



Effects of Blend By-Products as Fibre Source on the Growth Performance, Nutrient Digestibility, and Meat Quality of Rabbits

USMAN ALI*, BADAT MUWAKHID AND DEWI MASYITHOH

Animal Husbandry Faculty, University Islam Malang, East Java, Indonesia.

Abstract | The aim of this study was to determine the effect of feeding rabbits with fermented cassava by-products, coconut flesh skin, and soya bean skin on their performance, nutrient digestibility, and the cholesterol levels in their meat. A randomised block design was used. There were five treatments and three animal groups (two animals per group), classified by body weight. The treatments involved substituting soya bean with fermented cassava by-products, coconut flesh skin, and soya bean skin (FCCSB) at levels of 0%, 7.5%, 15%, 22.5%, and 30% of the diet. The results showed that substituting soya bean meal with FCCSB significantly ($P < 0.05$) improved production performance and feed digestibility in rabbits and had no significant effect on the cholesterol levels of rabbit meat. The optimal response was observed at the 30% substitution level of FCCSB.

Keywords | FCCSB, Fermentation, New Zealand white, Rabbit, Performance

Received | June 21, 2024; **Accepted** | July 05, 2024; **Published** | July 29, 2024

***Correspondence** | Usman Ali, Animal Husbandry Faculty, University Islam Malang, East Java, Indonesia; **Email:** usman.ali@unisma.co.id

Citation | Ali U, Muwakhid B and Masyithoh D (2024). Effects of blend by-products as fibre source on the growth performance, nutrient digestibility, and meat quality of rabbits. *Adv. Anim. Vet. Sci.* 12(9): 1664-1669.

DOI | <https://dx.doi.org/10.17582/journal.aavs/2024/12.9.1664.1669>

ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331



Copyright: 2024 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

INTRODUCTION

Rabbits are increasingly becoming a valuable alternative source of easily accessible animal protein in developing countries. Indonesia, as a developing nation, imports up to 24 million tons of soybean meal annually, constituting 35% of its total requirement. Notably, 82 percent of the world's rabbit meat production occurs in developed countries, leaving less than 18 percent in developing nations (Lukefahr and Cheeke 1990). Reducing imports of feed ingredients can mitigate greenhouse gas emissions, as sea freight is a major contributor (Adli *et al.*, 2024; Fernando *et al.*, 2023). Potential local feed ingredients that could replace maize include coconut skin waste (*Cocos nucifera*), soybean seed

(*Glycine max*), and cassava by-products (*Manihot esculenta*). These feedstuffs have high crude fibre content, which can be reduced through fermentation using *Cellulomonas* (Leke *et al.*, 2013).

Agro-industrial waste fermentation produces enzymes that decompose fibre and anti-nutrients into metabolites, adds nitrogen to cells, and enhances the palatability of feed products due to their specific fragrance (Tam *et al.*, 2009). This fermentation process is expected to improve feed efficiency by replacing the fermentation activity of feeds in the rabbit's organelle secretions. Currently, farmers use alternative feeds to stimulate growth, enhance production performance, and inhibit disease. Feed intake and feed con-

version are closely linked (Ardiansyah *et al.*, 2022). There is limited information in the literature on the response of growing rabbits to supplementary feeds containing different sources of protein and their combinations, particularly regarding the economic benefits in tropical environments (Mbanya *et al.*, 2005). This study was therefore purposed to determine the effects of replacing soybean with fermented cassava by-products, coconut skin waste, and soybean seed (FCCSB) on the performance, nutrient digestibility, and the cholesterol levels in their meats.

MATERIALS AND METHODS

ANIMAL, DIET TREATMENT, AND HOUSING

The animals used in this study were male crossbred weaned rabbits (New Zealand White x Local), 56 weeks old, with an initial weight ranging from 675 to 875 grams. A total of 30 rabbits were used in the study, distributed across five treatments and three groups (two animals per group), classified by body weight. The rabbits were housed in individual cages, and feed and drinking water were provided *ad libitum*. The diet used in this study was formulated based on dry matter. It contained maize, soybean meal, rice bran, cassava by-products, coconut flesh waste, and soybean skin waste. The formulation of the diet treatments, the chemical composition of the feed ingredients, and the nutrient composition of the diet treatments based on the formulation are presented in Table 1, 2 and 3.

Table 1: Diet treatment and nutrient content of diet treatment based on formulation.

	FCCSB replacing soybean, %				
	0	7.5	15	22.5	30
Maize (%)	57.7	52.2	46.7	41.2	35.7
FCCSB (%)	0	7.5	15	22.5	30
Rice bran (%)	20	20	20	20	20
Soybean meal (%)	18	16	14	12	10
Limestone (%)	1.1	1.1	1.1	1.1	1.1
Salt (%)	0.3	0.3	0.3	0.3	0.3
Soybean oil (%)	2.8	2.8	2.8	2.8	2.8
Vitamin premix (%)	0.05	0.05	0.05	0.05	0.05
Mineral premix (%)	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100
DM (%)	91	90	91	92	93
CP (%)	23	23	23	23	23
EE	5	5	5.4	5.2	5.4
CF (%)	5.2	5.2	5.1	5.1	5.3

Vitamin premix (per kg of diet); vitamin A 12,500 IU; Vitamin D3, 2,500; Vitamin E 20 IU; Mineral premix (Per kg of diet); Fe 70 IU, Zn, 90 IU; CU, 10 IU; Mn, 80 IU, Dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE).

PREPARATION OF THE FERMENTED CASSAVA BY-PRODUCT, COCONUT FLESH SKIN AND SOYA BEAN SKIN (FCCSB)

FCCSB contain 20% Cassava by product, 60% Coconut flesh skin waste, and 20% soya bean skin. FCCSB collection is taken from industrial. This organic waste separately sun dried for 3 - 4 days. All materials are milled to get the same particle size. Then took FCCSB as a sample to be analysed nutrient content and formulated 0, 7.5, 15, 22.5 and 30%. Starter bacteria cellulolytic using *Cellulomonas* from isolates organic compost with containing colonies 2.56×10^9 cfu/ml (Adli *et al.*, 2020). Furthermore, this inoculant was used to ferment CCSB at a dose of 10^8 cfu/g DM material and incubated for 8 days.

Table 2: Chemical composition of the feed ingredients (% air-dry basis).

	DM	CP	CF	Fat
Maize	88	8.0	2.4	8.2
Soya bean meal	89	37.6	5	5
Rice bran	90	10	26	3.5
Cassava by-product	94	16	2.04	6.5
Coconut flesh skin waste	93	5.6	9.13	4.5
Soybean seed skin waste	93	17.2	3.30	3.4
FCCSB	92	23.2	5.21	5.1

GROWTH PERFORMANCE

The body weight gain (BWG) of rabbits was measured by the difference in weight from the initial measurement to the previous weeks. Feed intake was calculated weekly by subtracting the remaining feed from the feed offered to the ducks. This calculation accounted for any dead broilers during the experiment. Feed conversion ratio (feed/gain) was determined by dividing the feed intake by the body weight gain of the rabbits.

Table 3: Nutrient content of Diet treatment based on proximate analysis

Parameters	FCCSB %				
	0	7.5	15	22.5	30
Dry Matter (%)	91.50	91.30	91.00	90.80	90.60
Moisture (%)	8.50	8.70	9.00	9.20	9.40
Ash (%)	88.70	88.62	88.54	88.48	88.36
Crude Protein (%)	18.05	18.17	17.19	16.43	15.67
Ether Extract (%)	10.48	9.82	11.59	14.42	16.71

NUTRIENT DIGESTIBILITY

Samples of feed were taken randomly, while in vivo digestibility data were collected daily. To ensure data validity, feed leftovers were collected proportionally, stored until all leftovers were gathered, then homogenised and sampled for further analysis. Faeces collection for digestibility data

was conducted during the final week of the study over ten days. The collection process ensured that the faeces were not mixed with urine, weighed every two days, and collected proportionally. The faeces were then placed in plastic bags and sprayed with 10% sulphuric acid (H₂SO₄) to prevent degradation. Once all faeces samples were collected, they were homogenised, sampled, and air-dried for further analysis. All fresh samples, both feed and faeces, were air-dried using an oven at a temperature of 60–70°C. They were weighed before and after drying to determine the air-dry matter content of the fresh samples. All air-dried samples were homogenised, and the air-dry matter content was calculated. A 250-gram sample was taken, ground, and stored in a tightly sealed jar until ready for further analysis.

MEAT QUALITY

Rabbits were slaughtered in accordance with Islamic law, following a specific procedure involving three incisions. These incisions were made in the blood vessels (carotid artery and jugular vein), the respiratory tract (trachea), and the digestive tract (oesophagus) using a sharp knife. Once the rabbit had died, as indicated by the cessation of blood flow, further processing commenced. After confirming the rabbit's death, it was hung by its Achilles tendon. The head was then removed at the atlanto-occipital joint. Next, the rabbit was skinned, and the abdominal cavity contents were removed. The chest was then separated from the front and hind legs at the carpus and tarsus joints. The carcasses were then chilled in a refrigerator at approximately 4°C for 24 hours. Finally, the carcasses were cut according to commercial specifications to obtain commercial cut weights.

Crude protein content was determined using the macro-Kjeldahl method. The crude protein content of products, obtained by multiplying the nitrogen content by 6.25. West noted that the nitrogen content of food proteins rarely varies enough from 16 percent to necessitate using a factor other than 6.25. Fat content was quantitatively analysed using the Soxhlet ether extraction method. The samples were heated to 120°C until the ether reached boiling point, then the temperature was reduced to 60°C. The extraction process lasted for 18 hours. The procedure followed was as described by Lees. Ground samples of each variety of meat were dried overnight at 100°C in a drying oven and then weighed. Two samples of each type of meat were used for the fat analysis. Five test tubes were prepared with standard cholesterol solutions in volumes of 0.5, 1.0, 1.5, 2.0, and 2.5 ml, while a sixth tube was kept as a blank. These tubes were labelled S1, S2, S3, S4, S5, and S6, respectively. Two millilitres of the Liebermann-Burchard reagent were added to all six tubes, and chloroform was used to equalise the final volume in each test tube. The test tubes were then covered with carbon black paper and kept in the dark for 15 minutes in a water bath. The baseline was taken on

a spectrophotometer using the blank (S6) at a maximum wavelength of 640 nm. The absorbance of all standards (S1 to S5) was then measured with the spectrophotometer, and the results were recorded.

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

The experimental design was used in this study is Randomly Block Design with 5 treatment and 3 group animal classified by body weight. In each group consists of 2 rabbits. Data were analyzed using Analysis of Variance (ANOVA). If there is a significant difference, continue with Duncan's test. The following model was used by following (Adli *et al.*, 2024).

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where Y_{ij} was parameters observed, μ was the overall mean, T_i the effect level of fermented cassava by-products, coconut flesh skin, and soya bean skin (FCCSB), and e_{ij} the amount of error number.

RESULTS AND DISCUSSION

EFFECTS OF TREATMENTS ON THE GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY OF THE RABBITS

The results of statistical analysis showed that the use of FCCSB at a level of 30% significantly increased feed intake, dry matter intake (DMI), organic matter intake (OMI), and crude fibre intake (CFI) in rabbits. This is because feed containing FCCSB is a fermented feed that helps the digestive process of feed in the digestive tract of rabbits. The fermentation process used cellulolytic bacteria which are bacteria that break down crude fibre. The cruder fibre that can be degraded, the higher the digestibility value of the feed or the more feed that can be digested by the digestive system. Cellulolytic bacteria produce cellulose enzymes that break down cellulose into cellulose and glucose which can provide nutrients for an animal (Katongole *et al.*, 2009). According to (Wang *et al.*, 2020) activity of cellulolytic microbes secrete the enzyme endoglucanase or carboxymethyl cellulose (CMC-ase), exoglycanase, and, glucosidase. The use of cellulolytic bacteria was able to reduce the levels of NDF, ADF, and cellulose but did not affect the levels of lignin.

The fermentation process in the rabbit cecum will be helped by the feed fermentation process because rabbits do not high effort in degrading high crude fibre. This process will help the effectiveness of absorption in the digestive tract. (Chujaemi *et al.*, 2014) stated that increasing the digestibility of the diet and lower feed density could increase feed intake. In addition, the rate of feed in the digestive organelles will also accelerate gastric emptying so that rab

Table 4: Fat and cholesterol levels of male rabbit meat are presented.

Parameters	FCCSB %				
	0	7.5	15	22.5	30
Cholesterol	60.4±3.20	60.83±5.10	60.73±5.10	60.93±2.90	60.96±4.20
Protein	32.2±1.80 ^a	33±1.60 ^a	34.72±1.72 ^b	35.90±1.90 ^b	35.89±2.15 ^b
Fat	3.5±0.20	3.4±0.25	3.4±0.15	3.2±0.05	3.00±1.30

ns=non significant.

bits increase feed intake to adjust their nutrient and energy needs. Furthermore, the quality feed usually has high palatability, this will also increase feed consumption for livestock (Ebeid *et al.*, 2024). The use of FCCSB as 7.5% can reduce feed intake but there is a trend in the data that increasing the use of FCCSB from 7% to 30% level will increase feed intake, DMI, OMI, and CFI. The trend of the data is shown in Figure 1.

The increase in rabbit feed intake with an increase in the treatment of feed containing FCCSB because the protein content in the treatment diet decreased. Rabbits will sufficient their crude protein needs by increasing feed intake. The data showed that the BWG of rabbits fed a diet containing 15-30% FCCSB significantly ($P<0.01$) increased BWG but not significantly at the 7% level. The increase in BWG is influenced by an increase in feed intake (Christopher *et al.*, 2022). The use of FCCSB in feed will result in better nutrient completeness than only basal feed ingredients (soybean meal based). The use of a combination of feed ingredients will produce more diverse micro-nutrients, especially the variation of amino acids. Several factors that can affect BWG are the nutrient content of the feed, the digestibility of the feed, and the balance of protein and energy of the feed. According to (Jimoh *et al.*, 2020) that the increase in body weight of an animal is influenced by the quality of the feed intake, besides that it differs due to sex livestock species, reared methods, and environmental temperature.

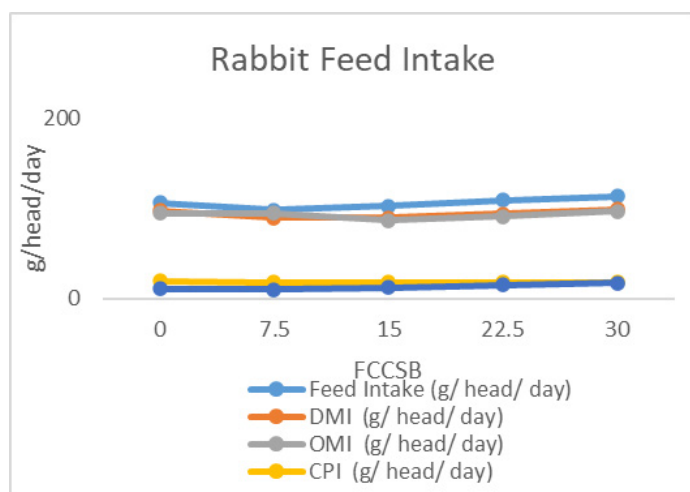


Figure 1: Feed Intake of Rabbit that feeding by FCCSB.

The feed conversion depends on the level of feed intake and BWG produced because this parameter is a comparison of total feed intake and body weight produced, both variables are related to the quality of the feed given (Blasco *et al.*, 2018). The data in this study showed that the use of FCCSB significantly ($P<0.01$) decreased the FCR. Feed conversion is the amount of feed intake to produce one unit of livestock production (Katongole *et al.*, 2009). The smaller the feed conversion value, indicate that increasing of the quality of the feed. The smaller of the FCR value also indicates the better feed digestibility.

Protein Efficiency Ratio (PER) significantly ($P<0.01$) increased on the rabbit feeding containing FCCSB. PER indicates the amount of protein consumed compared to the production of livestock products, in the case of this study, body weight gain. The higher the PER value indicates that the efficiency of the use of protein in the feed is getting better. The use of FCCSB increases the PER value because the protein source used in the FCCSB diet treatment comes from 3 ingredients, namely Cassava by-product, Coconut flesh skin waste, and soya bean skin. Variations in the use of protein sources will complement the lack of protein type of each feed ingredient, both based on protein content and limiting factors.

Dry matter digestibility, organic matter digestibility, digested dry matter consumption and digested organic matter consumption in rabbit feed increased significantly ($P<0.01$) in the treatment of feeding containing FCCSB. This increase in digestibility value indicates that there is an increase in feed quality. Increasing the digestibility value of feed is one of the important factors in increasing rabbit production performance. This increase in digestibility caused by the treated feed was fermented feed using cellulolytic microbes. Cellulolytic bacteria will degrade crude fibre so that crude fibre in complex form will become simpler. These changes make fibre easier to digest and use by the body. The more fibre that can be utilized, the faster the flow rate of feed in the feed so that the livestock will feel hungry faster and increase feed consumption until their needs will be fulfilled.

EFFECTS OF TREATMENTS ON THE MEAT QUALITY OF THE RABBITS

The use of FCCSB had no significant effect ($P > 0.05$) on

the cholesterol content of male rabbit meat. Data on fat and cholesterol levels of male rabbit meat are presented in Table 4. The cholesterol level of rabbit meat was not affected by the FCCSB treatment in the feed. This is because the type of feed used is plant-based feed. In addition, FCCSB is a fermented product. Fermented products usually produce organic acids that can inhibit cholesterol absorption. The body has the ability to homeostasis, when the condition of the digestive tract is acidic, bile salts will be released into the digestive tract so that the condition becomes neutral. Bile salts will decrease in number if continuously used to neutralize the acid condition. Bile salts are one of the ingredients that form cholesterol, so that cholesterol formation will be disrupted if bile salts are reduced a lot. Consumers demand for safe ingredients and concerns over harmful synthetic additives have prompted food manufacturers to seek safer and sustainable alternative solutions (Siddiqui *et al.*, 2023). According to (Tilman *et al.*, 1989) the mechanism of cholesterol synthesis through 5 stages, namely first, the synthesis of Human menopausal gonadotrophins (HMG CoA) from 2 molecules of acetyl CoA condensing to form acetoacetic CoA occurs in the cytoplasm; secondly the formation of mevalonate from the reduction of HMG CoA by the reductase enzyme; thirdly the formation of isoprenoid units from mevalonate which is phosphorylated by ATP to 3-phospho5-pyrophosphomevalonate, decarboxylation to form isopentenyl pyrophosphate; fourth, the synthesis of squalene by means of condensation between isopentenyl pyrophosphate and 3,3-dimethylallyl pyrophosphate to form geranyl pyrophosphate which is added by 1 unit of isoprenoid and condenses with dimethyl allyl pyrophosphate to form farnesyl pyrophosphate, then these two units are combined and reduced to produce squalene; The fifth change of squalene to cholesterol by squalene monooxygenase converts squalene to 2,3 epoxides with the help of NADPH and oxygen, then undergoes cyclization to lanosterol and then to cholesterol through reduction reactions, demethylation of carbon C4 and C14, rotation of the double bond from carbon C8 to C5 and reduction of double bonds at C24 and C25 carbons.

CONCLUSIONS AND RECOMMENDATIONS

Fermented cassava by-product, coconut flesh skin waste and soya bean skin in rabbit diets lead to improvements in body weight gain and feed conversion, increase the fat content of meat without affecting cholesterol levels. The best treatment in this study is the use of 12% FCCSB.

ACKNOWLEDGEMENTS

The authors thanks to Faculty of Animal Husbandry, UNISMA, Malang, for funding this research.

The novelty of this research is by using by-product blend as fibre source for the rabbit.

AUTHOR'S CONTRIBUTION

Usman Ali contributed to data collection, data analysis and manuscript preparation. Tri Badat Muwakhid and Dewi Masyithoh contributed to the research design, supervision and revision of the manuscript. All authors read and approved the final version of the manuscript in the journal at this time.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

- Adli DN, Sholikin MM, Ujilestari T, Ahmed B, Sadiqqua, A, Harahap, MA, Sofyan A, Sugiharto, S (2024). Effect of fermentation of herbal products on growth performance, breast meat quality, and intestinal morphology of broiler chickens: a meta-analysis. *Ital J. Anim. Sci.*, 23(1) 734-750. <https://doi.org/10.1080/1828051X.2024.2351441>
- Adli DN, Sjojan O, Natsir MH, Nuningtyas YF, Sholikah NU, Marbun AC (2020). The effect of replacing maize with fermented palm kernel meal (FPKM) on broiler performance. *Livest. Res. Rur. Dev.*, 32(7): 1-4.
- Ardiansyah W, Sjojan O, Widodo E, Suyadi S, Adli DN (2022). Effects of combinations of α -Lactobacillus sp. and Curcuma longa flour on production, egg quality, and intestinal profile of Mojosari ducks. *Adv. Anim. Vet. Sci.*, 10(8): 1668-1677. <https://doi.org/10.17582/journal.aavs/2022/10.8.1668.1677>
- Blasco A, Nagy I, Hernández P (2018). Genetics of growth, carcass and meat quality in rabbits. *Meat Sci.*, 145: 178-185. <https://doi.org/10.1016/j.meatsci.2018.06.030>.
- Cheeke PR (1987). *Rabbit Feeding and Nutrition* Academic Press Inc. New York.
- Christopher GI, Idiong IC, Ekpo JS, Okon UM, Ndak UU (2022). Growth performance and economics of feeding sole concentrate, sole forage and their mixtures to weaner rabbits. *Niger. J. Anim. Prod.*, 49(5);87-93. <https://doi.org/10.51791/njap.v49i5.3767>
- Chujaemi UAS, Soebarinoto, Sjojan O (2014). The Effect Fermentation of Local Agroindustry Waste Using Cellulolytic Bacteria Cellulomonas on Nutrient Content as Feed Stuff. *J. Biol. Agr. Healthc.*, 4(3), 68-72.
- Ebeid TA, Al-Homidan IH, Saleh AA, Barakat, HA (2024). Physiological and immunological aspects of feed restriction and its beneficial impacts in fattening rabbits' productivity—an updated review. *Trop. Anim. Health Prod.*, 56(1): 33. <https://doi.org/10.1007/s11250-023-03881-0>
- Fernando I, Siddiqui SA, Nugraha WS, Yudhistira B, Adli DN, Nagdalian AA, Mario MB (2023). Overview of larvae of red palm weevil, *Rhynchophorus ferrugineus* (Olivier)

- (Coleoptera: Curculionidae), as human food. *J. Insects as Food and Feed*, 1-20. <https://doi.org/10.1163/23524588-00001005>
- Katongole CB, Sabiiti EN, Bareeba FB, Ledin I (2009). Performance of growing indigenous goats fed diets based on urban market crop wastes. *Trop. Anim. Health Prod.*, 41: 329-336. <https://doi.org/10.1007/s11250-008-9193-7>
- Jimoh OA, Ayedun ES, Daramola OT, Oloruntola OD, Ayodele SO, Okin-Aminu HO (2020). Growth and haematological response of growing rabbits fed *Phyllanthus amarus* leaf meal supplemented diets. *Livest. Res. Rur. Dev.*, 32(20): 1-9.
- Leke JR, Sjoftan O, Najoan M (2013). Egg internal quality and n-3 fatty acids of native chicken fed on skipjack fish (*Katsuwonus pelamis*. i) industrial waste containing feed. *Int. J. Poul. Sci.*, 12: 484. <https://doi.org/10.3923/ijps.2013.484.488>
- Lukefahr SD, Cheeke PR (1990). Rabbit project planning strategies for developing countries. (1) Practical considerations. *Livest. Res. Rur. Dev.*,
- Mbanya JN, Ndoping BN, Mafeni JM, Fomunyam DW (2005). The effect of different protein sources and their combination on the performance of growing rabbits in tropical conditions. *Livest. Res. Rur. Dev.*, 17(3), 1-6.
- Siddiqui SA, Khan S, Mehdizadeh M, Bahmid NA, Adli DN, Walker TR, Câmara JS (2023). Phytochemicals and bioactive constituents in food packaging: A systematic review. *Heliyon*. 9(11): 1-18. <https://doi.org/10.1016/j.heliyon.2023.e21196>
- Tam NH, Tuan VT, Lam V, Hang BPT, Preston TR (2009). Effects on growth of rabbits of supplementing a basal diet of water spinach (*Ipomoea aquatica*) with vegetable wastes and paddy rice. *Livest. Res. Rur. Dev.*, 174 (21): 1-8
- Tillman AD, Hartadi H, Reksohadiprodjo S, Prawirokusumo S, Lebdoesoekojo S (1989). *Ilmu makanan ternak dasar*. Gadjah Mada University Press, Yogyakarta
- Wang J, Ni X, Wen B, Zhou Y, Liu L, Zeng Y and Zeng D (2020). *Bacillus* strains improve growth performance via enhancing digestive function and anti-disease ability in young and weaning rex rabbits. *Appl. Microbiol. and Biotechnol.*, 104, 4493-4504. <https://doi.org/10.1007/s00253-020-10536-9>