ISSN: 0852-3681
E-ISSN: 2443-0765

Jurnal Ilmu-Ilmu Peternakan 32(2): 174 – 182
Available online at http://jiip.ub.ac.id

The effect of red dragon fruit (*Hylocereus polyrhizus*) peel meal on internal organs, ileal coliform, and growth performances in broiler chickens

Iis Yuanita*[1)], Lisnawaty Silitonga[1)], Hanna Oktaviani Br. Ginting[1)], Elysabet Christiani[1)], Lisna[1)], Rizky Fajar[1)] and Efraim Tobias[1)]

[1)]Animal Science Study Program, Agriculture Faculty, University of Palangka Raya, Palangka Raya 73112, Central Kalimantan, Indonesia

Submitted: 13 September 2021, *Accepted: 13 July 2022*

ABSTRACT: The study evaluated the effect of feeding red dragon fruit (*Hylocereus polyrhizus*) peel meal on internal organs, ileal coliform counts, and growth performances in broiler chicken. A total of 96 birds of unsexed one-day-old broiler (Ross strain) were randomly divided into four dietary treatments and six replications with four birds each. The dietary treatments were basal diet as a control diet (DPM0), basal diet added with 0.5% red dragon fruit peel meal (DPM1), and 1% red dragon fruit peel meal (DPM2), and 1.5% red dragon fruit peel meal (DPM3). The cecum and carcass percentage in the broiler was significantly enhanced ($p<0.05$). At the same time, the coliform total in the ileum and abdominal fat were significantly decreased ($p<0.05$) with the increasing level of feeding dragon fruit peel meal. The difference in other internal organs' feed intake and body weight gain during the treatments were insignificant ($p>0.05$) after five weeks of feeding. In conclusion, the red dragon fruit peel meal effectively improves growth performance and gut health by increasing carcass percentage and decreasing abdominal fat production and ileal coliform count in broiler chickens.

Keywords: Abdominal fat; Carcass; Feed additive; Gut health

*Corresponding Author: iis.yuanita@pet.upt.ac.id

DOI: 10.21776/ub.jiip.2022.032.02.03

INTRODUCTION

Antibiotics growth promoters (AGPs) as feed additives in the poultry diet, especially broiler, to enhance productivity have been used for the last decades worldwide. Unfortunately, using feed additives as antibiotics poses some adverse effects on health and food safety, with residues found in animal products. Residues in the meat consumed by humans will increase bacterial resistance to antibiotics. Therefore, antibiotics have been restricted and banned in many countries. The ban on AGPs as a feed additive in the poultry diet has prompted researchers to investigate an alternative to substitute for the improvement of poultry production performance.

Feed additives derived from natural sources as an alternative have been studied to replace antibiotics as a growth promoter to improve feed efficiency and enhance poultry's health status. The active compounds from fruits or plants have several health benefits with their respective biological function as antioxidant, immunostimulant, or antimicrobial activity (Patra, 2012). Red dragon fruit is an example of a fruit with high antioxidant properties.

Red dragon fruit (*Hylocereus polyrhizus*), also called *pitaya* or *pitahaya*, is a kind of fruit plant-producing red pulp belonging to the vine cacti from the subfamily Cactoideae of the tribe Cacteae (Zainoldin and Baba, 2009). This fruit was reported to have high active compounds, specifically rich in phenolic, flavonoid, and carotenoid, which are highly valued for their antioxidant properties (Mahattanatawee et al., 2006). Phenolic compounds are the most prominent secondary metabolites produced by plants. Phenolic compounds, flavonoids, and carotenoids are powerful antioxidants and contain an antibacterial agent and antiviral and antibiotic activity (Babula et al., 2009). Dragon fruit contains oligosaccharides (90 g/kg) which are suggested to consist of some fructooligosaccharides (FOS). These fructooligosaccharides have prebiotic properties and are beneficial to the gastrointestinal system, which include resistance to acid conditions, and can enhance the capability to stimulate the growth of lactobacilli and bifidobacteria (Wichienchot et al., 2010). Fructooligosaccharides may be partly hydrolyzed by gastric acid, but they are thought to be completely digested in the upper intestine and be fermented by the colonic microflora (Cummings and Englyst, 1995).

A promising source of antioxidants is dragon fruit pulp and dragon fruit peel. According to a preliminary experiment, red dragon fruit has 30-35% of the peel. The peel meal obtained around 7-10% from fresh peel weight. In a previous study, bioactive compounds from plant extract and fruit waste are used to substitute the AGPs that can improve broiler productivity (Yuanita et al., 2019; Soesanto et al., 2012). Another research has justified that the fermented dragon fruit peel meal in a layer diet increased the egg production (egg weight, HU, and thickness) of the Isa Brown chickens (Dewi et al., 2020).

Although the previous study showed that the use of fruit waste as an antioxidant source has an impact on improving the productivity of broiler chickens, other fruit waste with its bioactive content effect needs to be clarified. The information on the use of red dragon fruit peel meal as a source of active compound additive and a substitute for AGP in poultry, especially broiler diet, is still rarely available in the literature.

Therefore, research needs to be conducted to clarify the effect of red dragon fruit peel meal in the broiler to increase productivity. The present study was conducted to evaluate the dietary inclusion of red dragon fruit peel meal as an antioxidant source as an alternative to AGP that could improve the productivity of broiler chickens. Thus, the specific aim of this study was to evaluate the effect of feeding red dragon fruit peel meal on internal organs and growth performances of broiler chickens.

MATERIALS AND METHODS

Red dragon fruit peel meal preparation

The red dragon fruit peels were separated from the fruit meat and thinly sliced. Then placed in an aluminum container and dried under a tin roof for 1-2 days at a temperature of around 30-32ºC. It was further mashed using a blender and filtered until powder form was obtained and stored at room temperature.

The fresh red dragon fruit peel was obtained from the fruit juice seller around the city. The powder was obtained at the Laboratory of Animal Science Study Program at Palangka Raya University.

Experimental animal and diet

A total of 96 birds of unsexed one-day-old broiler (Ross strain) were randomly divided into four dietary treatments, and six replications (4 birds each) with an initial body weight of birds was 44.9±1.85 grams. The chickens were kept in a 1x1 m litter-floored pen and given diet *ad libitum* and free access to drinking water until 35 days of age.

The chickens were fed with the BR1 commercial diet for the starter period (1-21 days of age) and continued with the BR2 commercial diet for the finisher period (22-35 days of age) as a basal diet. The commercial diets consisted of corn, rice bran, pollard brand, corn gluten meal, soybean meal, fish meal, crude palm oil, and essential amino acid. It was formulated according to the Indonesian National Standards (SNI) requirements, as shown in Table 1. The levels of DPM at 0, 0.5, 1, and 1.5% were added to the basal diet and composed as dietary treatments with the codes DPM0, DPM1, DPM2, and DPM3, respectively.

Table 1. Nutrient content of the basal diet

Nutrient Content	Composition (%)	
	Starter (<21days)*	Finisher (22-42 days)*
Water content, %	Max 14	Max 14
Crude protein, %	21-23	18-20
Crude fiber, %	Max 5	Max 5
Ether extract, %	Min 5	Min 6
Ash, %	Max 7	Max 8
Calcium, %	0.8-1.1	0.8-1.1
Phosphor, %	Min 0.5	Min 0.45
Asam amino		
Lysine, %	Min 1.20	Min 1.05
Methionine, %	Min 0.45	Min 0.40
Metionin cysteine, %	Min 0.80	Min 0.75
Threonine, %	Min 0.75	Min 0.65
Tryptophan, %	Min 0.19	Min 0.18
Metabolizable Energy, kcal/kg**	3000	3100

* Based on the analyzed value of PT. Wonokoyo Jaya Corp
** Based on Indonesian National Standard SNI 8173:2015

Sampling and parameters measurement

Broiler performances measurement were feed intake, body weight gain (BWG), and feed conversion ratio (FCR). Feed intake was the sum of daily recording, and BWG was obtained by subtracting the final body weight from the initial body weight. Feed intake divided by BWG was calculated as FCR. On day 35, one bird of each replication was randomly selected. The birds were slaughtered to obtain carcass, internal organs weight, and ileal digesta. Percentage carcass and internal organs were obtained by dividing the weight of carcass and internal organs by live body weight, then multiplied by 100%. Microbial counts in the ileal digesta were determined with slight modification (Engberg et al., 2004). Coliform counts were measured on MacConkey agar (Merck KGaA) following aerobic incubation at 38°C for 24 h as red colonies. An ileal digesta sample was collected from the end of the ileum (10 cm anterior to the ileo-ceca-colonic junction) and gently removed into a plastic container.

Experimental design and statistical analysis

The data were statistically analyzed based on a completely randomized design by ANOVA using the GLM procedure of SAS version 9.0. The significant differences among treatment means ($p<0.05$) were further analyzed using Duncan's multiple range test.

RESULT AND DISCUSSION

Internal organs percentage of chicks

The data on the internal organs percentage of the broiler chicken is presented in Table 2. Dietary inclusion of red dragon fruit peel meal (DPM) did not affect on proventriculus, duodenum, jejunum, ileum, colon, liver, bile, thymus, spleen, and bursa of Fabricius percentage among the treatments.

However, there was a tendency that chicks in the DPM treatment had a higher gizzard percentage (p=0.08), heart percentage (p=0.10), and pancreas percentage (p=0.10) as compared to DPM0 as a control group on 35th days of age. The cecum percentage was higher than ($p<0.05$) in DPM3 as compared to DPM0 (Table 2).

Table 2. Effect of red dragon fruit peel meal on internal organs relative weight of broiler chicken

Items (%)	DPM0	DPM1	DPM2	DPM3	SEM	*p*-value
Proventriculus	0.36	0.38	0.44	0.37	0.03	0.38
Gizzard	1.01	1.00	1.18	1.10	0.06	0.08
Duodenum	0.43	0.41	0.39	0.41	0.03	0.88
Jejunum	1.31	1.14	1.36	1.03	0.10	0.13
Ileum	0.23	0.24	0.24	0.21	0.02	0.52
Cecum	0.49^{a}	0.59^{ab}	0.66^{ab}	0.70^{b}	0.05	0.03
Colon	0.11	0.12	0.14	0.13	0.01	0.46
Pancreas	0.19	0.24	0.22	0.22	0.11	0.10
Heart	0.33	0.34	0.37	0.40	0.02	0.10
Liver	1.95	2.11	2.23	2.11	0.09	0.28
Bile	0.09	0.08	0.08	0.06	0.01	0.24
Thymus	0.11	0.14	0.14	0.11	0.02	0.50
Spleen	0.11	0.11	0.11	0.14	0.01	0.60
Bursa of Fabricius	0.11	0.11	0.11	0.14	0.02	0.60

$^{a-b}$ *Means within row followed by different superscripts differ at* p*<0.05*, DPM0 (basal diet as a control), DPM1 (basal diet added with 0.5% DPM), DPM2 (basal diet added with 1% DPM), DPM3 (basal diet added with 1.5% DPM)

The weight of the proventriculus of our study was still classified as usual Ukim et al. (2012) stated that the proventriculus of broiler weight ranges from 0.4-0.54% of live weight. The percentage of gizzard weight was between 1-1.18 %, lower than Huang et al. (2009), who reported the gizzard percentage ranged from 1.35 to 1.41. The percentage of the weight of the small intestine, including the duodenum, jejunum, and ileum, in the present study was lower than that Wang et al. (2015), which ranged from 3.5-4%. The percentage of cecum weight in this study ranged from 0.58-0.73%. This result was higher than Icharoen (2013), which is 0.46-0.49%, but lower than Sharifi et al. (2012), between 0.65-0.85% of live weight. The percentage of liver weight in this experiment was 2.13-2.38% of the live weight. This result was similar to

Icharoen (2013), who reported that liver weight ranged from 2.32%-2.67% of live weight, but lower than Retnani (2009), which ranged from 2.7-2.9% of live weight. The thymus, spleen, and bursa of Fabricius percentage of DPM treatments were the same 0.11-0.14%, respectively. The percentage of the thymus was below the standard size. However, the percentage of the bursa Fabricius and spleen were within the normal range. The standard percentage of broiler chickens' bursa Fabricius and thymus is 0.09% and 0.48% (Toghyani, 2010), and the standard percentage of broiler spleen ranges from 0.10-0.23% (Putnam, 1991).

The dietary inclusion level of DPM was the essential factor affecting internal organs' growth and performance. Red fruit peel meal contains phenolic and flavonoid as serve as an antioxidant and antibacterial agent (Babula et al., 2009) and prebiotic properties fructooligosaccharides (FOS) (Wichienchot et al., 2010). The antioxidant and prebiotic may affect the enlargement of the cecum due to the dietary inclusion of DPM ($p<0.05$). The present result was in contrast to the previous studies that dietary inclusion of prebiotics found no effect on cecum weight (Wang et al., 2015). However, the enlargement of the cecum due to the dietary inclusion of DPM is a sign of the cecum's function as microbial digestion, as well the reabsorption of nutrients and residual water from chyme was more effective.

Except for the cecum percentage, another internal organ was not affected by DPM inclusion in the broiler diet. These results agree with Baurhoo et al. (2007), who found no improvement in liver, heart, and gizzard weights effect of different prebiotic supplementation. Contrarly, Waqas et al. (2018) reported that the liver, heart, and gizzard weight presented significant variations among supplemented prebiotic groups. On the other hand, results revealed no significant effect of prebiotic supplementation on intestinal weight, corroborating the findings of Hosseini et al. (2016). Some other researchers (Askri et al., 2020; Lutfullah et al., 2011) showed that dietary additives reduced intestine weight. However, Wang et al. (2015) found that dietary prebiotics may improve intestine weight. The varying effect of feeding dietary feed additive containing bioactive on internal organs is undoubtedly possible due to the variation of bioactive source, processing method, additional level, and combination of treatments.

Growth performances

The data on accumulative feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR), carcass, and abdominal fat percentage are presented in Table 3. A significant difference was not observed in broiler chickens' FI, BWG, and FCR. However, the chicks in the DPM treatments had higher ($p<0.05$) carcass percentage and lower ($p<0.05$) abdominal fat percentage as compared to DPM0 treatment as a control group. The ileal coliform bacteria count was significantly ($p<0.05$) reduced by feeding DPM (Table 3) as compared to the control group. The best carcass, fat, and coliform bacteria abdominal percentage found in the present study was due to the addition of DPM at 1.5%.

The antioxidant and prebiotic properties in DPM may mediate the improvement of the growth of endogenous lactic acid bacteria (LAB). The LAB led to increased bile salt hydrolase (BSH) enzyme production. It is well documented that the BSH enzyme can inactivate the work of bile salt from the pancreas to be deconjugated form, so that it decreases fat digestion and absorption, and finally impact reduced fat deposition. The result of ileal coliform supported these results, and fat percentage significantly decreased ($p<0.05$) in the current study. Although DPM has phenolics and flavonoids and also serves as an antibacterial agent, some flavonoid derivatives, such as phenolic acid, had no inhibiting effect on the growth of lactic acid bacteria. However, it depressed the growth of gram-negative bacteria like *Escherichia coli* and *Salmonella* sp. (Puupponen-Pimia et al., 2001). Previous studies indicated the positive influence on carcass production of broiler fed diet containing fermented dragon fruit peel meal compared to that given diet without fermented dragon fruit peel meal (Dewi et al., 2017). A similar result was reported by Soesanto et al. (2012) that adding fruit waste that contains antioxidants to the broiler diet positively affected growth, characteristics, and carcass quality. However, these results contradict Daneshman et al. (2015) findings that the propolis (a phenolic-rich source plant) did not significantly affect broiler chicken's performance. The different results may be due to the different antioxidant activity of each plant species.

Table 3. Effect of red dragon fruit peel meal on coliform bacteria and growth performance

Items	DPM0	DPM1	DPM2	DPM3	SEM	*p*-value
Coliform (log CFU/mL)	7.04^{b}	6.34^{a}	6.01^{a}	5.89^{a}	0.45	0.02
FI (g/bird)	2795	2746	2741	2709	33.0	0.38
BWG (g/bird)	1704	1723	1725	1725	25.3	0.94
FCR	1.64	1.60	1.59	1.57	0.03	0.38
Carcass percentage (%)	70.3^{a}	71.8^{ab}	72.8^{ab}	75.4^{b}	1.27	0.04
Abdominal fat percentage (%)	1.51^{b}	1.09^{a}	1.08^{a}	0.98^{a}	0.14	0.03

$^{a-b}$ *Means within row followed by different superscripts differ at* $p<0.05$, FI (feed intake), BWG (body weight gain), FCR (feed conversion ratio), DPM0 (basal diet as a control), DPM1 (basal diet added with 0.5% DPM), DPM2 (basal diet added with 1% DPM), DPM3 (basal diet added with 1.5% DPM)

The beneficial activity of active compounds of DPM at 1.5% (DPM3) increased cecum percentage (Table 2) and decreased coliform count in the ileum (Table 3). As described previously, the positive relationship of those parameters impacted the carcass percentage improvement.

Therefore, it can be assumed that the addition of the red dragon peel meal that contains antioxidants and FOS prebiotic can indirectly increase the efficiency of nutrient utilization for body tissue synthesis. Similar to previous studies, feeding FOS prebiotic from Dayak onion extract was reported to stimulate the development of beneficial lactic acid bacteria (LAB) and suppressed coliform count in the ileum of broiler chicken (Yuanita et al., 2020). FOS prebiotic could be fermented by the beneficial intestinal microbes, such as *Lactobacillus* sp., which stimulated the increase in the amounts of non-pathogenic bacteria (Roberfroid, 2007). Similarly, a beneficial gut condition through the improvement of growth performance concerning the better balance of intestinal bacteria (higher LAB and low coliform counts) was found in broiler fed diet with the addition of glucomannan derived from porang (*Amorphophallus onchophyllus)* tuber (Perdinan et al., 2019). It seems like there was a positive effect of the antioxidant activity and prebiotic properties derived from the red dragon peel meal that would stimulate the gut health condition of the host and support the animal productivity.

CONCLUSIONS

The red dragon fruit peel meal (DPM), especially at 1.5%, possesses some performance advantages and maintains gut health as indicated by the increases in carcass percentage and the decreases in coliform bacteria and fat percentage.

ACKNOWLEDGMENTS

This study was funded by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesian through PNBP University of Palangka Raya in the fiscal year 2021 with contract No 294/UN24.13/PL/2021.

REFERENCES

Askri, A., Moujahed, A.R., M'Hamdi, N., Maalaoui, Z., & Debbabi H. (2020). Broiler's performance and carcass characteristics improvement by prebiotic supplementation. *Large Animal Review*, *26*, 249-256.

Babula, P., Adam, V., Havel, L., & Kizek, R. (2009). Noteworthy secondary metabolites naphthoquinones-their occurrence, pharmacological properties and analysis. *Current Pharmaceutical Analysis*, *5*(1), 47-68, https://doi.org/10.2174/157341209787314936

Baurhoo, B., Phillip, L., & Ruiz-Feria, C.A. (2007). Effects of purified lignin and mannan oligosaccharides on intestinal integrity and microbial populations in the ceca and litter of broiler chickens. *Poultry Science*, *86*(6), 1070-1078. https://doi.org/10.1093/ps/86.6.1070

Cummings, J.H., & Englyst, H.N. (1995). Gastrointestinal effects of food carbohydrate. *American Journal of Clinical Nutrition*, *61*, 938S-945S. https://doi.org/10.1093/ajcn/61.4.938S

Daneshmand, A., Sadeghi, G.H., Karimi, A., Vaziry, A., & Ibrahim, S.A. (2015). Evaluating complementary effects of ethanol extract of propolis with the probiotic on growth performance, immune response and serum metabolites in male broiler chickens. *Livestock Science*, *178*, 195-201. https://doi.org/10.1016/j.livsci.2015.04.012

Dewi, G.A.M.K., Nuriyasa, I.M., & Wijana, I.W. (2017). Production of chicken carcass and non carcass of kampung chickens who received rations skin dragon fruit flour (*Hylocereus polyrhizus*) fermented. *ISTAP Proceeding*, 244-250.

Dewi, G.A.M.K., Wirapartha, M., Wiyana, I.K.A., & Suartiningsih, N.P.M. (2020). Quality of eggs from fermented dragon fruit (*Hylocereus polyrhizus*) flour fed Isa Brown. *IOP Conference Series: Materials Science and Engineering*, *823*, 012013. https://doi.org/10.1088/1757-899X/823/1/012013

Engberg, R.M., Hedemann, M.S., Steenfeldt, S., & Jensen, B.B. (2004). Influence of whole wheat and xylanase on broiler performance and microbial composition and activity in the digestive tract. *Poultry Science*, *83*, 925-938. https://doi.org/10.1093/ps/83.6.925

Hosseini, S.M., Nazarizadeh, H., Ahani, S., & Azghandi, M.V. (2016). Effects of mannan oligosaccharide and Curcuma xanthorrhiza essential oil on the intestinal morphology and stress indicators of broilers subjected to cyclic heat stress. *Archives Animal Breeding*, *59*, 285-291. https://10.5194/aab-59-285-2016

Huang, Y., Yoo, J.S., Kim, H.J., Wang, Y., Chen, Y.J., Cho, J.H., & Kim, I.H. (2009). Effect of bedding types and different nutrient densities on growth performance, visceral organ weight, and blood characteristics in broiler chickens. *Journal of Applied Poultry Research*, *18*, 1-7. https://doi.org/10.3382/japr.2007-00069

Icharoen, T. (2013). Histological adaptations of the gastrointestinal tract of broilers fed diets containing insoluble fiber from rice hull meal. *American Journal of Animal and Veterinary Sciences*, *8*(2), 79-88. https://doi.org/10.3844/ajavsp.2013.79.88

Lutfullah, G., Akhtar, T., Ahmad, I., Khattak, M.U.A., Durrani, F., & Qureshi, M.S. (2011). Effects of probiotics on the intestinal morphology with special reference to the growth of broilers. *Journal Chemical Society of Pakistan*, *33*, 129-133.

Mahattanatawee, K., Manthey, J.A., Luzio, G., Talcott, S.T., Goodner, K., & Baldwin, E.A. (2006). Total antioxidant activity and fiber content of select Florida-grown tropical fruits. *Journal of Agricultural and Food Chemistry*, *54*(19), 7355-7363. https://doi.org/10.1021/jf060566s

Patra, AK (2012). Dietary Phytochemicals and Microbes. eBook Springer Dordrecht Heidelberg.

Perdinan, A., Wahyuni, H.I., & Suthama, N. (2019). Body Resistance and growth performance of broiler fed glucomannan extracted from *Amorphophallus onchophyllus* tuber. *Tropical Animal Science Journal*, *42*, 33 – 38. https://doi.org/10.5398/tasj.2019.42.1.33

Putnam, P.A. (1991). Handbook of Animal Science. San Diego: Academy Press.

Puupponen-Pimia, R., Nohynek, L., Meier, C., Heinonen, M., Hopia, A., & Caldentey, K.M. (2001). Antimicrobial properties of phenolic compounds from berries. *Journal of Applied Microbiology*, *90*, 494-507. https://doi.org/10.1046/j.1365-2672.2001.01271.x

Retnani, Y., Suprapti, E., Firmansyah, I., Herawati, L., & Mutia, R. (2009). Effect of coloring agent addition in the broiler chicken rations on performance, percentage of bursa of Fabricius, carcass and viscera. *Journal of the Indonesian Tropical Animal Agriculture*, *34*(2), 115-121.

Roberfroid, M. B. (2007). Inulin-type fructans: functional food ingredients. *Journal of Nutrition*, *137*, 2493S-2502S. https://doi.org/10.1093/jn/137.11.2493S

Sharifi, S.D., Shariatmadari, F., & Yaghobfar, A. (2012). Effects of inclusion of hull-less barley and enzyme supplementation of broiler diets on growth performance, nutrient digestion and dietary metabolisable energy content. *Journal of Central European Agriculture*, *13*(1), 193-207.

Soesanto, I.R.H., Yuanita, I., Mutia, R., Alimon, A.R., & Sukemori, S. (2012). Growth performance, carcass characteristics and quality responses of broiler fed red fruit (*Pandanus conoideus*) waste. *Journal Agriculture Science*, *57*(1), 57-62.

Toghyani, M., Tohidi, M., Gheisari, A.A., & Tabeidian, S.A. (2010). Performance, immunity, serum biochemical and hematological parameters in broiler chicks fed dietary thyme as alternative for an antibiotic growth promoter. *African Journal of Biotechnology*, *9*, 6819-6825.

Ukim, C.I., Ojewola, G.S., Obun, C.O., & Ndelekwute, E.N. (2012). Performance and carcass and organ weights of broiler chicks fed graded levels of Acha grains (*Digitaria exilis*). *Journal of Agriculture and Veterinary Science*, *1*(2), 28-33. https://doi.org/10.9790/2380-0122833

Wang, W., Yang, H., Wang, Z., Han, J., Zhang, D., Sun, H., & Zhang, F. (2015). Effects of prebiotic supplementation on growth performance slaughter performance growth of internal organs and small intestine and serum biochemical parameters of broilers. *Journal of Applied Poultry Research*, *43*, 33-38. https://doi.org/10.1080/09712119.2014.887010

Waqas, M., Mehmood, S., Mahmud, A., Saima, N., Hussain, J., Ahmad, S., Tahir, K.M., Rehman, A., Zia, M.W., & Shaheen, M.S. (2018). Effect of yeast-based mannan oligosaccharide, Actigen™, supplementation on growth, carcass characteristics and physiological response in broiler chickens. *Indian Journal of Animal Research*, *53*, 1475-1479. https://doi.org/10.18805/ijar.B-923

Wichienchot, S., Jatupornpipat, M., & Rastall, R.A. (2010). Oligosaccharides of pitaya (dragon fruit) flesh and their prebiotic properties. *Food Chemistry*, *120*(3), 850-857. https://doi.org/10.1016/j.foodchem.2009.11.026

Yuanita, I., Sunarti, D., Wahyuni, H.I., & Suthama, N. 2019. Feeding *Dayak* onion (*Eleutherine palmifolia*) extract and *Lactobacillus acidophilus* mixture on blood biochemicals, meat quality characteristics and growth performance in broiler chickens. *Livestock Research for Rural Development*, *31*, 144.

Yuanita, I., Sunarti, D., Wahyuni, H.I., & Suthama, N. (2020). A combination of *Dayak* onion (*Eleutherine palmifolia*) extract and *Lactobacillus acidophilus* on antioxidant capacity and intestinal bacteria in broiler chickens. *IOP Conference Series: Earth Environmental Science*, *518*, 012014. https://doi.org/10.1088/1755-1315/518/1/012014