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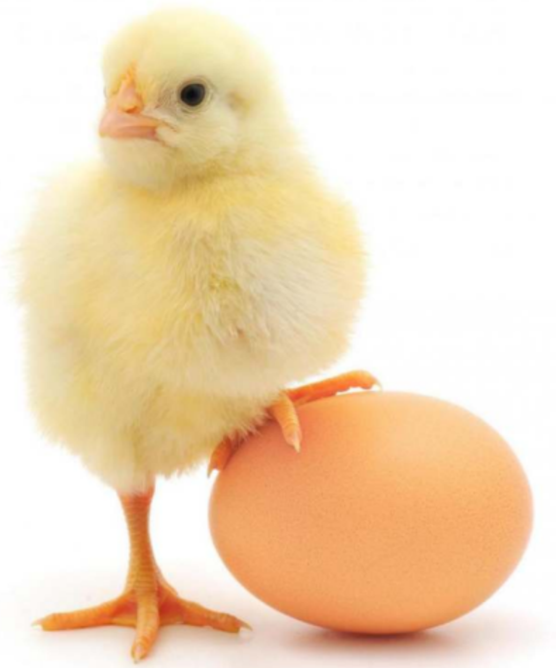

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Research Article

Effect of the Balance of Energy and Protein in Rations Given to Pitalah Ducks along with the Probiotic *Bacillus amyloliquefaciens* on the Live Weight, Percentage of Carcass, Percentage of Abdominal Fat and Income Over Feed Cost

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Abstract

Background and Objective: The Pitalah duck is one of Indonesia's native ducks that has a uniform physical form and a genetic composition that is well adapted to environmental conditions. However, the Pitalah duck has a high feed conversion, so it is necessary to improve its feed efficiency. The purpose of this study was to determine the effect of the balance of energy and protein in the diet, which includes a probiotic, *Bacillus amyloliquefaciens* (*B. amyloliquefaciens*), on the performance of the Pitalah duck. **Methodology:** In this study a 3×3 group-randomized factorial design was employed that included 2 factors with 3 groups of body weight as replicates. Factor A is the energy level (E1: 2800, E2: 2700 and E3: 2600 kcal kg^{-1}) and factor B is the protein level (P1: 18, P2: 17 and P3: 16%). Live weight, percentage of carcass, percentage of abdominal fat and income over feed cost were the measured variables. **Results:** The results showed that the combination of energy level and protein level and an interaction between these factors had a significant impact (p<0.05) on the live weight, percentage of carcass, percentage of abdominal fat and increased income over feed cost. **Conclusion:** The combination of energy and protein, along with administering 2000 ppm of the probiotic *B. amyloliquefaciens*, can improve the efficiency of the ration while decreasing the need for duck ration energy by 3.57% and decreasing the protein requirement by 5.56% at an energy level of 2700 kcal kg^{-1} and 17% protein in the ration.

Key words: *Bacillus amyloliquefaciens*, feed efficiency, Pitalah duck, probiotic, the balance of energy and protein

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The Pitalah duck is native to Indonesia and exhibits a uniform physical form and genetic composition that is well adapted to environmental conditions. The Pitalah duck has distinctive characteristics from other Indonesian ducks and has a wealth of genetic resources for local Indonesian livestock. Duck is a widely utilized type of poultry after chicken[1]. In the poultry industry, cost savings on rations is a goal of breeders to achieve maximum profit. The ration is perceived as a burden by breeders, especially the provision of quality ration materials with guaranteed continuity and reasonable price.

Information about poultry nutrition is important for improving the economic efficiency of feeding rations. The nutrient requirements for growth are usually associated with various daily nutrients necessary to support the maximum weight gain of the livestock. The most basic and necessary information to know is energy and protein requirements for every animal species and every life stage. Furthermore, the efficient use of rations supporting maximum growth and the balance between the nutrient content (such as essential amino acids, vitamins and essential inorganic elements) in the ration should be determined. Economically, the ration should be structured in such a way to achieve maximum growth efficiency and affordability[2].

A duck's ration consumption will decrease when a ration has higher energy content. If the content of other food substances, especially proteins are not considered, there will be deficiencies that adversely affect productivity. The level of protein consumption is determined by the level of ration consumption. Thus, if the ration has high energy content, then it must be followed by high protein content. If the ration has a low energy level, then it should be followed by low protein content as well. The appropriate balance of energy and protein will produce maximum productivity and performance. Other food substances contained in the ration cannot be digested entirely by poultry. To achieve the necessary feed efficiency there needs to be a way for the protein used in the ration to be digested optimally, so it can give the optimal effect on productivity. One way to achieve this outcome is to add probiotics. Probiotics can change the movement of mucin and microbial populations in the small intestine of the chicken. Therefore, probiotics can improve the health and function of intestines, increase the absorption of nutrients and improve the microflora composition of the cecum[3].

Probiotics help facilitate digestion in poultry, so that it is easier to digest and increase the capacity of digestibility to obtain more nutrients for growth and production[4]. Though to aid digestion, enzymes produced by probiotic bacteria will petrify the absorption of food substances and consumed rations are much more likely to be incorporated into the tissues rather than being excreted in the feces. *Bacillus amyloliquefaciens* bacteria have two functions to help in that regard, they can be used as a fermentation inoculum and as a probiotic. *Bacillus amyloliquefaciens* effectively reduces the content of crude fiber of tapioca by-products (onggok)[5] and bran[6]. *Bacillus amyloliquefaciens* can be used as a probiotic, having a positive influence on the performance and morphology of the intestines as well as suppressing the growth of pathogenic bacteria[7-9]. *Bacillus amyloliquefaciens* can be used as a probiotic because it meets the requirements for probiotics, such as production of heat-resistant endospores, the ability to degrade xylan and carbohydrates, growth at 40°C and pH 6, resistance to pasteurization and ability to grow in highly concentrated saline solution (10%)[10]. *Bacillus amyloliquefaciens* can survive in the small intestine of laying chickens for 32 days, with the number of colonies at 18×10^7 CFU g^{-1} in fresh intestine, can decrease feed consumption by 0.9% and increase the egg period by 5.39%[11]. The administration of *B. amyloliquefaciens* to the drinking water of starter Pitalah ducks for 6 weeks decreased feed consumption and improved the efficiency of the ration, with a >15% decrease in feed conversion due to an increase in the small intestinal CFU and acidity. This, in turn, resulted in an increase in the income over feed cost (IOFC) but had no influence on weight gain[12]. Based on that described above, the present research was conducted to determine the balance of energy and protein in the ration of Pitalah ducks that were given 2000 ppm of *B. amyloliquefaciens* probiotics and determined the influence on the live weight, percentage of carcass, percentage of abdominal fat and income over feed cost of Pitalah ducks.

MATERIALS AND METHODS

Duck: The current study used Indonesian Pitalah ducks. As many as 135 1-day-old male ducks were obtained from Payakumbuh, West Sumatra, Indonesia, purchased from duck farms. Ducks were housed in 80×60×60 cm box cages, with 5 ducks/box. Each box was supplied with a 60-W incandescent lamp for light and warmth. Food and drinking water were supplied *ad libitum* for the entire 8 week study period. Rations were comprised of corn flour, bran, fish flour, soybean meal, bone meal and top mix. The nutrient (%) and metabolic energy (kcal kg^{-1}) contents of the bird feed are shown in Table 1.

Table 1: Composition, nutrient content and metabolic energy of Pitalah duck feed

	Composition of the treatment material (%)								
Feed materials (%)	E1P1	E1P2	E1P3	E2P1	E2P2	E2P3	E3P1	E3P2	E3P3
Corn	52.50	55.00	56.50	48.00	50.50	52.00	42.50	45.50	47.00
Bran	18.00	19.00	19.50	22.00	23.00	24.00	28.00	27.00	28.00
Fish flour	14.00	12.00	11.50	14.00	13.00	11.00	14.00	12.00	10.50
Soybean meal	14.50	12.50	11.00	14.50	12.00	11.50	14.00	13.50	12.50
Bone meal	0.50	1.00	1.00	1.00	1.00	1.00	1.50	1.50	1.50
Top mix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Crude protein	18.40	17.02	16.43	18.42	17.36	16.41	18.37	17.35	16.47
Crude fat	5.21	5.33	5.40	5.58	5.71	5.84	6.17	6.08	6.20
Crude fiber	5.48	5.22	5.54	5.95	6.00	6.10	6.66	6.51	6.60
Calcium	0.80	0.84	0.81	0.93	0.87	0.80	0.93	0.99	0.93
Phosphorus	0.46	0.49	0.48	0.53	0.50	0.48	0.53	0.57	0.55
Energy metabolism (kcal kg^{-1})	2811.43	2804.15	2810.24	2728.42	2736.65	2734.18	2632.83	2646.90	2645.83

Table 2: Average live weight, percentage of carcass, percentage of abdominal fat and IOFC of Pitalah ducks treated with difference of the balance energy and protein in rations for 8 weeks

Energy metabolism (kcal kg^{-1})	Protein (%)	Live weight (g/bird)	Percentage of carcass	Percentage of abdominal fat	IOFC ($/bird)
2800	18	1172.60^{a}	58.81^{a}	0.95^{a}	0.88
	17	1169.28^{a}	58.68^{a}	0.93^{ab}	0.95
	16	944.77^{b}	49.46^{b}	0.87^{b}	0.31
2700	18	1168.72^{a}	58.65^{a}	0.91^{ab}	0.88
	17	1168.33^{a}	58.52^{a}	0.89^{ab}	0.96
	16	884.39^{b}	45.79^{c}	0.67^{d}	0.14
2600	18	887.35^{b}	46.89^{bc}	0.74^{c}	0.43
	17	870.89^{b}	45.45^{c}	0.59^{e}	0.46
	16	857.32^{b}	44.58^{c}	0.51^{f}	0.24

$^{a-f}$Values in the same column with different letters are significantly different ($p<0.05$)

Experimental design: The research employed a 3×3 randomized factorial design that included 2 factors with 3 groups of body weight as replicates. Factor A is the energy level (2800, 2700 and 2600 kcal kg^{-1}) and factor B is the protein level (18, 17 and 16%) and was used to distinguish between groups. The treatments were as follows: EIP1 ration (energy: 2800 kcal kg^{-1}, protein: 18%), EIP2 (energy: 2800 kcal kg^{-1}, protein: 17%), EIP3 (energy: 2800 kcal kg^{-1}, protein: 16%), E2P1 (energy: 2700 kcal kg^{-1}, protein: 18%), E2P2 (energy: 2700 kcal kg^{-1}, protein: 17%), E2P3 (energy: 2700 kcal kg^{-1}, protein: 16%), E3P1 (energy: 2600 kcal kg^{-1}, protein: 18%), E3P2 (energy: 2600 kcal kg^{-1}, protein: 17%) and E3P3 (energy: 2600 kcal kg^{-1}, protein: 16%). Each treatment was given 2000 ppm of *B. amyloliquefaciens* probiotic. Live weight, percentage of carcass, percentage of abdominal fat and income over feed cost were the measured variables. Data were collected by weighing each Pitalah duck at the end of the study.

Statistical analysis: All data were analyzed by analysis of variance, using a general linear model procedure in SPSS v.16.0 software and differences among treatments were evaluated by two-way ANOVA. Duncan's multiple range test (DMRT) was used for comparison of means of treatments[13].

RESULTS AND DISCUSSION

The effect of the balance of energy and protein in rations given to Pitalah ducks with the probiotic *B. amyloliquefaciens* on live weight, percentage of carcass, percentage of abdominal fat and income over feed cost, Table 2 shows that at the end of the 8-week study period, it is observed that administration of 2000 ppm of *B. amyloliquefaciens* probiotic can increase the efficiency of the ration by 2700 kcal kg^{-1} energy and 17% protein. Significant differences ($p>0.05$) in live weight, percentage of carcass and percentage of abdominal fat can increase the income over feed cost of Pitalah duck.

Live weight: Statistical analysis showed that the interaction between energy level and protein level was significant ($P<0.05$) on live weight, so data were further analyzed using the Duncan's multiple range test (DMRT). Table 2 shows the weight range of live Pitalah ducks for 8 weeks of experimental treatment is 1172.60-857.32 g/bird. The results showed a decrease in the live weight consistent with decreased energy levels and protein in the ration. The live weight of ducks was lowest at energy levels of 2600 kcal kg^{-1} and 16% protein. The treatment with an energy level of 2800 kcal kg^{-1} and 18% protein exhibited the highest live weight but was not significantly different ($p>0.05$) from the treatments with an energy level of 2800 kcal kg^{-1} and 17% protein, energy level of 2800 kcal kg^{-1} and 16% protein, energy level of 2700 kcal kg^{-1} and 18% protein and energy level of 2700 kcal kg^{-1} and 17% protein. This is due to the provisional effects of different energy levels and proteins on feed consumption. Live weight is influenced by feed consumption, energy and protein content[14]. Nutrients are used to meet the basic necessities for the growth of organs and tissues. There is a relationship between growth and feed consumption[15]. Utilization of feed that is efficient in poultry is not only seen from the aspect of growth but also should be considered from the efficient use of protein and energy levels in the diet to produce maximum live weight, carcass weight and low abdominal fat content[16]. Feed consumption is largely determined by the protein content in the diet because it is closely related to the proportion of essential amino acid availability needed by that particular livestock[17-19]. Feed consumption can be influenced by various factors, including the quality of feed given and the nutrient content contained in the feed[20]. The amount of feed consumption of animals with high protein levels and high energy metabolism tend to decrease and conversely, feed consumption will increase if protein and energy levels decrease[20-22].

Percentage of carcass: Statistical analysis showed a significant interaction between energy level and protein level ($p<0.05$) on the percentage of carcass, so data were further analyzed using the Duncan's multiple range test (DMRT). Table 2 shows percentage of carcass of Pitalah ducks for 8 weeks of the experiment ranging from 58.81-44.58%. The percentage of carcass declined along with low energy and protein in the ration. The energy level of 2800 kcal kg^{-1} and 18% protein treatment exhibited the highest percentage of carcass but was not significantly different ($P>0.05$) from the treatments of an energy level of 2800 kcal kg^{-1} and 17% protein, energy level 2800 kcal kg^{-1} and 16% protein, energy level 2700 kcal kg^{-1} and 18% protein and energy level 2700 kcal kg^{-1} and 17% protein. However, the treatments with an energy level of 2700 kcal kg^{-1} and 16% protein, energy level 2600 kcal kg^{-1} and 18% protein, energy level 2600 kcal kg^{-1} and 17% protein and energy 2600 kcal kg^{-1} and 16% protein in rations had significantly different ($p<0.05$) effects on the percentage of carcass. The results showed a decrease in the percentage of carcass consistent with decreased energy levels and protein in the ration. The protein content in the ration greatly affects the percentage of carcass. Increasing the protein content in ration can significantly increase the carcass weight and percentage of carcass[23]. Moreover, the percentage of carcass is also influenced by body weight gain. The growth exhibited by the body weight gain will affect the live weight result and will affect percentage of carcass[24]. Carcass weight follows the live weight. Higher live weight will produce a high carcass weight and low live weight will produce low carcass weight. Differences in percentage of carcass are influenced by the live weight diversity[25].

The average percentage of carcass was 58.52% after 8 weeks of study period in the treated of energy level 2700 kcal kg^{-1} and protein 17% in the ration given 2000 ppm of *B. amyloliquefaciens* probiotic. The results of this study were higher than those reported elsewhere. The percentage of carcass of duck age 5-10 weeks ranged between 52.0 and 55.7%[26]. The percentage of carcass of another local Indonesian duck (Cihateup) ranged from 58.07-58.43%[27].

Percentage of abdominal fat: Statistical analysis showed that the interaction between energy level and protein level had a significant ($p<0.05$) effect on the percentage of abdominal fat, so further analysis was conducted using the Duncan's multiple range test (DMRT). Table 2 shows the percentage of abdominal fat of Pitalah ducks for 8 weeks of the research ranging from 0.95-0.51%. The percentage of abdominal fat continued to decrease with low energy and protein in the ration. The highest percentage of abdominal fat was found at energy levels of 2800 kcal kg^{-1} and protein 18% in the rations. However, this was not significant different ($p>0.05$) from the treatments of an energy level of 2800 kcal kg^{-1} and 17% protein, energy level 2800 kcal kg^{-1} and 16% protein, energy level 2700 kcal kg^{-1} and 18% protein and energy level 2700 kcal kg^{-1} and 17% protein. Treatment with an energy level of 2700 kcal kg^{-1} and 16% protein, energy level 2600 kcal kg^{-1} and 18% protein, energy level 2600 kcal kg^{-1} and 17% protein and energy level 2600 kcal kg^{-1} and 16% protein in the ration had significantly different ($p<0.05$) effects on the percentage of abdominal fat. The results showed a decrease in the percentage of abdominal fat consistent with decreased energy levels and protein levels in the ration. This is because the treatment with different energy levels and protein contents in the diet and the administration of 2000 ppm of *B. amyloliquefaciens* probiotic affects the availability of energy for the abdominal fat increase, thus influencing the percentage of abdominal fat produced. The growth of fatty tissue is determined by the presence or absence of excess metabolic energy in the body[28]. The energy used in the body comes from carbohydrates and fat reserves.

Sources of carbohydrates in the body are able to produce body fat stored around the internal organs and under the skin[29].

The average percentage of abdominal fat in the treatment with an energy level of 2700 kcal kg^{-1} and 17% protein in the ration that was also given 2000 ppm of *B. amyloliquefaciens* probiotic for 8 weeks was 0.89%. The results of this study were lower than those previously reported[30], with the average abdominal fat of male ducks 8 weeks old ranging from 1.04 to 1.68%. The percentage of abdominal fat of local male ducks aged 8 weeks that were given fermented enceng gondok (eichornia crassipes) was 0.63%[31].

Income over feed cost: Table 2 shows that IOFC of ducks increased from 2700-2800 kcal kg^{-1} and proteins from 17-18%. The highest IOFC value was observed in the treatment with an energy level of 2700 kcal kg^{-1} and 17% protein ($0.96/bird). This is because of the low feed consumption and high body weight gain compared to other treatments. This resulted in the increase in IOFC, which is calculated based on the cost of feed and the selling price of each duck. The IOFC is the difference between farm income and feed cost[32]. Revenue is the multiplication between the production of the farm and the selling price. The factors that affect IOFC are feed price, feed consumption, final body weight, feed conversion and mortality[33]. Treatments with an energy level of 2700 kcal kg^{-1} and 16% protein, energy 2600 kcal kg^{-1} and 18% protein, energy 2600 kcal kg^{-1} and 17% protein and energy 2600 kcal kg^{-1} and 16% protein resulted in high consumption. However, this was not accompanied by high body weight gain, so the IOFC decreased. This is because of a significant decrease in energy and protein levels in the ration. This study can be applied to the duck growth period with energy at 2700 kcal kg^{-1} and 17% protein in the rations. However, 2600 kcal kg^{-1} energy and 16% protein were not able to improve ration efficiency.

CONCLUSION

Administration of 2000 ppm of *B. amyloliquefaciens* probiotic in each treatment could improve the feed efficiency of the Pitalah duck, while decreasing the energy needs of the ration by as much as 3.57% and decreasing the protein needs of the ration by as much as 5.56% with an energy level of 2700 kcal kg^{-1} and 17% protein in the ration.

SIGNIFICANCE STATEMENT

This study revealed that the balance of energy and protein in the rations of Pitalah duck that were given 2000 ppm of *B. amyloliquefaciens* probiotic in each treatment can be beneficial for breeders in arranging the rations of duck feed and provides new information to poultry farms. This study will help researchers uncover the critical areas of energy and protein balance in rations given to Pitalah ducks that include *B. amyloliquefaciens* probiotics over a growth period that many researchers were not able to explore. Thus, a new hypothesis on the balance of energy and protein in the rations of Pitalah ducks may be attained.

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