O., Makanjuola, B. A., Adebayo, A. O., and Durotoye, E. S. (2010). Utilization of sun-dried on-farm generated poultry litter as a feed resource for growing-finishing pigs. *African Journal of Biotechnology*, 9(19), 2821-2825.

AL-Sa'ady, A. J. R. (2014). Optimization of invertase production from *Saccharomyces cerevisiae* by solid state fermentation. *Current Research in Microbiology and Biotechnology,* 2(3), 373-377.

AOAC (2000). *Official Methods of Analysis*, 17th, Gaithersburg: The Association of Official Analytical Chemists, pp. 200-210.

Batista, A. S., Miletti, L. C., and Stambuk, B. U. (2004). Sucrose fermentation by *Saccharomyces cerevisiae* lacking hexose transport. *Journal of Molecular Microbiology and Biotechnology*, 8(1), 26-33.

Boonnop, K., Wanapat, M., Nontaso, N., and Wanapat, S. (2009). Enriching nutritive value of cassava root by yeast fermentation. *Scientia Agricola*, 66(5), 629-633.

Camacho-Ruiz, L., Perez-Guerra, N., and Roses, R. P. (2003). Factors affecting the growth of *Saccharomyces cerevisiae* in batch culture and in solid-state fermentation. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 2(5), 531-542.

Hang, D. T., Chau, H. L. Q., Hang, L. T. T., and Preston, T. R. (2019). Protein-enrichment of cassava pulp as feed for growing pigs. *Livestock Research for Rural Development*, 31(5), 73.

Flachowsky, G. (1997). Animal excreta as feedstuff for ruminants-A review. *Journal of Applied Animal Research,* 12(1), 1-40.

Ghimire, A., Sen, R., and Annachhatre, A. P. (2015). Biosolid management options in cassava starch industries of Thailand: Present practice and future possibilities. *Procedia Chemistry,* 14, 66-75.

Heuzé, V., Tran, G., Archimede, H., Regnier, C., Bastianelli, D., and Lebas, F. (2016). *Cassava peels, cassava pomace and other cassava by-products*. [Online URL: https://agritrop.cirad.fr/582525/1/ID582525.pdf] accessed on 15 February, 2020.

Huu, H., and Khammeng, T. (2014). Effect of yeast fermented cassava pulp (FCP) on nutrient digestibility and nitrogen balance of post-weaning pigs. *Livestock Research for Rural Development,* 26(8), 149.

Iyayi, E. A., and Losel, D. M. (2001). Protein enrichment of cassava by-products through solid state fermentation by fungi. *Journal of Food Technology in Africa*, 6(4), 116-118.

Jiranek, V., Langridge, P., and Henschke, P. A. (1995). Amino acid and ammonium utilization by *Saccharomyces cerevisiae* wine yeasts from a chemically defined medium. *American Journal of Enology and Viticulture*, 46(1), 75-83.

Kasprowicz-Potocka, M., Borowczyk, P., Zaworska, A., Nowak, W., Frankiewicz, A., and Gulewicz, P. (2016). The effect of dry yeast fermentation on chemical composition and protein characteristics of blue lupin seeds. *Food Technology and Biotechnology*, 54(3), 360-366.

Kayombo, S. A., Poommarin, P., and Duangkaew, P. (2021). Improvement of cassava pulp nutrients by yeast fermentation with chicken manure. *Rattanakosin Journal of Science and Technology*, 2(2), 56-69.

Kayombo, S. A., Poommarin, P., and Duangkaew, P. (2022). Efficacy of fermented cassava pulp with chicken manure on nutrients digestibility, haematological parameters, and growth performance of barrow pigs. *International Research Journal of Science, Technology, Education, and Management,* 2(1), 208-216.

Khampa, S., Ittharat, S., and Koatdoke, U. (2011). Enrichment value of yeast-malate fermented cassava pulp and cassava hay as protein source replace soybean meal in concentrate on rumen ecology in crossbred native cattle. *Pakistan Journal of Nutrition*, 10(12), 1126-1131.

Lanyasunya, T. P., Wang H. Rong, S. A. Abdulrazak, P. K. Kaburu, J. O. Makori, T. A. Onyango, and Mwangi D. M. (2006). Factors limiting use of poultry manure as protein supplement for dairy cattle on smallholder farms in Kenya. *International Journal of Poultry Science* 5(1), 75-80.

Li, X., Zhao, X., Yang, J., Li, S., Bai, S., and Zhao, X. (2020). Recognition of core microbial communities contributing to complex organic components degradation during dry anaerobic digestion of chicken manure. *Bioresource Technology*, 314(1), 123765.

Magasanik, B., and Kaiser, C. A. (2002). Nitrogen regulation in *Saccharomyces cerevisiae*. *Gene,* 290(1-2), 1-18.

Manyelo, T. G., Sebola, N. A., van Rensburg, E. J., and Mabelebele, M. (2020). The probable use of Genus amaranthus as feed material for monogastric animals. *Journal of Animals,* 10(9), 1504.

Nukreaw, R., Kongruksa, A., Sikulap, A., Srinakruea, T., Poosuwan, K., and Comsangtong, T. (2019). *The study of yeast fermented cassava pulp with methionine supplementation in diet of native chicken small holder farm at Rayong province*. Bangkok: Department of Livestock Development.

Okrathok, S., Pasri, P., Thongkratok, R., Molee, W., and Khempaka, S. (2018). Effects of cassava pulp fermented with *Aspergillus oryzae* as a feed ingredient substitution in laying hen diets. *Journal of Applied Poultry Research*, 27(2), 188-197.

Parapouli, M., Vasileiadis, A., Afendra, A. S., and Hatziloukas, E. (2020). *Saccharomyces cerevisiae* and its industrial applications. *AIMS Microbiology*, 6(1), 1-31.

Sengxayalth, P., and Preston, T. R. (2017). Fermentation of cassava (*Manihot esculenta* Crantz) pulp with yeast, urea and di-ammonium phosphate (DAP). *Livestock Research for Rural Development,* 29(9), 177.

Serrano, R., Bernal, D., Simón, E., and Ariño, J. (2004). Copper and iron are the limiting factors for growth of the yeast Saccharomyces cerevisiae in an alkaline environment. *Journal of Biological Chemistry*, 279(19), 19698-19704.

Souza, T. A. C., Soares Júnior, M., Campos, M. R. H., Souza, T. S. C., and Bandeira, L. C. (2013). The effect of chemical treatments on the pH & microbial flora of cassava residues during storage. *Food Science and Technology*, 33, 457-462.

Spring, P. (2013). The challenge of cost-effective poultry and animal nutrition: Optimizing existing and applying novel concepts. *Lohmann Information*, 48(1), 38-46.

Sugiharto, S., Yudiarti, T., Isroli, I., Widiastuti, E., and Putra, F. D. (2017). Effects of feeding cassava pulp fermented with *Acremonium charticola* on growth performance, nutrient digestibility and meat quality of broiler chicks. *South African Journal of Animal Science*, 47(2), 130-137.

Trevino, H. M., Ornelas, E. G., and Barragan, H. B. (2002). Using high quality poultry litter for growing beef cattle in an intensive feeding system increases animal performance. *Tecnica Pecuaria en Mexico,* 40(1), 1-16.