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Potency of Bioactive Compound of Cassava Leaf Paste to Support Physiological Performance of Quail

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ABSTRACT

Cassava leaf paste is an alternative substance in supporting the physiological performance of quail. Cassava leaf paste contains nutritional compositions such as water, ash, crude protein, crude fiber, fat, and carbohydrate. Cassava leaf paste has high crude protein and low crude fiber. The content of β-carotene and chlorophyll in cassava leaf paste has the ability as an antioxidant. Cassava leaf paste also contains phytochemicals such as flavonoids, saponins, tannins, sitosterol, and stigmasterol. The concentration of phytochemical has slightly higher flavonoid content, moderate tannins and saponins, and high sitosterol and stigmasterol. These phytochemicals act as antioxidants, antimicrobials, anti-inflammatory, improve the immunomodulatory system and reduce cholesterol. In addition, cassava leaf paste contains macro minerals such as P and Ca, as well as microminerals (Fe, Cu, Mn, and Zn). These minerals act as an antioxidant increases nutrient absorption, enhances immune response, and take part in mineralization during eggshell formation. Cassava leaf paste also has low levels of cyanide. Based on the nutritional content, phytochemicals, macro and micro minerals, and cyanide acid, cassava leaf paste has the potential to increase the physiological performance of quail.

Keywords: cassava leaf paste; macro and micro minerals; nutrition; physiological performance; phytochemicals

INTRODUCTION

Phytochemicals are bioactive compounds from plants that can improve the performance of poultry (Sugiharto 2016). This compound is available in various forms (Duskaev et al., 2018). This compound can come from all parts of a plant such as roots, tubers, leaves, and fruits.

Cassava has leaves with high antioxidant activity (Gatto et al., 2016; Koubala et al., 2015; Oresegun et al. 2016). Cassava leaves contain starch, crude protein, crude fiber, minerals, vitamins, and chlorophyll (Morgan & Choct, 2016; Pereira et al., 2016). Cassava leaves also contain vitamins A, B1, B2, and C as well as carotene (Morgan & Choct 2016), flavonoids, triterpenoids, saponins, and tannins (Jumadin et al., 2017; Mustarichie et al., 2020; da Silva et al., 2019). Substances in the cassava plant have properties and benefits for the physiological performance of the body's organs.

Cassava leaves so far have been used in the process of wound healing, anti-inflammatory, antioxidant, anticancer, and antimicrobial processes (Laya & Koubala 2020; Mustarichie et al. 2020). The flavonoids and saponins in the ethanol extract of cassava leaves have antibacterial activity against clinical isolates of *Streptococcus epidermidis* and *Propionibacterium acnes* (Mustarichie et al., 2020).

On the other hand, cassava leaves contain toxic materials such as linamarin, lotaustralin, and cyanogenic glucoside that will turn into cyanide acid (HCN) are enzymatically hydrolyzed (Wirawati et al., 2017). According to Hermanto & Fitriani (2018), the cyanide content of fresh cassava leaves is 183 ppm. The use of cassava leaf products in the form of paste is an alternative to overcome this is. This form of paste can reduce the content of cyanide acid.

Research regarding cassava leaf products in the form of paste to see the production performance and erythrocyte profile of quail exposed to heat has been conducted (Jumadin et al., 2017; Jumadin et al., 2018). However, its role in the physiological performance of quail reared under natural conditions has not been widely studied. The purpose of the presents study was to examine and evaluate scientific information about the benefits of cassava leaf paste in supporting the physiological performance of quail (*Coturnix coturnix japonica*) reared under natural conditions in tropical regions, such as in Indonesia.

MATERIAL AND METHOD

Experimental Time and Locations

The research was conducted for three months, from July to October 2020. This research was conducted in various places. The preparation of cassava leaf paste extraction was carried out at the Pilot Plant Laboratory of the Seafast Center of the Institute for Community Service Research (LPPM), IPB University.

Analysis of nutritional of cassava leaf paste (water, ash, crude fiber, fat, protein, and carbohydrate); analysis of chlorophyll, β-carotene, and antioxidants; analysis of quantitative phytochemical (flavonoid, saponin, tannin, sitosterol, and stigmasterol), and analysis of mineral element (P, Ca, Fe, Cu, Mn, and Zn) was carried out at the Laboratory of the Research Institute for Spices and Medicines (BALITTRO), Ministry of Agriculture of the Republic of Indonesia. Analysis of cyanide acid content was carried out at the Laboratory of the Center Research and Development for Agricultural Post Harvest (BB Pascapanen) Ministry of Agriculture of the Republic of Indonesia.

Production of Cassava Leaf Paste (*Manihot esculenta* Crantz)

Fresh cassava leaves were collected from Rancabungur Village, Ranca Bungur District, Bogor Regency, West Java Province. The cassava leaves used are intact and undamaged leaves. Part of the leaves is the sixth leaf tip. The leaves are first washed with clean water, then dried at room temperature. Then cut into small pieces to facilitate the crushing process which is done in a blender.

Extraction of cassava leaf paste was carried out according to the working procedure of Jumadin et al. (2017). A total of ± 50 grams of cassava leaf pieces are crushed in a blender using 125 mL of 70% ethanol for 3 minutes, intermittently every 1 minute. The solution of cassava leaves in ethanol is then filtered by a fine cloth, then the filtrate obtained is filtered again with a Buchner funnel using filter paper. The residue is washed with 75 mL 70% ethanol, then filtered again with a Buechner funnel. The filtrate is taken as a cassava leaf extract. Furthermore, the extract of the cassava leaves is evaporated for one hour at a temperature of 70 $^{\circ}$C, resulting in cassava leaf paste.

Analysis of Nutritional Content

Water content, ash, and crude fiber were analyzed using the gravimetric method (Balittanah 2009). Fat content was analysed using the extraction method (Soxlet) (Balittanah, 2009). Protein content was measured using Kjehdal method (Balittanah 2009). Carbohydrate content analysis was obtained using the titrimetric method (Balittanah, 2009). Analysis of β-carotene levels was obtained using the TLC scanner method and chlorophyll and antioxidants were obtained using the spectro-photometer method (Balittanah, 2009). Quantitative phytochemical analysis such as flavonoid levels and tannin levels were measured using a spectro-photometer method (Balittanah, 2009) while saponin levels were obtained using the TLC scanner method (Balittanah, 2009) and levels of sitosterol and stigmasterol were measured using the HPLC method (Balittanah, 2009). Analysis of mineral elemental (P, Ca, Fe, Cu, Mn, and Zn) was measured using the ASS method (Balittanah, 2009). Analysis of cyanide acid levels were obtained using the spectrophotometer method (Balittanah, 2009).

RESULT AND DISCUSSION

Nutritional Composition of Cassava Leaf Paste

The nutritional composition of cassava leaf paste contains water content, ash content, crude fiber content, fat content, crude protein content, and carbohydrate content, which can be briefly seen in Table 1.

Table 1. Nutritional composition of cassava leaf paste

Composition	Content (%)
Water	18.54
Ash	3.75
Crude fiber	1.87
Fat	2.09
Crude protein	44.54
Carbohydrate	8.31

Quail need nutrients for health, survival, productivity, energy sources, and egg production and quality (Alders et al., 2018; Şengül & Çalişla,r 2020). Nutritional requirements in quail feed contain 19.9% crude protein and 3.3% crude fiber (Abou-Elkhair et al., 2020). High crude fiber content is a limiting factor for quail. Kamel et al. (2019) stated that the maximum crude fiber content limit for quail is 6%. Characteristically, quail requires high protein, sufficient carbohydrates, and fat, and low crude fiber (Ibrahim et al., 2021). Moringa seed powder containing 14.2% ash, 36% crude protein, 3.1% crude fiber, 37.2% fat, and 7.2% carbohydrates were was used to increase egg production and quality in quail (Abou-Elkhair et al., 2020). Cassava leaf paste in this study contained 3.75% ash, 44.54 % crude protein, 1.87% crude fiber, 2.09% fat, and 8.31% carbohydrates. To fulfill the nutrient requirements of quail with high protein, sufficient carbohydrates, and fat, and low crude fiber, cassava leaf paste are more suitable for quail compare to moringa seed powder. Thus, high crude protein content and low crude fiber can be applied and do not further worsen the physiological performance of quail. Cassava leaf paste contains high protein and low crude fiber so it has the potential to be used for components and feed supplements for quail.

β-Carotene, Chlorophyll, and Antioxidant Content of Cassava Leaf Paste

The content of β-carotene, chlorophyll, and antioxidants, is presented in Table 2.

Table 2. β-carotene, chlorophyll, and antioxidant of cassava leaf paste

Nutritional	Content (%)
β-carotene	20.00
Chlorophyll	0.26
Antioxidant	2.36

β-carotene and chlorophyll have the ability as antioxidants and increase body weight (Abdel-Moneim et al., 2021; Ningrum et al., 2019). According to Ningrum et al. (2019), the chlorophyll content of 0.8-1.5% of alfalfa leaf extract was able to increase body weight in poultry including quail. Edi (2020) stated that the β-carotene content of 7-10% of tomatoes can lower cholesterol and as an antioxidant in poultry including quail. The need for antioxidants in quail feed contains 0.0012 % (Ansaripoor et al., 2020). Edi (2020), stated that the leaf extract of the god crown contains 0.0009% antioxidant which can be used in poultry including quail. The results of this study contain β-carotene 20.00%, chlorophyll 0.26%, and 2.36% antioxidants. Based on the analysis result of β-carotene, chlorophyll, and antioxidant of cassava leaf paste in Table 2 and based on previous results by other researchers, cassava leaf paste can be trusted to improve the physiological performance of quail. Cassava leaf paste is expected to increase metabolic processes, reduce oxidative stress, and potentially increase egg yolk color intensity.

Quantitative Phytochemical Content of Cassava Leaf Paste

Quantitative phytochemical content of cassava leaf paste such as flavonoid content, tannin content, saponin content, sitosterol level, and stigmasterol content, which can be briefly see in Table 3.

Table 3. Quantitative phytochemical content of cassava leaf paste

Phytochemical	Content (%)
Flavonoid	6.30
Tannin	5.08
Saponin	3.52
Sitosterol	4.38
Stigmasterol	6.68

Flavonoids are very important as antioxidants, improve the immunomodulatory system, and lower blood cholesterol (Park et al., 2019; Santoso et al., 2013; Van De Wier et al., 2017). Flavonoids have the ability as antioxidants because they can reduce the production of free radicals, make free radicals more stable and less reactive, and protect or increase endogenous antioxidants. Flavonoids can reduce the production of free radicals by inhibiting pro-oxidant enzymes, such as xanthine oxidase, lipoxygenase, and cyclooxygenase. Flavonoids can make radicals more stable and less reactive by transferring an electron to these free radicals. Flavonoids can protect or increase endogenous antioxidants by inducing glutathione S-transferase, heme-oxygenase 1 (HO-1), and superoxide dismutase. Flavonoids also can increase the immunomodulatory system by increasing the effectiveness of the proliferation of lymphokines produced by T cells, thereby stimulating phagocytic cells to carry out a phagocytic response. In addition, flavonoids can also lower cholesterol by forming complex bonds that are insoluble in cholesterol and increasing lipoprotein lipase activity. According to Tugiyanti et al. (2019), the concentration of flavonoids from avocado seed flour contains 5.41% which functions as an antioxidant and lowers blood cholesterol in quail. Cassava leaf paste contains 6.30% of flavonoid which is higher than from avocado seed flour, therefore cassava leaf paste can be more useful as an antioxidant and can lower blood cholesterol.

Tannins act as antioxidants, antimicrobials, and lower blood cholesterol (Choi & Kim, 2020; Liu et al., 2020; Marzoni et al., 2020; Tugiyanti et al., 2019). Tannins functioned as antioxidants by reducing the production of antioxidants, preventing oxidation during the digestive process, increasing the antioxidant capacity of the liver, and increasing SOD in the jejunum mucosa of quail. Tannins also have antimicrobial activity by depriving the substrate necessary for microbial growth, inhibiting oxidative phosphorylation, forming complexes with bacterial cell membranes, causing morphological changes in cell walls, and increasing membrane permeability. Tannins also work as antimicrobials by interfering with the permeability of cell membranes so that the exchange of substances needed by bacterial cells is disrupted, which ultimately results in stunted growth and death. On the other hand, tannins can inhibit cholesterol by forming reactions with mucosal proteins and epithelial cells thereby inhibiting fat absorption. Tannins also decrease cholesterol metabolism by reducing the activity of liver coenzyme A glutaryl 3-hydroxy-3-methyl (MHG-CoA) in poultry including quail. Tugiyanti et al. (2019) stated that the tannin concentration of avocado seed flour contains 5.54% which acts as an antioxidant and lowers blood cholesterol in quail. According to Huang et al. (2018), the tannin concentration of chestnut containing 0.15-1.2% can be used as an antimicrobial in poultry including quail. Cassava leaf paste has 5.08% tannins which close to the tannin concentration of avocado seed flour and higher than the tannin concentration of chestnut. It means that the tannin of cassava leaf paste can be expected to work as an antioxidant, reduce cholesterol, and as an antimicrobial.

Saponins are very important as antimicrobial, anti-inflammatory, and lower blood plasma cholesterol (Chaudhary et al., 2018; Tugiyanti et al. 2019). Saponins work as antimicrobials by disrupting the stability of the bacterial cell membrane, causing the bacteria to lyse. Saponins also function as an anti-inflammatory. Saponins inhibit the action of the cyclooxygenase enzyme by catalyzing the reaction of arachidonic acid into endoperoxides. On the other hand, saponins can also lower blood cholesterol by binding to bile acids and increasing bile acid excretion. Tugiyanti et al. (2019) stated that the concentration of saponins from avocado seed flour contains 7.59% which functions as an anti-inflammatory and lowers blood cholesterol in quail. According to Wina et al. (2017), the concentration of saponins from Moringa leaf extract contains 2.46-3.42% which acts as an antimicrobial in poultry including quail. The analysis result for saponin of a cassava leaf paste is about 3.52% which is lower than saponin of avocado seed flour but it is closed to moringa leaf extract. In this case, saponin of cassava leaf paste will be expected to play the role of antimicrobial.

Sitosterol is used as an antioxidant and lowers blood cholesterol (Cheng et al., 2020; Xia et al., 2020). Sitosterol functions as an antioxidant because of its ability to neutralize free radicals or as a hydrogen donor and increases antioxidant capacity by increasing the activity of atioxidant enzymes such as SOD. Sitosterol also can lower cholesterol by decreasing the absorption of cholesterol in the intestines. According to Cheng et al. (2020), a sitosterol content of 0.006-0.01% can function as an antioxidant and increase immunoglobulin Y (IgY) in poultry including quail. The high content of sitosterol which about 4.38% is more trusted to act as an antioxidant and increase IgY.

Stigmasterol functions to lower cholesterol levels (Bo et al., 2015; Cheng et al., 2020; Feng et al., 2020; Zhao et al., 2019). Stigmasterol lowers cholesterol levels by decreasing the absorption of cholesterol in the intestine and activating the lipase enzyme thereby increasing cholesterol catabolism. According to Ali et al. (2021), the stigmasterol content of 0.002-0.048% from tomatoes can be used to reduce cholesterol absorption in the intestine. The stigmasterol content of cassava leaf paste also showed high concentration. It can be predicted to have a stronger function to lower cholesterol levels.

Based on analysis results of quantitative phytochemical content which are flavonoids, tannins, saponins, sitosterol, and stigmasterol, cassava leaf paste can be given to quail to increase physiological performance. Cassava leaf paste can be given to quail to increase immunity and is expected to reduce oxidative stress in quail reared in tropical areas with high environmental temperatures.

Macro and Micro Minerals of Cassava Leaf Paste

Macrominerals of cassava leaf paste contain P and Ca, while micro-minerals contain Fe, Cu, Mn, and Zn, which can be briefly seen in Table 4.

Table 4. Macro and micro minerals of cassava leaf paste

Phytochemical	Kandungan (ppm)
Macro	
P	3840
Ca	220
Micro	
Fe	230.16
Cu	21.36
Mn	175.96
Zn	361.72

Minerals are needed by quail as antioxidants, increasing nutrient absorption, increasing immune responses, and mineralization during eggshell formation (Alagawany et al., 2021; Zhang et al., 2017). The minerals needed by quail consist of macro and micro minerals. Macro mineral requirements in quail feed contain 3300 ppm P and 24610 ppm Ca, while micro-minerals contain 30 ppm Fe, 10 ppm Cu, 100 ppm Mn, and 600 ppm Zn (Abou-Elkhair et al., 2020). Moringa seed powder containing 73 ppm P, 45 ppm Ca, 2 ppm Fe, and 4.2 ppm Cu was used to support increased egg production and quality in quail (Abou-Elkhair et al., 2020). According to Olgun (2017), the Mn content of 5-45 ppm from corn and soybean seeds plays a role in supporting the performance and quality of eggs in poultry including quail. The Zn content of 17.08 ppm from licorice is used to support growth and production performance in poultry including quail (Alagawany et al., 2019). The results of this study showed cassava leaf paste contained 3840 ppm P and 220 ppm Ca and 230.16 ppm Fe, 21.36 ppm Cu, 175.96 ppm Mn, and 361.72 ppm Zn. These compositions are expected to be works more to support the physiological performance of quail. The macro mineral content of cassava leaf paste can be used as a calcium supplement as the main element for forming egg shells, while micro-minerals act as antioxidants that can reduce oxidative reactions.

Cyanide Acid Content of Cassava Leaf Paste

Cassava leaf paste contains 1.01 ppm of cyanide acid. Cyanide is a toxic compound (Alqahtani et al., 2020; Hendry-Hofer et al., 2019). High cyanide has an impact on the physiological mechanisms of animals, including in quail such as disrupting hemoglobin function and liver function (Prachumchai et al., 2021). Cyanide's toxicity is due to its binding to iron ions in the cytochrome oxidase complex in the mitochondrial electron transport chain (Alqahtani et al., 2020). This binding inhibits oxidative phosphorylation, which causes a decrease in intracellular adenosine triphosphate (ATP) resulting in cell injury or death (Alqahtani et al., 2020). Cyanide poisoning related to the amount of feed consumed and the physiological condition of the animal over 200 ppm is considered dangerous (Prachumchai et al., 2021). A low concentration of cyanide acid is believed to be non-toxic or not dangerous for quail to consume.

CONCLUSION

Based on analysis results of quantitative phytochemical content which are flavonoids, tannins, saponins, sitosterol, and stigmasterol, cassava leaf can be given to quail to increase physiological performance. The composition of macro and micro minerals of cassava leaf paste is also expected to support the physiological performance of quail.

CONFLICT OF INTEREST

The authors whose names are listed have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

REFERENCES

Abdel-Moneim, A.M.E., A.M. Shehata, R.E. Khidr, V.K. Paswan, N.S. Ibrahim, A.A. El-Ghoul, S.A. Aldhumri, S.A. Gabr, N.M. Mesalam, A.M. Elbaz, M.A. Elsayed, M.M. Wakwak, & T.A. Ebeid. 2021. Nutritional manipulation to combat heat stress in poultry–A comprehensive review. J Therm Biol 98:1-20.

Abou-Elkhair, R., H.A. Basha, W.S.H.A. E. Naby, J.S. Ajarem, S.N. Maodaa, A.A. Allam, & M.A.E. Naiel. 2020. Effect of a diet supplemented with the *Moringa oleifera* seed powder on the performance, egg quality, and gene expression in japanese laying quail under heat-stress. Animals 10(5):1-12.

Alagawany, M., S.S. Elnesr, & M.R. Farag. 2019. Use of liquorice (*Glycyrrhiza glabra*) in poultry nutrition: Global impacts on performance, carcass and meat quality. Worlds Poult Sci J 75(2):293-304.

Alagawany, M., S.S. Elnesr, M.R. Farag, R. Tiwari, M.I. Yatoo, K. Karthik, I. Michalak, & Dhama, K. 2021. Nutritional significance of amino acids, vitamins and minerals as nutraceuticals in poultry production and health–a comprehensive review. Vet Q 41(1):1-29.

Alders, R.G., S.E. Dumas, E. Rukambile, G. Magoke, W. Maulaga, J. Jong, & R. Costa. 2018. Family poultry: Multiple roles, systems, challenges, and options for sustainable contributions to household nutrition security through a planetary health lens. Matern Child Nutr 14(3):1-14.

Ali, M.Y., A.A.I. Sina, S.S. Khandker, L. Neesa, E.M. Tanvir, A. Kabir, M.I. Khalil, & S.H. Gan. 2021. Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: A review. Foods 10(1):1-32.

Alqahtani, R.M., M.Y. Alyousef, Z.H. AlWatban, & M.K. Ghandour. 2020. Long-Term Neuro-psychiatric sequelae in a survivor of cyanide toxicity patient with arterialization. Cureus 12(6):1-6.

Ansaripoor, A., M. Sedghi, A. Sadeghi-Sefidmazgi, & M. Pilevar. 2020. Optimization of growth performance responses of Japanese quail with different concentrations of metabolizable energy, lysine, and sulfur amino acids using Taguchi method. Livest Sci 241:1-12.

[Balittanah] Balai Penelitian Tanah (Indonesian Soil Research Institute). 2009. Analisis Kimia Tanah, Tanaman, Air, dan Pupuk (Chemical Analysis of Soil, Plants, Water, and Fertilizer). Balai Penelitian Tanah. Bogor. Indonesia.

Bo, L., A. Hussain, Y. Xue, W.J. Jun, & W. Tian. 2015. Effects of phytosterols on growth performance and fat metabolism in broilers. Pak J Zool 47(1):111-118.

Chaudhary, S.K., J.J. Rokade, G.N. Aderao, A. Singh, M. Gopi, A. Mishra, & K. Raje. 2018. Saponin in Poultry and Monogastric Animals: A Review. Int J Curr Microbiol Appl Sci 7(7):3218-3225.

Cheng, Y., Y. Chen, J. Li, H. Qu, Y. Zhao, C. Wen, & Y. Zhou. 2020. Dietary β-sitosterol regulates serum lipid level and improves immune function, antioxidant status, and intestinal morphology in broilers. Poult Sci 99(3):1400-1408.

Choi, J. & W.K. Kim. 2020. Dietary application of tannins as a potential mitigation strategy for current challenges in poultry production: A review. Animals 10(12):1-21.

Duskaev, G.K., N.M. Kazachkova, A.S. Ushakov, B.S. Nurzhanov, & A.F. Rysaev. 2018. The effect of purified Quercus cortex extract on biochemical parameters of organism and productivity of healthy broiler chickens. Vet World 11(2):235-239.

Edi, D.N. 2020. Pemanfaatan kandungan bioaktif tanaman lokal untuk menunjang produktifitas ternak unggas. Briliant J Ris dan Konseptual 5(4):819-839. [Indoensia]

Feng, S., T. Belwal, L. Li, J. Limwachiranon, X. Liu, & Z. Luo. 2020. Phytosterols and their derivatives: Potential health-promoting uses against lipid metabolism and associated diseases, mechanism, and safety issues. Compr Rev Food Sci Food Saf 19:1243-1267.

Gatto, M.A., L. Sergio, A. Ippolito, & D. Di Venere. 2016. Phenolic extracts from wild edible plants to control postharvest diseases of sweet cherry fruit. Postharvest Biol Technol 120:180-187.

Hendry-Hofer, T.B., P.C. Ng, A.E. Witeof, S.B. Mahon, M. Brenner, G.R. Boss, & V.S. Bebarta. 2019. A review on ingested cyanide: risks, clinical presentation, diagnostics, and treatment challenges. J Med Toxicol 15(2): 128-133.

Hermanto, H. & F. Fitriani. 2018. The Effect of long the proses of fermentation on levels of hydrogen cyanida, and protein content on the skin and cassava leaves. J Ris Teknol Ind 12(2):169-180.

Huang, Q., X. Liu, G. Zhao, T. Hu, & Y. Wang 2018. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. Anim Nutr 4(2):137-150.

Ibrahim, N.S., M.A. El-Sayed, H.A.M. Assi, A. Enab, & A.M.E. Abdel-Moneim. 2021. Genetic and physiological variation in two strains of Japanese quail. J Genet Eng Biotechnol 19(1):1-12.

Jumadin, L., A.S. Satyaningtijas, & K. Santoso. 2017. Extract of cassava leaves is a good antioxidant for mature quail which exposed to heat in short time. J Vet 18(1):135-143.

Jumadin, L., A.S. Satyaningtijas, Z.M. Letis, L. Darlian, W. Ummah, & K. Santoso. 2018. The total erythrocyte count, hematocrit value, hemoglobin, concentration, and erythrocyte index in quail exposed heat exposure and cassava leaves extract. J Vet 19(3):335-341.

Kamel, E.R., L.S. Mohammed, & F.A.I. Abdelfattah. 2019. Effect of a diet containing date pits on growth performance, diet digestibility, and economic evaluation of Japanese quail (*Coturnix coturnix japonica*). Trop Anim Health Prod 52(1):339-346.

Koubala, B.B., A. Laya, H. Massaï, H. Kouninki, & E.N. Nukenine. 2015. Physico-chemical characterization leaves from five genotypes of cassava (*Manihot esculenta* Crantz) Consumed in the Far North Region (Cameroon). Am J Food Sci Technol 3(2):40-47.

Laya, A. & B.B. Koubala. 2020. Polyphenols in cassava leaves (*Manihot esculenta* Crantz) and their stability in antioxidant potential after in vitro gastrointestinal digestion. Heliyon 6(3):1-7.

Liu, H.S., S.U. Mahfuz, D. Wu, Q.H. Shang, & X.S. Piao. 2020. Effect of chestnut wood extract on performance, meat quality, antioxidant status, immune function, and cholesterol metabolism in broilers. Poult Sci 99(9):4488-4495.

Marzoni, M., A. Castillo, A. Franzoni, J. Nery, R. Fortina, I. Romboli, & A. Schiavone. 2020. Effects of dietary quebracho tannin on performance traits and parasite load in an italian slow-growing chicken (White livorno breed). Animals 10(4):1-11.

Morgan, N.K. & M. Choct. 2016. Cassava: nutrient composition and nutritive value in poultry diets. Anim Nutr 2(4):253-261.

Mustarichie, R., S. Sulistyaningsih, & D. Runadi. 2020. Antibacterial activity test of extracts and fractions of cassava leaves (*Manihot esculenta* Crantz) against Clinical isolates of *Staphylococcus epidermidis* and *Propionibacterium acnes* Causing Acne. Int J Microbiol 2020(1):1-9.

Ningrum, E.Z., L.F. Fajri, & D. Oktaviana. 2019. Effect of liquid chlorophyll from alfalfa leaves (*Medicago sativa* L) as a supportif supplement to the performance of broiler chickens. Bantara J Anim Sci 1(1):1-10.

Olgun, O. 2016. Manganese in poultry nutrition and its effect on performance and eggshell quality. World's Poultry Science Journal 73(1):45-56.

Oresegun, A., O.A. Fagbenro, P. Ilona, & E. Bernard. 2016. Nutritional and anti-nutritional composition of cassava leaf protein concentrate from six cassava varieties for use in aqua feed. Cogent Food Agric 2(1):1-16.

Park, Y.M., H.Y. Lee, Y.G. Kang, S.H. Park, B.G. Lee, Y.J. Park, H.G. Oh, D.I. Moon, Y.P. Kim, D.S. Park, L.H. Man, K.O. Jin, Y. Hye-Jeong, K.M. Jung, & L. Young-Rae. 2019. Immune-enhancing effects of *Portulaca oleracea* L.–based complex extract in cyclophosphamide-induced splenocytes and immunosuppressed rats. Food Agric Immunol 30(1):13-24.

Pereira, I.G., J.M. Vagula, D.F. Marchi, C.E. Barão, G.R.S. Almeida, J.V. Visentainer, S.A. Maruyamab, & O.O.S. Júnior. 2016. Easy method for removal of cyanogens from cassava leaves with retention of vitamins and omega-3 fatty acids. J Braz Chem Soc 27(7):1290-1296.

Prachumchai, R., A. Cherdthong, & M. Wanapat. 2021. Screening of cyanide-utilizing bacteria from rumen and in vitro evaluation of fresh cassava root utilization with pellet containing high sulfur diet. Vet Sci 8(1):1-14.

Santoso, T.A., D. Diniatik, & A.M. Kusuma. 2013. Imunostimulator Ekstrak Etanol Daun Katuk (*Sauropus androgynus* L Merr) Terhadap Aktivitas Fagositosis Makrofag Pharmacy 10(1):63-70. [Indonesia]

Şengül, A.Y. & S. Çalişlar. 2020. Effect of partial replacement of soybean and corn with dietary chickpea (raw, autoclaved, or microwaved) on production performance of laying quails and egg quality. Food Sci Anim Resour 40(3):323-337.

da Silva, G.N.S., M. Primon-Barros, A.J. Macedo, & S.C.B. Gnoatto. 2019. Triterpene derivatives as relevant scaffold for new antibiofilm drugs. Biomolecules 9(2):58-69.

Sugiharto, S. 2016. Role of nutraceuticals in gut health and growth performance of poultry. J Saudi Soc Agric Sci 15(2):99-111.

Tugiyanti, E., N. Iriyanti, & Y.S. Apriyanto. 2019. The effect of avocado seed powder (*Persea americana* Mill.) on the liver and kidney functions and meat quality of culled female quail (*Coturnix coturnix japonica*). Vet World 12(10):1608-1615.

Van De Wier, B., G.H. Koek, A. Bast, & G.R.M.M. Haenen. 2017. The potential of flavonoids in the treatment of non-alcoholic fatty liver disease. Crit Rev Food Sci Nutr 57(4):834-855.

Wina, E., T. Pasaribu, S. Rakhmani, & B. Tangendjaja. 2018. The role of saponin as feed additive for sustainable poultry production. Indones Bull Anim Vet Sci 27(3):117-124.

Wirawati, C.U., M.B. Sudarwanto, D.W. Lukman, & I. Wientarsih. 2017. Local plants as feed supplementation to improve ruminant milk production and quality. Indones Bull Anim Vet Sci 27(3):145-157.

Xia, G., J. Sun, Y. Fan, F. Zhao, G. Ahmed, Y. Jin, Y. Zhang, & H. Wang. 2020. β-Sitosterol attenuates high grain diet-induced inflammatory stress and modifies rumen fermentation and microbiota in sheep. Animals 10(1):1-16.

Zhang, L., Y.X. Wang, X. Xiao, J.S. Wang, Q. Wang, K.X. Li, T.Y. Guo, & X.A. Zhan. 2017. Effects of zinc glycinate on productive and reproductive performance, zinc concentration and antioxidant status in broiler breeders. Biol Trace Elem Res 178(2):320-326.

Zhao, Y.R., Y.P. Chen, Y.F. Cheng, H.M. Qu, J. Li, C. Wen, & Y.M. Zhou. 2019. Effects of dietary phytosterols on growth performance, antioxidant status, and meat quality in Partridge Shank chickens. Poult Sci 98(9):3715-3721.