

Original Article

Carcass Quality Percentage and Carcass Components of Stunted Broiler Chickens Supplemented with Moringa (*Moringa Oleifera*) Leaf Meal in The Diet

Sugiarto¹, Nuun Marfuah¹, Aynan Hismafanti Gunawan²

¹ Departement of Animal Husbandry, Tadulako University, Indonesia.

² Departement of Animal Husbandry, Faculty of Faculty of Agriculture and Animal Husbandry, Universitas Abdul Azis Lamadjido, Palu, Indonesia

*Corresponding author: aynanhismafantigunawan@gmail.com

Received: November 9th, 2025; Accepted: December 15st, 2025; Published online: March 4th, 2026

Abstract

Objective: This study aimed to evaluate the effect of different inclusion levels of Moringa (*Moringa oleifera*) leaf meal on carcass percentage and carcass components of broiler chickens affected by stunting syndrome.

Methods: Describe briefly the main materials and methods or treatments applied including data analysis. A Completely Randomized Design (CRD) with five dietary treatments was used: P0 = 0% (control), P1 = 4%, P2 = 6%, P3 = 8%, and P4 = 10% Moringa leaf meal. Each treatment was replicated five times. Parameters measured included final body weight, carcass percentage, and carcass components (breast, thigh, drumstick, back, and wing). Data were analyzed using ANOVA, and significant means were compared with Duncan's Multiple Range Test.

Results: The inclusion of Moringa leaf meal had a highly significant effect ($P < 0.01$) on final body weight, breast, and thigh components, and a significant effect ($P < 0.05$) on back percentage. However, it had no significant effect ($P > 0.05$) on overall carcass percentage, drumstick, and wing components. Stunting syndrome reduced growth performance due to abnormal physical conditions and limited nutrient utilization.

Conclusions: Supplementation of Moringa leaf meal, which contains high levels of protein, vitamins, minerals, and bioactive compounds with antibacterial and antioxidant activities, has the potential to enhance nutrient absorption, improve muscle development, and contribute to better carcass yield and quality in broiler chickens with stunting syndrome.

Keywords: Broiler chicken; Carcass components; Carcass percentage; Moringa leaf meal; Stunting syndrome

INTRODUCTION

The growth disturbance in chickens caused by abnormal conditions (stunting syndrome/slow growth syndrome/Infectious Stunting Syndrome) is a growth disorder that prevents chickens from reaching the same size as normal chickens due to slow growth. This syndrome usually occurs at 4-7

days of age. Enteritis or gastrointestinal infection directly reduces feed absorption, resulting in growth retardation, impaired feed efficiency, immunosuppression, and sometimes increased mortality due to secondary infections (Yegani and Korver, 2008). Enteric viruses have significant economic impacts on broiler chickens due to reduced production, poor feed conversion, and

low body weight gain. The presence of enteric viruses causes stunting, growth retardation, and hatchery diseases, thereby affecting the market value of chickens (Adebiyi et al., 2019).

The causes of stunting syndrome in broiler chickens include poor quality day-old chicks (DOCs) or genetic defects; lack of house disinfection; inadequate nutrition and feed; poor management practices; stress conditions; infection with Reoviruses that attack the intestines, impairing feed digestion and growth; and unstable brooding temperatures (too hot, too cold, or overcrowding). Enteric viruses cause severe diseases such as runting-stunting syndrome (RSS) and are considered a major source of economic losses in broiler production due to the presence of undersized birds that fail to develop properly and are more susceptible to other diseases. These chickens show reduced feed efficiency and are less attractive to consumers (Kang et al., 2012).

Stunting in broilers can be classified as permanent stunting (runting) and temporary stunting. Permanent stunting (runting) is caused by genetic abnormalities that prevent normal growth, resulting in body weights only 50–70% of those of normal chickens of the same age. Temporary stunting, on the other hand, is caused by feed competition or impaired nutrient absorption, resulting in disrupted nutrient availability. Chickens with stunting may only reach 75–90% of the body weight of normal chickens of the same age (Anonymous, 2023).

The clinical symptoms of stunting syndrome appear from hatching, characterized by primary feathers growing upward and irregularly (helicopter disease), hardened gastrointestinal tracts leading to poor digestion, and pale meat color. The condition is usually controlled through culling. Stunting syndrome (slow growth syndrome), also referred to as RSS, is observed in broilers aged 4–21 days and is characterized by growth retardation. In this condition, body weight is about 40% lower than normal. The prevalence within a population varies from 5–40%. Stunting syndrome is categorized as mild when it affects 5–10% of the population, severe when it affects >10–30%, and catastrophic when it affects >30% of the population (Undari, 2019). Some approaches to stimulate growth include supplementation with amino acids, multivitamins, and minerals.

Moringa (*Moringa oleifera*) is a medicinal plant with beneficial properties, in which almost all parts, including the leaves, bark, seeds, and roots, can be utilized. Moringa leaves are rich in provitamin A and C, especially β -carotene, which is converted into vitamin A in the body (Bharali, 2023). The nutritional composition of Moringa leaf meal per 100 g is as follows: protein 27.1%; fat 2.3%; carbohydrate 38.2%; crude fiber 19.2%; energy 205 kcal; vitamin B1 2.64 mg; vitamin B2 20.5 mg; vitamin B3 8.2 mg; vitamin C 17.3 mg; vitamin E 113 mg; calcium 2003 mg; magnesium 368 mg; phosphorus 204 mg; potassium 1324 mg; iron 28.2 mg; and sulfur 870 mg (Gopalakrishnan et al., 2016).

Moringa is widely recognized as an excellent nutritional source with high protein content for broiler chickens. It is also known as a natural antioxidant source due to its carotenoid, selenium, flavonoid, and phenolic contents, which can improve production performance and meat quality. Antioxidants protect the structure of essential biological macromolecules, inhibit the oxidation of easily oxidized substances, and neutralize reactive oxygen free radicals associated with diseases (Teteh et al., 2013; Ologhobo et al., 2014). Furthermore, glucosinolates and isothiocyanates present in Moringa are known for their antihypertensive, anticancer, antibacterial, and antifungal properties (Anwar et al., 2007). The leaves of this so-called “miracle tree” from India can be used to alleviate stunting syndrome in chickens because of their antioxidant, anticancer, anti-inflammatory, antidiabetic, and antimicrobial properties (Gopalakrishnan et al., 2016).

The bioactive compounds in Moringa leaves, which are highly nutritious and have antibacterial and antioxidant activities, are expected to enhance digestive organ performance, nutrient absorption, and prevent internal organ damage. Consequently, Moringa leaf meal can improve carcass percentage, carcass components, and antioxidant content of meat in stunted broiler chickens, leading to healthier meat.

MATERIALS AND METHODS

Materials

A total of 100 one-day-old broiler chickens (DOC) with stunting syndrome were used in this study. The birds were reared for five weeks under standard management conditions. Diets were formulated based on

the nutrient requirements for broilers and the nutrient composition of feed ingredients. Moringa (*Moringa oleifera*) leaf meal was

added to the diets at inclusion levels of 0, 4, 6, 8, and 10% as shown in Table 1.

Table 1. Composition and Nutrient Content of Experimental Diets

Feed Ingredients (%)	Treatments				
	R0	R1	R2	R3	R4
Yellow corn	56.0	51.0	48.0	45.5	43.5
Rice barn	6.0	6.0	6.0	6.0	6.0
Copra meal	9.5	9.5	9.5	9.5	9.5
Soybean meal	13.5	13.5	13.5	13.5	13.5
Fish meal	14.0	14.0	14.5	14.5	14.5
Premix	1.0	1.0	1.0	1.0	1.0
Moringa leaf meal	0.0	4.0	6.0	8.0	10.0
Total	100	100	100	100	100
Nutrient Composition	R0	R1	R2	R3	R4
Crude protein (%)	20.08	19.92	20.05	19.96	19.89
Crude fat (%)	5.30	5.12	5.03	4.93	4.85
Metabolizable energy (Kcal/kg)	3036.35	3043.51	3010.21	3009.12	3009.73
Crude fiber (%)	4.34	5.09	4.51	4.56	4.62
Calcium (%)	0.65	0.70	0.72	0.75	0.77
Phosphorus (%)	0.35	0.38	0.40	0.41	0.43

Research methods

The experiment was arranged in a Completely Randomized Design (CRD) consisting of five dietary treatments (P0 = 0%; P1 = 4%; P2 = 6%; P3 = 8%; P4 = 10% Moringa leaf meal) with four replications, and each experimental unit consisted of five broilers. The variables observed included final body weight, carcass percentage, and carcass components (breast, thigh, drumstick, back, and wing). Final body weight was obtained by weighing chickens prior to slaughter. Carcass percentage was calculated as the ratio between carcass weight and live body weight multiplied by

100%. Carcass components were measured as the proportion of each carcass part (breast, thigh, drumstick, back, and wing) relative to total carcass weight.

Data analysis

All data were analyzed using Analysis of Variance (ANOVA) based on the CRD model. When significant differences among treatments were found, mean comparisons were conducted using Duncan's Multiple Range Test (DMRT) to determine treatment effects.

RESULTS

Table 2. Average Final Body Weight, Carcass Percentage, and Carcass Component Percentage of Chickens (%)

Variabel	Treatments				
	P0	P1	P2	P3	P4
Body weight**	438.64±7.71 ^a	448.08±4.48 ^b	457.61±6.77 ^c	485.02±2.99 ^d	457.94±4.22 ^e
Carcass Percentage ^{ns}	61.96±1.90 ^a	62.80±1.33 ^b	62.99±0.64 ^c	62.51±0.88 ^d	62.52±1.90 ^e
Breast Percentage**	36.15±0.12 ^a	36.40±0.15 ^b	36.41±0.20 ^c	36.83±0.37 ^d	36.91±0.50 ^e
Thigh Percentage**	16.99±0.32 ^a	17.40±0.32 ^b	17.98±0.40 ^c	17.94±0.49 ^d	17.13±0.12 ^e
Drumstick Percentage ^{ns}	15.16±0.26 ^a	15.31±0.63 ^b	15.43±0.10 ^c	15.52±0.29 ^d	15.24±0.58 ^e
Back Percentage*	15.16±0.26 ^a	15.31±0.63 ^b	15.43±0.10 ^c	15.52±0.29 ^d	15.24±0.58 ^e
Wing Percentage ^{ns}	13.63±0.62 ^a	14.09±0.15 ^b	14.29±0.21 ^c	14.23±0.24 ^d	14.10±0.56 ^e

Note: ** highly significant effect; * significant effect; ^{ns} not significant

P0 = Diet + 0% Moringa leaf meal; P1 = Diet + 4% Moringa leaf meal; P2 = Diet + 6% Moringa leaf meal; P3 = Diet + 8% Moringa leaf meal; P4 = Diet + 10% Moringa leaf meal.

DISCUSSION

Body Weight

The results of the analysis of variance showed that the treatment had a highly significant effect ($P < 0.01$) on final body weight, namely: 438.64 ± 7.71 – 485.02 ± 2.99 g, with an increase in final body weight of 46.38 g. With the addition of Moringa leaf meal in the feed which contains vitamins, minerals, and antioxidants, it helps improve the chicken's immune system, so that it is able to fight the negative effects of stunting syndrome. These nutrients also improve nutrient absorption and metabolism in the chicken's digestive tract, encourage more optimal growth, and stimulate an overall increase in feed intake, which ultimately contributes directly to the increase in body weight and final harvest weight.

The nutritional content of Moringa leaf meal plays a role in overcoming stunting syndrome. Stunting syndrome can be detected earlier if there are chicks whose body weight is 40% below the standard, they must immediately be culled (Anonymous, 2020). Stunted chickens will consume less feed compared to normal chickens of the same age because their growth is inhibited.

The results of the Duncan test showed that treatments P4, P3, P2, and P1 were significantly different from R0. The causes of stunting in chickens can be influenced by parental genetic factors, small hatching egg size originating from young breeders (less than 25 weeks), low maternal antibodies against Reovirus, or breeders of DOC positive infected with *Salmonella enteritidis* (Anonymous, 2017), so that the addition of Moringa leaf meal in chicken feed proved effective in increasing feed intake and improving the condition of chickens that experienced growth retardation (stunting). The nutrient content which is rich, such as protein, vitamins, and minerals, in Moringa leaves helps stimulate the chicken's digestive system and improve nutrient absorption from the feed. This directly has an impact on increasing the final body weight of chickens.

Carcass Percentage

The results of the analysis of variance showed that the treatment had no significant effect ($P > 0.05$) on carcass percentage, namely: 61.96 ± 1.90 – $62.52 \pm 1.90\%$. The treatment of commercial feed containing 18% and 21% protein in slow growth chickens had no significant effect ($P > 0.05$) on the carcass percentage of chickens (Safardi, 2007). Growth disorders in cells and inefficient feed metabolism resulted in suboptimal growth performance and carcass formation in chickens. Stunting syndrome is characterized by lower body weight and slow growth, with an incidence rate of 5%–20%. Hepatocytes (the main cells that form most of the liver tissue) of RSS chickens contain many mitochondria with damaged outer and inner membranes as well as hydropic vacuolar degeneration. Abnormal expression of these genes is most likely to impair OXPHOS (oxidative phosphorylation), resulting in reduced ATP synthesis in the hepatocytes of stunted chickens, which can cause growth retardation in chicks (Adebiyi et al., 2019).

Stunting syndrome causes chicken growth to be suboptimal because stunting syndrome is a genetic factor that disrupts metabolic efficiency. The genetic factor of stunted chickens plays a dominant role in determining growth potential and the percentage of the lower thigh carcass component. The addition of Moringa leaf meal only gives a minor effect and is unable to change genetic characteristics, so the lower thigh component does not develop optimally.

Its high crude fiber content in Moringa leaf meal and the presence of antinutritional compounds, such as tannins and phytates, can inhibit digestion and the absorption of essential nutrients in the chicken's digestive tract. These antinutritional compounds can bind proteins and minerals, thereby reducing their bioavailability and disrupting the efficiency of feed metabolism. As a result of the disturbance in nutrient metabolism, the carcass percentage of chickens did not grow optimally.

Breast Percentage

The results of the analysis of variance showed that the treatment had a highly significant effect ($P < 0.01$) on the percentage of breast carcass component, 36.15 ± 0.12 – $36.91 \pm 0.50\%$, with an increase in chicken breast

component by 0.76%. The addition of Moringa leaf meal to broiler diets can increase the percentage of chicken breast components, because Moringa leaf meal is rich in nutrients such as protein, vitamins, minerals, and antioxidants essential for optimal chicken growth. This high nutrient content helps chickens absorb nutrients from feed more efficiently, reducing the amount of wasted feed. Bioactive compounds in Moringa leaves, such as flavonoids and polyphenols, can improve gut health and enhance the immune system of chickens. The addition of *Moringa oleifera* in animal feed can improve growth performance, gut health, and animal immunity without side effects (Jiang et al., 2023), so chickens can digest feed better and convert it into muscle mass more effectively, ultimately resulting in more profitable chicken breast components for farmers.

The Duncan test results showed that treatments P4, P3, P2, and P1 were significantly different from R0. The addition of Moringa leaf meal to the diet was proven to increase the percentage of breast carcass components in stunted chickens. This is due to the rich nutrient content of Moringa leaves, including protein, vitamins, and minerals, which help improve nutrient absorption and digestive efficiency in chickens. Moringa leaves are a rich source of diverse bioactive compounds, including polyphenols, alkaloids, terpenoids, flavonoids (quercetin, kaempferol), saponins, and tocopherols. These compounds provide significant immunomodulatory effects by modulating cytokine production and immune cell activity, thereby improving feed digestibility to produce higher chicken breast carcass components.

Thigh Percentage

The results of the analysis of variance showed that the treatment had a highly significant effect ($P < 0.01$) on the percentage of upper thigh carcass component, which was 16.99 ± 0.32 – 17.13 ± 0.12 . The supplementation of Moringa leaf meal (*Moringa oleifera*) has been scientifically proven to have a highly significant effect on the upper thigh carcass component of stunted chickens. The abundant essential nutrients in Moringa leaf meal (protein, vitamins, minerals, and bioactive compounds such as flavonoids and polyphenols), act as antioxidants and anti-inflammatory agents that can enhance metabolism and muscle cell health.

Improvements in nutrient absorption efficiency and protein synthesis directly contribute to muscle growth and development, making Moringa leaf meal supplementation an effective and sustainable strategy to increase body weight and carcass quality of stunted chickens.

The Duncan test results showed that treatments P4, P3, P2, and P1 were highly significantly different from P0. The inclusion of Moringa leaf meal in the diets of stunted chickens has the potential to improve carcass quality due to its nutritional content. Moringa leaf meal contains 26.67% protein in 100% dry matter. The high crude protein content of Moringa leaf meal makes it a valuable protein source for feed (Einsenbrand, 2020). The crude protein content of Moringa leaf meal in this study was also high, at 24.14% (Kantja et al., 2022). The protein content in Moringa leaf meal can reach up to 27% (Dewi et al., 2014), thereby contributing to the increased percentage of the upper thigh carcass component in chickens.

Drumstick Percentage

The results of the analysis of variance showed that the treatment had no significant effect ($P > 0.05$) on the percentage of lower thigh carcass component, which was 15.16 ± 0.26 – $15.248 \pm 0.58\%$. Growth disturbances at the cellular level and inefficiencies in feed metabolism resulted in suboptimal chicken growth performance and carcass formation.

Stunting syndrome causes chickens to have suboptimal growth. Stunting syndrome is a genetic factor that disrupts metabolic efficiency. The genetic factor of stunted chickens plays a dominant role in determining growth potential and the percentage of lower thigh carcass component. The addition of Moringa leaf meal only provided a minor effect and was unable to alter genetic characteristics, so that the lower thigh component did not develop optimally.

Back Percentage

The results of the analysis of variance showed that the treatment had a significant effect ($P < 0.05$) on the percentage of the back carcass component, which was 15.16 ± 0.26 – $15.24 \pm 0.58\%$. The rich nutritional content of Moringa leaves, such as protein, vitamins, minerals, and bioactive compounds, plays an important role in influencing chicken growth metabolism and the formation of the back carcass component

percentage. This is possibly due to chickens experiencing suboptimal growth. Dwarfism syndrome in chickens is a genetic or nutritional condition that causes stunted growth, preventing chickens from reaching normal size.

The high crude fiber content and the presence of antinutritional compounds such as tannins and phytates can inhibit digestion and absorption of essential nutrients in the chicken's digestive tract. These antinutritional compounds can bind proteins and minerals, thereby reducing their bioavailability and disrupting feed metabolism efficiency. As a result of impaired nutrient metabolism, the percentage of the back carcass component of chickens does not grow optimally.

Wing Percentage

The results of the analysis of variance showed that the treatment had no significant effect ($P>0.05$) on carcass percentage, which was 13.63 ± 0.62 – $14.29\pm 0.21\%$. The treatment of providing commercial feed with protein contents of 18% and 21% to chickens experiencing slow growth had no significant effect ($P>0.05$) on chicken carcass percentage (Safardi, 2007). Growth disturbances at the cellular level and inefficiencies in feed metabolism resulted in suboptimal chicken growth performance and carcass formation. Runting stunting syndrome is a condition in which chickens experience slow growth and have a body weight of less than 200 g within 5 weeks. Stunting syndrome is a condition in which chickens have a stunted body size and only reach a body weight of more than 200 g but less than 1 kg (Anonymous, 2024).

Stunting syndrome causes the presence of antinutritional compounds such as tannins and phytates, which can inhibit digestion and absorption of essential nutrients in the chicken digestive tract. These antinutritional compounds can bind proteins and minerals, thereby reducing their bioavailability and disrupting feed metabolism efficiency. As a result of impaired nutrient metabolism, the wing carcass percentage of chickens does not grow optimally. Chickens experiencing stunting syndrome may face: growth retardation (slower growth rate compared to normal chickens), which may be caused by growth hormone (somatotropin) abnormalities or other metabolic issues that inhibit protein synthesis, smaller body size, impaired bone development especially in legs and back, and blindness.

CONCLUSION

The treatment of adding Moringa leaf meal had a highly significant effect on increasing final body weight, breast carcass components, and thigh (upper) components. It had a significant effect on increasing back percentage, and no effect on carcass percentage, drumstick (lower thigh), and wing components. Dwarfism syndrome causes growth retardation due to the abnormal physical condition of the chickens.

CONFLICT OF INTEREST

The authors declare no conflict of interest with any financial organization regarding the material discussed in the manuscript.

REFERENCES

1. Adebisi, I.A., Tregaskis, P.L., Oluwayelu, D. O. and Smyth, V. 2019. Investigation of Enteric Viruses Associated With Runting and Stunting in Day-Old Chicks and Older Broilers in Southwest Nigeria. *Veterinary Infectious Diseases*. Vol. 6. <https://doi.org/10.3389/fvets.2019.00239>
2. Anonymous. 2017. Ayam Kerdil. Medion Ardhika Bhakti. Bandung. <https://www.medion.co.id/>
3. Anonymous. 2020. AMIVIT-E Multivitamin, Asam amino dan Elektrolit. PT. Mitavet Produsen dan Distributor Obat Hewan. Tangerang, Banten. <https://mitravet.com/waspada-ayam-kerdil/#:~:text=Sedangkan%20untuk%20ayam%20kerdil%20dengan,di%20www.mitra-vet.com>.
4. Anonymous. 2023. Kenali Penyebab Ayam Broiler Kerdil dan Cara Mencegahnya. Broiler X Blok. <https://broilerx.com/blog/kenali-penyebab-ayam-broiler-kerdil-dan-cara-mencegahnya/>
5. Anonymous. 2024. Sindrom Kekerdilan Ayam: Penyebab, Gejala, dan Penanganan. Chickin. PT Sinergi Ketahanan Pangan. <https://chickin.id/blog/penyakit-sindrom-kekerdilan-pada-ayam/>
6. Anwar, F., Latif, S., Ashraf, M., Gilani, A.H., 2007. *Moringa oleifera*: A Food Plant with Multiple Medical Uses. *Phytother Res* 21(1), 17-25. <https://pubmed.ncbi.nlm.nih.gov/17089328/>

7. Dewi, T., Bidura, I. G. N. G., dan Candrawati, D. P. M. A. 2014. Pengaruh Pemberian Ekstrak dan Kelor (*Moringa oleifera*) dan Bawan Putih (*Allium sativa*) Melalui Air Minum terhadap Penampilan Broiler Umur 2-6 Minggu. Jurnal Peternakan Tropika, 2(3), 461-475.
8. Einsenbrand. 2005. Toxicological Evaluation Of Red Mold Rice. DFG-Senate Commission on Food Safety. New York.
9. Gopalakrishnan, L., Doriya K., and Kumar, D. S. 2016 Moringa oleifera: A review on nutritive importance and its medicinal application Food Sci. Hum. Wellness 5 49-56. <https://magistralbr.caldic.com/storage/product-files/232507723.pdf>
10. Jiang, X., Yang, J., Zhou, Z., Yu, L., He, J., Zhu, K., Luo, Y., Wang, H., Dua, X., Huang, Q., Zhao, C., Liu, Y and Fang, C. 2023. *Moringa oleifera* leaf improves meat quality by modulating intestinal microbes in white feather broilers. Elsevier. Food Chemistry: X 20, 1-16. www.sciencedirect.com/journal/food-chemistry-x
11. Kang, K. I., Bimenya, G.S., Ojok, L., Ochieng, J. and Ogwal-okeng, J.W. 2010. Investigation into the etiology of runting and stunting syndrome in chickens. Avian Pathol. 41(1):41-50. <https://pubmed.ncbi.nlm.nih.gov/22845320/>
12. Nuryadi, Astuti, T.D. dan M. Bidiantara. 2017. Dasar-Dasar Statistik Penelitian. Gramasurya, Jogjakarta. https://eprints.mercubuana-yogya.ac.id/id/eprint/6667/1/Buku-Ajar_Dasar-Dasar-Statistik-Penelitian.pdf
13. Ologhobo, A.D., Akangbe, E.I., Adejumo, I.O. and Adeleye, O. 2014. Effect of *Moringa oleifera* Leaf Meal as Replecement for Oxytetracycline on Carcass Characteristics of the Diets of Broiler Chickens. Annual Research & Review in Biology. 4(2): 423-431. <https://www.scribd.com/document/283076217/Ologhobo-2014>
14. Safardi. 2007. Pengaruh Pemberian Beberapa Level Protein Ransum dan Bobot Badan Awal Ayam Broiler Umur Dua Minggu yang Mengalami Slow Growth terhadap Persentase Karkas. Skripsi. Fakultas Peternakan, Universitas Andalas. <http://repository.unand.ac.id/9194/1/IMG.pdf>
15. Teteh, A., E. Lawson., K. Tona., E. Decuyper and M. Gbeassor. 2013. *Moringa oleifera* leaves: Hydro-alcoholic extract and effect on growth performan of broilers. Int. J. Poult. Sci., 12(7): 401-405. <https://scialert.net/abstract/?doi=ijps.2013.401.405>
16. Undari, F. 2019. Mengenal Sindrom Kekerdilan Pada Ayam Broiler. BBPP. Balai Besar Pelatihan Peternakan Kupang. <https://bbppkupang.bppsdp.pertanian.go.id/blog/mengenal-sindrom-kekerdilan-pada-ayam-broiler>
17. Yegani M. and Korver, D. 2008. Factors affecting intestinal health in poultry. Poult Sci. 87:2052-63. <https://doi.org/10.3382/ps.2008-00091>.