OPEN ACCESS
Journal of Animal Health and Production

Research Article

Performance Enhancement in Male Bayang Ducks after Oral Administration of the Probiotic *Bacillus subtilis* FNCC 0059

Zurmiati[1*], Ade Trisna[2], Ridho Kurniawan Rusli[1], Yelsi Listiana Dewi[3], Ulvi Fitri Handayani[4], Wizna[1]

[1]Department of Animal Feed and Technology, Faculty of Animal Science, Universitas Andalas, Padang 25163, Indonesia; [2]Department of Animal Husbandry, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155; [3]Department of Livestock Breeding, Faculty of Military Logistics, Indonesia Defence University, Belu, 85752; [4]Department of Animal Nutrition and Feed Technology, Faculty of Agriculture and Animal Science, Universitas Kotabumi, 34517, Kotabumi, Indonesia.

Abstract | Ducks have a strategic position in Indonesian society, apart from providing quality feed, ducks also offer excellent opportunities to village communities to earn income. However, the high feed conversion of duck is an obstacle in the intensive development of duck farming because 70% of poultry production costs come from feed costs. The purpose of this study was to investigate the effect of *Bacillus subtilis* FNCC 0059 administration as a probiotic on growing male Bayang duck performance. A randomized design was used in this study. The probiotic *Bacillus subtilis* FNCC 0059 was included in drinking water of male Bayang ducks at different doses (0, $76x10^6$, $69x10^8$, $65x10^{10}$, $53x10^{12}$ CFU/ml), and each of these five treatment was replicated four times. Feed intake, body weight gain, feed conversion, and final body weight were the parameters studied. The results revealed that the probiotic *Bacillus subtilis* FNCC 0059 has a significant ($p<0.05$) effect on feed intake (being low in $53x10^{12}$ and $65x10^{10}$ CFU/ml), body weight, body weight gain (being high in $69x10^8$, $65x10^{10}$ and $53x10^{12}$ CFU/ml) and feed conversion (being low in $53x10^{12}$ and $65x10^{10}$ CFU/ml) of male Bayang ducks. In conclusion, the administration of probiotic *Bacillus subtilis* FNCC 0059 in drinking water to male Bayang ducks at a dose of $65x10^{10}$ CFU/ml can improve the performance and feed efficiency of male Bayang ducks.

Keywords | Body weight gain, feed efficiency, feed intake, final body weight, local duck, Probiotic

Received | October 30, 2023; **Accepted** | November 25, 2023; **Published** | January 05, 2024
***Correspondence** | Zurmiati, Department of Animal Feed and Technology, Faculty of Animal Science, Universitas Andalas, Padang 25163, Indonesia; **Email:** zurmiati@ansci.unand.ac.id
Citation | Zurmiati, Trisna A, Rusli RK, Dewi YL, Handayani UF, Wizna (2024). Performance enhancement in male bayang ducks after oral administration of the probiotic *Bacillus subtilis* fncc 0059. J. Anim. Health Prod. 12(1): 11-16.
DOI | http://dx.doi.org/10.17582/journal.jahp/2024/12.1.11.16
ISSN | 2308-2801

INTRODUCTION

Ducks have a strategic position in Indonesian society, they not only provide quality food but also a great opportunity for villagers to earn income. The duck population in Indonesia has increased, from 56,570 in 2021 to 58,651 in 2022 (BPS, 2022). The Bayang duck is a local duck species which is the germplasm of West Sumatra, first found in South Pesisir Regency, Indonesia, and is potentially a meat- and egg-purpose breed (Kusnadi and Rahim, 2009; Rusfidra et al., 2013). However, from economic point, the productivity of ducks is lower as compared to chickens for meat or eggs, which is shown by the high ration conversion rate. The high diet conversion of ducks elevates production costs, so farmers are constrained in maintaining intensively. In this regard, breakthroughs need to be made

in the field of animal husbandry technology, especially technology related to ration issues so that the rations given to livestock are more efficient. Efforts to improve ration efficiency include adding various feed additives such as enzymes and antibiotics. However, many governments, have restricted the use of antibiotics (Mehdi et al., 2018; Roth et al., 2019). To overcome these issues, livestock-safe feed additives such as probiotics are required.

Probiotics are live, non-pathogenic microorganisms that assist the host by balancing the intestinal microflora. Several researchers have previously reported that probiotics in ducks can improve performance, ration efficiency, gut health, and even reduce the use of crude protein in the ration from 18% to 14% without disturbing duck performance (Zurmiati et al., 2017a; Yang et al., 2020; Naumova et al., 2021; Khattab et al., 2021; Khabirov et al., 2022; Lokapirnasari et al., 2022). *Bacillus subtilis* is a gram-positive bacterium with probiotic characteristics (Duanis-Assaf et al., 2020). It secretes exogenous digestive enzymes (Abd El-Moneim and Sabic, 2019), which can improve nutrient digestion. Also, it can improve health, performance, ration efficiency, and it can ameliorate the intestinal morphology of ducks (Guo et al., 2016; Zurmiati et al., 2017b; Li et al., 2022; Sun et al., 2022). However, to date there have been no reports concerning the response of male Bayang duck supplemented with a probiotic *Bacillus subtilis* FNCC 0059. Currently, there are no guidelines regarding the appropriate dose of probiotic *Bacillus subtilis* FNCC 0059 for male Bayang duck. This article aims to answer the question of what is the impact of probiotic *Bacillus subtilis* FNCC 0059 on the performance of male Bayang duck. To do this, we measured the male Bayang duck's feed intake, body weight increase, feed conversion, and final body weight while supplementing *Bacillus subtilis* FNCC 0059 in drinking water.

MATERIALS AND METHODS

Ethical approval

The study was approved by the Research Ethics Committee of the Universitas Andalas, Padang, Indonesia, in accordance with ethical animal research standards, registration no. 520/UN.16.2/KEP-FK/2023.

Experimental Birds

A total of 100 day-old male Bayang ducks were purchased from a duck farm and were equally divided into five treatment groups and supplemented with *Bacillus subtilis* FNCC 0059 at a dose rate of 0, $76x10^6$, $69x10^8$, $65x10^{10}$, and $53x10^{12}$ CFU/ml. Each group has four replicates and each replicate was consisted of 5 male Bayang ducks. Ducks were placed in box cages of 80x60x60 cm, with 5 ducks per box. The average body weight of each group was noted before the start of treatment.

Experimental Diet and probiotic administration

Diets were prepared separately using the diet ingredients listed below: Soybean meal, rice bran, fish meal, corn, mineral feed supplement, and coconut oil. Nutrients (%) and metabolic energy (kcal / kg) profile of diet can be found in Table 1. During the research, diet and water were always provided freely.

Table 1: Feed ingredients, nutritional value, and metabolic energy of male Bayang duck feed.

Feed ingredients	Composition of feed ingredients in the diet (%)
Corn	59.00
Rice bran	13.00
Soybean meal	18.5
Fish meal	7.00
Mineral feed supplement	0.70
Coconut oil	1.80
Total	100
Calculated nutrient content (%) and metabolic energy (Kcal/kg)	
Crude protein	20.25
Crude fibre	5.53
Crude fat	4.67
Calcium	0.83
Phosphorus	0.38
Metabolic energy (Kcal/kg)	2905.90

Note: The diet used in each treatment was the same. The difference was the dose of probiotic *Bacillus subtilis* FNCC 0059, which was administered through drinking water.

Ducks were given an adaptation period of one week by providing drinking water without adding probiotics. Then, probiotic *Bacillus subtilis* FNCC 0059 was administered through drinking water according to the treatment. The inclusion of probiotics was done once a week, starting at week 2 until week 5, while performance data was collected until the ducklings were 6 weeks old.

Parameters measured

Feed conversion, total feed intake, daily feed intake, total body weight gain, and daily body weight gain were recorded (Ojediran et al., 2017). In addition, the final body weight was obtained by weighing the ducks at the end of the study without subtracting the initial weight (before treatment).

Statistical analysis

The data was analyzed using analysis of variance (ANOVA). Following that, the treatment differences were analyzed using Duncan's multiple range test (DMRT) with a

significance threshold of p<0.05 (Steel and Torrie, 1991).

RESULTS AND DISCUSSION

A statistically significant (p<0.05) effect was seen on the average feed intake when *Bacillus subtilis* FNCC 0059 was supplemented to ducks (Table 2). During the initial 5 week phase, an increase in the dosage of probiotics resulted in a notable decrease in the total feed intake and daily feed intake of male Bayang ducks. Data indicated significant decrease in feed intake for ducks fed *Bacillus subtilis* FNCC 0059 at the dose of $65x10^{10}$ and $53x10^{12}$. These results indicate that the addition of probiotic *Bacillus subtilis* FNCC 0059 produces more efficient feed. The utilization of probiotics has been shown to enhance the health of ducks by the augmentation of non-pathogenic bacterial populations, including *Lactobacillus* and *Bifidobacteria*, while concurrently reducing the number of pathogenic bacteria such as *Escherichia coli* (Li et al., 2011; Plaza-Diaz et al., 2019; Khabirov et al., 2022). The augmentation of enzyme activity in the small intestine of ducks can be attributed to the existence of non-pathogenic bacterial colonies, which is altered by probiotic supplementation. Reducing feed intake is most likely due to the help of enzymes produced by *Bacillus subtilis* FNCC 0059 as probiotics in the digestive tract. *Bacillus subtilis* produces extracellular digestive enzymes (Li et al., 2014; Abd El-Moneim and Sabic, 2019), which can improve nutrient digestion. Previous studies have demonstrated that the administration of probiotics to ducks can lead to an augmentation in the activity of digestive enzymes inside the small intestine (Khattab et al., 2021). This, in turn, contributes to the enhancement of digestive system functionality and an increase in the digestibility of feed (Sun et al., 2022; Siti et al., 2023). According to Khattab et al. (2021), the inclusion of probiotics in the diet of ducks resulted in the increased activity of digestive enzymes, including amylase, lipase, and protease, within their small intestines, as compared to those not administered with probiotics. Enzymes play a vital role in the process of hydrolyzing complicated nutrients into more readily assimilable forms, hence facilitating efficient absorption within the duck's digestive system.

The inclusion of probiotic *Bacillus subtilis* FNCC 0059 had a statistically significant effect (p<0.05) on daily body weight gain (g/bird/d) and total body weight gain (g) (Table 3). This indicates that the male Bayang ducks obtained the available and necessary nutrients from the feed administrated with probiotic for growth. Body weight gain is an indicator for the efficiency of poultry in changing their feed. If the feed intake is high but needs to be followed by an appropriate weight gain, it indicates inefficiency in the ration (Skinner-Noble and Teeter, 2004). The occurrence of weight gain was closely correlated with diet consumption. The findings of this study show that the administration of probiotic *Bacillus subtilis* FNCC 0059 has the potential to decrease feed consumption while maintaining body weight gain. The increased in feed absorption can be attributed to the biological capacity of probiotics to generate digestive enzymes, including protease, cellulase, and lipase (Khattab et al., 2021). Thus, the body's nutrients for tissue growth and energy are more than those come out through faces. Lokapirnasari et al. (2022), reported that giving probiotics to Peking ducks increased body weight gain.

Table 2: The average total feed intake and daily feed intake of male Bayang ducks administered probiotic *Bacillus subtillus* FNCC 0059.

Bacillus subtilis FNCC 0059 dose (CFU/ml)	Total feed intake (g)	Daily feed intake (g/bird/d)
0	3860.85^{a}	110.31^{a}
$76x10^{6}$	3810.38^{ab}	108.87^{ab}
$69x10^{8}$	3760.87^{b}	107.45^{b}
$65x10^{10}$	3558.62^{c}	101.67^{c}
$53x10^{12}$	3506.27^{c}	100.18^{c}
SE	27.98	0.80

Note: Significant effect (P<0.05) among treatments are indicated by different superscripts in the same column. SE stands for Standard Error.

Table 3: The average total body weight gain, daily body weight gain, and feed conversion of male Bayang ducks administered probiotic *Bacillus subtillus* FNCC 0059.

Bacillus subtilis FNCC 0059 dose (CFU/ml)	Total body weight gain (g)	Daily body weight gain (g/bird/day)	Feed conversion
0	803.34^{c}	22.95^{c}	4.86^{a}
$76x10^{6}$	813.78^{c}	23.25^{c}	4.74^{ab}
$69x10^{8}$	854.69^{b}	24.42^{b}	4.42^{b}
$65x10^{10}$	879.18^{ab}	25.12^{ab}	4.07^{c}
$53x10^{12}$	897.31^{a}	25.64^{a}	3.93^{c}
SE	12.18	0.35	0.11

Note: Significant effect (P<0.05) among treatments are indicated by different superscripts in the same column. SE stands for Standard Error.

Feed conversion was significantly (p<0.05) affected by the probiotic *Bacillus subtilis* FNCC 0059 treatment (Table 3). Feed conversion decreases with the inclusion of probiotics, probably due to the role of probiotics in digestion improvement, which in turn can increase the absorption of food nutrients. Increased absorption of the consumed diet will have a positive effect on body weight gain and feed intake, both of which are closely related to feed conversion. The efficiency of feed utilization is closely linked to both feed intake and body weight increase (Patience et al., 2015, Wen et al., 2018). The concept of feed efficiency refers to the capacity of diets ingested at a given timeframe to gen-

erate the body weight of an animal concurrently (Yamin, 2008). A lower feed conversion value corresponds to improved feed efficiency, whereas a higher feed conversion value is associated with reduced feed efficiency (Wen et al., 2018). Feed conversion can serve as a means to exemplify the level of efficiency in production. According to Khattab et al. (2021) and Zhang et al. (2022) the administration of probiotics has been associated with improved feed efficiency and a reduction in dietary protein content.

The administration of probiotics had a significant impact ($p<0.05$) on the final body weight of male Bayang duck (Table 4). The observed increase in the final body weight of male Bayang ducks due to probiotic administration can be attributable to the enzymatic help of *Bacillus subtilis* FNCC 0059. It helps the digestive process and increases the absorption of food ingredients. This can be seen from the decrease in feed intake with still have increased body weight gain. Previous researchers reported that giving probiotics can increase the body weight of ducklings (Bidura et al., 2019; Daud et al., 2019).

Table 4: The average initial body weight and final body weight of male Bayang ducks administered probiotic *Bacillus subtillus* FNCC 0059.

***Bacillus subtilis* FNCC 0059 dose (CFU/ml)**	**Initial body weight (g)**	**Final body weight (g)**
0	117.66	921.00^{c}
$76x10^{6}$	118.15	931.93^{c}
$69x10^{8}$	117.55	972.24^{b}
$65x10^{10}$	118.50	997.68^{ab}
$53x10^{12}$	117.43	1014.74^{a}
SE	0.54	12.28

Note: Significant effect ($P<0.05$) among treatments are indicated by different superscripts in the same column. SE stands for Standard Error.

CONCLUSION

The administration of probiotic *Bacillus subtilis* FNCC 0059 at a dose of $65x10^{10}$ CFU/ml can improve the performance and feed efficiency of male Bayang ducks, so it can used in the intensive development of duck farming. This dose was found equally effective as that of higher dose ($53x10^{12}$) to enhance performance of growing ducks. These findings provide insight and further validate that probiotic *Bacillus subtilis* FNCC 0059 supplementation can improve the performance and feed efficiency of ducks.

ACKNOWLEDGMENTS

The author wishes to thank Andalas University's Research Centre and Community Engagement Service (LPPM). This research was supported by the Beginner Lecturer Research Scheme, contract number T/51/UN16.19/PT.01.03/Pangan-RDP/2023.

CONFLICT OF INTEREST

There are no conflicts of interest for the work reported in this article

NOVELTY STATEMENT

To date, there have been no reports concerning the response of male Bayang duck supplemented with a probiotic *Bacillus subtilis* FNCC 0059. The purpose of this study is to address the subject of how male Bayang duck performance is affected by the probiotic *Bacillus subtilis* FNCC 0059.

AUTHOR'S CONTRIBUTION

Zurmiati was involved in all phases of the investigation, including research design, experiment implementation, sample examination, data analysis, paper drafting, and revision. Wizna took part in the research and helped with manuscript review and editing. Ade Trisna and Ridho Kurniawan Rusli handled the investigation, data analysis, and review. Yelsi Listiana Dewi and Ulvi Fitri Handayani contributed to the writing of the original draft, and methodology. The text was coauthored by all authors, who also reviewed the statistical analysis and gave their approval for the publishing of the edited version.

REFERENCES

Abd El-Moneim AE and Sabic EM (2019). Beneficial effect of feeding olive pulp and *Aspergillus awamori* on productive performance, egg quality, serum/yolk cholesterol and oxidative status in laying Japanese quails. J. Anim. Feed Sci., 28: 52–6. https://doi.org/10.22358/jafs/105537/2019

Bidura IGNG, Siti NW, Candrawati DPMA, Puspani E, and Partama IBG (2019). Effect of probiotic Saccharomyces spp. On duck egg quality characteristics and mineral and cholesterol concentrations in eggshells and yolks. Pakistan J. Nutr., 18 (11): 1075-1083. https://dx.doi.org/10.3923/pjn.2019.1075.1083

BPS (2022). Statistics Indonesia. Central Bureau of Statistics. Jakarta. Available at: https://www.bps.go.id publication/2022/02/25/0a2afea4fab72a5d052cb315/statistikindonesia-2022.html

Daud M, Yaman MA, and Zulfan (2019). The Effects of Functional Feed Additive Probiotic and Phytogenicin Rations on The Performance of Local Ducks. IOP Conf. Series: Earth Environ. Sci. 372 (2019) 012061. https://doi.org/10.1088/1755-1315/372/1/01206

Duanis-Assaf D, Steinberg D, Shemesh M (2020). Efficiency of *Bacillus subtilis* metabolism of sugar alcohols governs its probiotic effect against cariogenic *Streptococcus mutans*. Artificial Cells, Nanomed. Biotechnol., 48 (1): 1222–1230.

https://doi.org/10.1080/21691401.2020.1822855
Guo M, Hao G, Wang B, Li N, Li R, Wei L and Chai T (2016). Dietary Administration of *Bacillus subtilis* Enhances Growth Performance, Immune Response and Disease Resistance in Cherry Valley Ducks. Front. Microbiol. 7:1975. https://doi.org/10.3389/fmicb.2016.01975
Khabirov A, Avzalov R, Tsapalova G, Andreeva A and Basharov A (2022). Effect of a probiotic containing *Lactobacilli* and *Bifidobacteria* on the metabolic processes, litter microbiocenosis, and production indicators of broiler Pekin ducklings. Vet. World., 15(4): 998-1005. https://doi org/10.14202/vetworld.2022.998-1005
Khattab AAA, El Basuini MFM, El-Ratel IT, and Fouda SF (2021). Dietary probiotics as a strategy for improving growth performance, intestinal efficacy, immunity, and antioxidant capacity of white Pekin ducks fed with different levels of CP. Poult. Sci., 100:100898. https://doi.org/10.1016/j.psj.2020.11.067
Kusnadi E F. Rahim (2009). Effect of floor density and feeding system on the weight of bursa of fabricius and spleen as well as the plasma triiodothyronine level of Bayang duck. Pakistan J. Nut. 8 (11): 1743-1746
Li C, Li Y, Li S, Che S, Liu G, Deng X, Chang W, Cai, H (2022). *Bacillus subtilis* Protects the Ducks from Oxidative Stress Induced by Escherichia coli: Efficacy and Molecular Mechanism. Antioxidants, 11: 1951. https://doi.org/10.3390/antiox11101951
Li WF, Bai J, Li YL, Qin Y, Yu DY (2014). Effects of *Bacillus subtilis* on meat quality, nutrient digestibility and serum biochemical parameters of broilers. Chinese J. Vet. Sci., 34 (10): 1682-1685.
Li WF, Rajput IR, Xu X, Li YL, Lei J, Huang Q and Wang MQ (2011). Effects of Probiotic (*Bacillus subtilis*) on Laying Performance, Blood Biochemical Properties and Intestinal Microflora of Shaoxing Duck. Int. J. Poult. Sci. 10 (8): 583-589. https://doi.org/10.3923/ijps.2011.583.589
Lokapirnasari WP, Agustono B, Al Arif MA, Maslachah L, Chandra EH, Yulianto AB (2022). Effect of probiotic and Moringa oleifera extract on performance, carcass yield, and mortality of Peking duck, Vet. World., 15(3): 694-700. https://doi.org/10.14202/vetworld.2022.694-700
Mehdi Y, Létourneau-Montminy MP, Gaucher ML, Chorfi Y, Suresh G, Rouissi T, Brar SK, Côté C, Ramirez AA and Godbout S (2018). Use of antibiotics in broiler production: Global impacts and alternatives. Anim. Nutr., 4(2): 170-178. https://doi.org/10.1016/j.aninu.2018.03.002
Naumova NB, Alikina TY, Zolotova NS, Konev AV, Pleshakova VI, Lescheva NA, Kabilov (2021). MR. *Bacillus*-Based Probiotic Treatment Modified Bacteriobiome Diversity in Duck Feces. Agriculture., 11: 406. https://doi.org/ 10.3390/agriculture11050406
Ojediran TK, Fasola MO, Oladele TO, Onipede TL and Emiola IA (2017). Growth performance, flock uniformity and economic indices of broiler chickens fed low crude protein diets supplemented with lysine. Archiv. Zoot., 66 (256): 543-550. https://www.doi.org/10.21071/AZ.V66I256.2770
Patience JF, Rossoni-Serão MC and Gutiérrez NA (2015). A review of feed efficiency in swine: biology and application. J. Anim. Sci. Biotechnol., 6 (33): 2-19. https://doi.org/10.1186/s40104-015-0031-2
Plaza-Diaz J, Ruiz-Ojeda FJ, Gil-Campos M, and Gil A (2019). Mechanisms of Action of Probiotics. Adv. Nutrit., 10: S49–S66. https://doi.org/10.1093/advances/nmy063
Ralahalu TN, Latupeirissa CCE, Maks A, Tukalpaly (2020). Carcass weight of broiler given coconut milky juice and brown sugar water as dringking water. Agrinimal, 8 (1): 39-43. Available at: https://ojs3.unpatti.ac.id/index.php/agrinimal/article/view/2241/1948
Roth N, Käsbohrer A, Mayrhofer S, Zitz U, Hofacre C, and Domig KJ (2019). The application of antibiotics in broiler production and the resulting antibiotic resistance in *Escherichia coli:* A global overview. Poult. Sci., 98(4): 1791-1804. https://doi.org/10.3382/ps/pey539
Rusfidra, Heryandi Y, Jamsari, dan Rahman EY (2013). Variasi Genetik Itik Bayang Berbasis Marka Mikrosatelit Pada Lokus AY287 dan Lokus AY283. Sains Peternakan, 11 (2): 91-98. Available at: https://jurnal.uns.ac.id/Sains-Peternakan/article/view/4848
Siti NW, Bidura IGNG, Puspani E, nad Sukasana IW (2023). Effect of Moringa leaves fermented by probiotics (Saccharomyces spp.) on abdominal fat and pathogenic bacteria in the intestines of ducks. World J. Biol. Pharm. Health Sci., 14(1): 288–293. https://doi.org/10.30574/wjbphs.2023.14.1.0199
Skinner-Noble D.O, Teeter R.G (2004). Components of feed efficiency in broiler breeding stock: The use of fasted body temperature as an indicator trait for feed conversion in broiler chickens. Poult. Sci., 83(4): 515–520. https://doi.org/10.1093/ps/83.4.515
Steel RGD, and Torrie JH (1991). Principles and Procedures of Statistics. Mc. Graw-Hill Book Co. Inc. Pub. Ltd, London.
SunH,GuT,LiG,ChenL,TianY,XuW,ZengT,LuL(2022).Effects of Compound Probiotics on Growth Performance, Serum Biochemical and Immune Indices, Antioxidant Capacity, and Intestinal Tissue Morphology of Shaoxing Duck. Animals, 12, 3219. https://doi.org/10.3390/ ani12223219
Wen C, Yan W, Zheng J, Ji C, Zhang D, Sun C, and Yang N (2018). Feed efficiency measures and their relationships with production and meat quality traits in slower growing broilers. Poult. Sci., 97 (7): 2356-2364. https://doi.org/10.3382/ps/pey062
Yamin M (2008). Pemanfaatan Ampas Kelapa dan Ampas Kelapa Fermentasi dalam Ransum Terhadap Efisiensi Ransum dan Income Over Feed Cost Ayam Pedaging. J. Agroland. 15 (2) : 135-139, Juni 2008 ISSN hal : 1854- 641.
Yang J, Huang K, Wang J, Wu D, Liu Z, Yu P, Wei Z, Chen F (2020). Combined use of *Bacillus subtilis* yb-114,246 and *Bacillus licheniformis* yb-214,245 improves body growth performance of Chinese Huainan Partridge Shank chickens by enhancing intestinal digestive profiles. Probiotics Antimicrob. Protein., 13: 327–342. https://doi.org/10.1007/s12602-020-09691-2
Zhang Q, Li J, Wang G, Wang L, Zhang Z, Fang Z, Lin Y, Xu S, Feng B, Zhuo Y, Hua L, Jiang X, Zhao X, Wu D, and Che L (2022). The replacement of bacitracin methylene disalicylate with *Bacillus subtilis* PB6 in the diet of male Cherry Valley Ducks reduces the feed conversion ratio by improving intestinal health and modulating gut microbiota. Poult. Sci., 101:102155. https://doi.org/10.1016/j.psj.2022.102155
Zurmiati, Wizna, Abbas H, Mahata ME, Fauzano R (2017a). Effect of *B. amyloliquefaciens* as a probiotic on growth performance parameters of Pitalah ducks. Int. J. Poult. Sci., 16(4): 147-153. https://doi.org/10.3923/ ijps.2017.147.153
Zurmiati, Wizna, Abbas MH, Mahata ME (2017b). Effect of the balance of energy and protein in rations given to pitalah

ducks along with the probiotic *B. amyloliquefaciens* on the live weight, percentage of carcass, percentage of abdominal fat and income over feed cost. Int. J. Poult. Sci., 16(12): 500-505. https://doi.org/10.3923/ijps.2017.500.505