Buletin Peternakan 42 (1): 8-14, February 2018

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

Bulletin of Animal Science

ISSN-0126-4400/E-ISSN-2407-876X Acredited: 36a/E/KPT/2016
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v42i1.24772

Utilization of Jack Bean (*Canavalia ensiformis*) Meal as a Substitute for Soybean Meal in Diet for Broiler Reared for 35 Days

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Article history
Submitted: 4 May 2017
Accepted: 15 January 2018

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ABSTRACT

This study was aimed to evaluate the utilization of jack bean meal as a substitution of soybean meal in the diets and the effect on broiler performance. A total number of two hundred Lohmann MB 202 Platinum broiler chickens were kept in five weeks rearing period, consisted of three weeks of starter phase (0-3 weeks) and two weeks of finisher phase (3-5 weeks). This study used a completely randomized design with four treatments and five replicates. The dietary treatments were: JB_{0-0} (control ration: basal diet without jack bean meal substitution in starter and in finisher phase), JB_{50-0} (basal diet with jack bean meal substitution in starter phase only), JB_{50-50} (basal diet with jack bean meal substitution in starter and in finisher phase), JB_{0-50} (basal diet with jack bean meal substitution in the finisher phase only). The data obtained were statistically analyzed using analysis of variance and followed with Duncan's multiple-range test for the data with significant difference. The variables measured were: growth performance, carcase yield, visceral organ weight and immune organ. Results showed that the dietary treatment had no effect on performance, carcass yield and commercial cut, visceral organ or immune organs of 35 days old broiler chickens, except for the thymus ($P<0.05$). It can be concluded that as a source of protein, soybean meal can be replaced by jack bean meal up to 50%. Jack bean meal can be given either in starter phase only, in finisher phase only, or in both starter and in finisher phase.

Keywords: Broiler, Carcass, Jack bean meal, Performance, Soybean meal

Introduction

Animal proteins, such as chicken, are needed by the human body because its amino acids can not be replaced by vegetable proteins. In line with that, broiler farms in Indonesia are growing very rapidly. This is because broilers are quickest and efficient in producing animal protein. The demand for chicken meat is very high because it tastes good and the price is more affordable than any other types of meat, such as ruminants. Based on data of DITJENPKH (2017), public consumption of chicken in the period 2015 - 2016 has increased from 4,797 to 5,110 kg/capita.

To support growth, broiler chickens need high-quality feed. One of the dominant feed stuffs in formulating broiler rations is soybean meal, which is a valuable source of vegetable protein. However, in its fulfillment, animal feed companies in Indonesia still have to import 100% of soybean meal. Imports of soybean meal in 2016 have reached 1,994.3 million tons (KEMENDAG, 2017). If the rate of rupiah to US Dollars weakens, this will affect the increase of feed. For farmers, this is very burdensome, because about 70% of total operational costs allocated for feed. If this condition lasts for a long period of time, allowing the level of chicken meat production will decrease due to the number of chicken farming businesses that become bankrupt. Therefore, it is necessary to find alternative feed ingredients that are easy to obtain, its availability is sustainable, with adequate nutrient content and affordable price. Utilization of local feed ingredients becomes a necessity to anticipate the dependence of high price imported feed stuffs. One of the local feed ingredients that potentially could be utilized as a protein source is the jack bean (*Canavalia ensiformis*).

Nowadays, jack bean has become an interesting topic to be studied, because it is believed to be an alternative feed ingrediant of vegetable protein source (Suharsi *et al.*, 2013). Jack bean has spread in several regions of Indonesia, including in the province of Central Java. The area of land for jack bean cultivation reaches 1,590 ha with an average of production 5 tonnes/ha/year (Kasno, 2016).

Jack bean seed has water content 3.8-13.5%, crude protein 22.8-35.3%, crude fiber 4.7-11.4%, crude fat 1.6-12.1%, ash 2.3-5.8%, total starch 24.7-36.9% and energy content 351.3-456.5 kcal/100 g. Jack bean seed contains essential amino acids that also found in soybean meal (Sridhar and Seena, 2006), but in smaller amount. Leucine in jack bean appears to be a major limiting factor. Our previous analysis with leucine data showed that jack bean had an amino acid score (0.29) lower than that of soybean meal (0.40). Jack bean also contains a variety of nutrients that have hipocholesterolemic properties, such as: phenol, isoflavones, niacin, saponins, and fiber. Another advantage of sword bean is its cheaper price and more easy to be cultivated than those of soybean (Primawestri and Rustanti, 2014).

Preliminary study was done by testing the substitution of soybean meal protein by the protein of jack bean meal (JB) at the level of 0, 25, 50, and 75% in rations on chicken performance (Sudarman *et al*., 2017). The results showed that 50% level gave better chicken performance compared to JB protein substitution at the level of 25% or 75%. For that reason, in this study, the ration containing 50% substitution of soybean meal protein by JB protein in broiler rations was used. The aim of present study was to evaluate the effect of soybean meal substitution by jack bean protein as the source of protein on performance, carcass production, visceral and immunity organ of chickens reared for 35 days.

Materials and Methods

This experiment was carried out from September to December 2015 in the the field laboratory of The Department of Animal Nutrition and Feed Technology, Faculty of Animal Science, Bogor Agriculture Institute (IPB) in Bogor. Proximate analysis was conducted at the Laboratory of Research Center for Biological Resources and Biotechnology, IPB.

Two hundred mixed-sex DOC Lohmann MB 202 Platinum broiler chickens were placed randomly at 20 cages, each containing 10 birds. The dimension of cage was 1.5 x 1.5 x 1.5 m^3 with rice husk litter provided with a 60 watt heating lamp, and container for feed and drinking water.

Experimental diets (Table 1) were formulated based on broiler nutrient requirements according to Leeson and Summers (2005). Jack beans used were purchased from Cibatok, Bogor. The procedure for making jack bean meal (JBM) was as follow: jack beans were soaked with water at room temperature for 24 hours then boiled for 20 minutes. After that, the jack beans skin were completely peeled and the jack bean is put into the oven at 50°C for 24 hours. Jack beans were then ground and stored in a dry bag to prevent oxidation (modification of Ekanayake *et al*., 2007).

Substitution of soybean meal protein by JBM protein was done up to 50% level. Here is the calculation of substitution of soybean protein by jack bean protein in the ration:

$$\text{JBM proportion in the diets} = \frac{\text{SBM protein proportion in the diets (\%)}}{\text{JBM protein content in the diets (\%)}} \times 100\%$$

Chickens were reared for 35 days which divided into 2 phases, starter (0-3 weeks) and finisher (3-5 weeks) phases. Feed and drinking water were given *ad libitum*. Body weight and feed intake were measured weekly to obtain initial and final body weight data, weight gain, feed intake and feed conversion during experiment. Multi vitamins (Vitastress) in drinking water was provided after the placement of chicken in the cage and weighing the body weight to reduce stress with the dose of 1 g per 1 liter of drinking water. In addition, the cage temperature was also monitored daily. At the end of rearing period (35 days old), one chicken from each replicate of each treatment was slaughtered and weight of carcass, abdominal fat, internal organs (liver, heart, ampela, pancreas, bile, and kidneys), commercial cuts (wings, thighs, chest, and back), and immune organs (spleen, thymus and bursa fabricius) were measured.

Variables of chicken performance were measured as follows: feed intake, protein intake, weight gain, feed conversion, and efficiency of protein use. Feed intake (g/head): ration consumption was calculated from the difference in the amount of ration given to the remaining feed. Measurement of the rest of the ration is done every week in the morning. Protein intake (g/head): protein intake was calculated by multiplying the feed intake with protein content of the diet. Weight gain (g): the weight gain was obtained from the difference between the final body weight and the initial body weight. Feed conversion: feed conversion was calculated from the ratio between feed intake and body weight gain. Efficiency of protein use: the efficiency of protein use was calculated by comparing the increase in body weight with protein intake (Leeson and Summers, 2001).

Experimental design and data analysis

The experimental design used in this study was a completely randomized design with four treatments and five replicates. The dietary treatments were: JB0-0 (control ration: basal diet without jack bean meal substitution in the starter and finisher phase), JB50-0 (basal diet with jack bean meal substitution in starter phase only), JB_{50-50} (basal diet with jack bean meal substitution in starter and in finisher phase), JB_{0-50} (basal diet with jack bean meal substitution in the finisher phase only).

The data were analyzed using ANOVA using Statistical Package for Social Sciences (IBM SPSS® version 17.0). Duncan multiple range test was used to separate means.

Result and Discussion

Effect of treatment on the performance of broiler

Growth performance is one of the variables that need to be evaluated in determining the successful utilization of non-conventional local feed ingredients. Growth performance data of 35 days old broiler were presented in Table 2.

Feed intake of broiler during rearing period ranged from 2902.28-3087.21 g/head. Based on the data in Table 2, the treatment did not affect

Tabel 1. Feed ingredient and nutrient content of experimental diets

Feed ingredient (%)	JB0		JB50	
	Starter	Finisher	Starter	Finisher
Corn	53.1	56.39	46.65	51.8
Rice bran	3.5	3.07	2.5	1.3
Corn gluten meal	4	4	5.13	5.01
Soybean meal	34.5	31.5	17.25	15.75
Jack bean meal	0	0	24.64	22.5
Crude palm oil	3	3.2	1.55	2.1
DCP (Dicalcium Phospat)	0.4	0.5	0.5	0.5
NaCl (salt)	0.3	0.2	0.3	0.1
$CaCO_3$ (Calcium Carbonat)	1	1	1.18	0.9
Premix[1]	0.2	0.1	0.1	0.1
L-Lysine	0	0.01	0.05	0.01
DL-Methionine	0.1	0.03	0.15	0.03
Total	100	100	100	100
Metabolisable energy (kcal/kg)	3088.55	3128.45	3089.15	3164.76
Crude protein (%)	21.17	20.19	21.19	20.18
- Soybean meal	13.80	12.60	6.90	6.30
- Jack bean meal[3]	0	0	6.90	6.30
- others	7.37	7.60	7.37	7.58
Ether extract (%)	5.47	5.75	4.30	4.82
Crude fiber (%)	2.88	2.82	2.56	2.46
Methionine (%)	0.53	0.44	0.61	0.47
Methionine+cysteine (%)	1.28	1.16	0.97	0.83
Lysine (%)	1.27	1.19	1.25	1.12
Glyserine+serine (%)	0.92	0.87	1.23	1.15
Calcium (%)	0.55	0.57	0.69	0.57
Phosphor (%)	0.30	0.31	0.33	0.31
Na (%)	0.17	0.13	0.36	0.27
Cl (%)	0.23	0.17	0.34	0.21

[1]TOP MIX (PT. Medion); [2]kandungan protein kasar: 40% (Leeson dan Summers, 2005); [3]kandungan protein kasar: 28.02%; EM = 3027 Kkal/kg (hasil analisa Lab Pusat Penelitian Sumberdaya Hayati dan Bioteknologi IPB, 2015).

feed intake. This result indicates that diets containing JB (jack bean meal) did not affect the palatability of diets, either on starter or finisher phases, so that the treatment gave the same effect to the feed intake. The use of JB in the starter period alone has the highest feed intake value whereas the use of JB in the finisher period alone has the lowest feed intake value.

Giving JB in the diets up to 50% did not affect protein intake. The value of feed intake correlated with protein intake value. Situmorang *et al*. (2013) reported that high feed intake cause protein intake was also higher, and vice versa if the feed intake is low then protein intake was also lower. Protein is an essential nutrient for the body because it consists of amino acids while the body can not synthesize itself. The amino acids available on the diets will be utilized for building body proteins or protein skeletal muscle synthesis (Gropper and Smith, 2013).

Treatment had no significant effect on final body weight, weight gain, feed conversion and protein utilization efficiency (Table 2). This clearly indicates that jack bean meal protein can replace 50% of soybean meal protein in broiler diets. Result of our calculation of amino acid score of jack bean seed was 0.21 lower than that of soybean meal, i.e., 0.40. However, this inferior feature of jack bean meal did not cause negative effect to the performance of broiler when given equal to the level of 50% of soybean meal protein. Different results were reported by Akande (2016) that the addition of jack bean up to 15% had no effect on weight gain, but in the addition of 20% signiificantly lowered the weight gain. The difference in the results of this study appears to be more due to differences in pretreatment of jack bean seed. While our previous results showed that broiler performance decreased when 75% of soybean meal protein was substituted by jack bean protein (Sudarman *et al*., 2017).

Giving method of jack bean meal either at starter period only (JB50-0), in whole time (JB50-50) or at finisher period only (JB0-50) had similar effect on the performance variables. This probably because the broilers in all giving methods, up to

Tabel 2. The effect of treatment on performance of 35 day old broiler

Variables	Treatment			
	JB_{0-0}	JB_{50-0}	JB_{50-50}	JB_{0-50}
Feed intake (g/chicken)	3021.14±62.66	3087.21±133.67	2943.43±280.59	2902.28±71.71
Protein intake (g/chicken)	627.13±13.02	641.46±27.77	611.47±58.29	602.92±14.90
Weight gain, g/chicken)	1443.20±81.05	1484.84±64.87	1296.88±69.24	1217.83±79.46
Final body weight (g/chicken)	1486.67±80.83	1526.67±64.29	1340.00±69.28	1260.00±80.00
Feed convertion ratio	2.04±0.11	2.02±0.06	2.20±0.16	2.31±0.11
Protein utilization efficiency	2.30±0.13	2.32±0.07	2.13±0.16	2.02±0.10

JB_{0-0}: starter 0% JB+finisher 0% JB, JB_{50-0}: starter 50% JB+finisher 0% JB, JB_{50-50}: starter 50% JB+finisher 50% JB, JB_{0-50}: starter 0% JB+finisher 50% JB.

35 days old, were still in very fast growth phase. Where according to Goliomytis *et al.* (2003) maximum growth rate is achieved between the ages of 44 and 49 days.

All these variables had similar pattern with the tendency that, eventhough statistically not different, the treatment of JB50-0 had slightly higher values compare to the others. Pesti and Miller (1993) reported that broiler chickens have a high level of sensitivity to convert protein and energy of diet into chicken body components, especially during starter period.

Effect of treatment on carcass production and commercial cuts of broiler aged 35 days

Data of carcass and commercial cut yields of broilers maintained for 35 days are presented in Table 3. The results showed that the treatment did not affect of broiler carcass yield. Conducting experiment with rabbits, Esonu *et al*. (1996) also reported that rations containing 20% of jack bean in rations did not affect the production of rabbit carcasses. The diets prepared in this study were iso-energy and –protein, with the same energy:protein ratio. Pesti and Bakali (1997) reported that there was a close relationship between the ratio of energy and protein to the percentage of carcass. This may explain why the treatment in this study did not affect the percentage of carcasses, as the ratio of energy and protein rations made tended to be equivalent. According to Karaoğlu *et al.* (2014) carcass and commercial cuts yield in broilers were more affected by ages, the carcass and commercial cuts yield were higher when the broilers were slaughtered at older age.

The treatment did not affect the broiler's abdominal fat percentage. This may be due to all factors affecting the percentage of abdominal fat, as Jones and Farrell (1987) reported i.e., age, climate in a region, genetic factors and nutritional quality of feed, in this study were no different. The data in Table 3 shows that the abdominal fat of broiler aged 35 days ranged from 1.07 to 1.41%. The relative weight of abdominal fat is usually about 2 to 3% of broiler body weight (Leeson and Summers, 2005). The smaller abdominal fat weights in this study than those reported by Leeson and Summers (2005) may be due to the genetics of broilers in this study derived from improved breeding results.

Commercial cuts of broiler in this study are presented in the form of percentage of live weight. The treatment did not affect percentage of commercial cuts of broilers. Percentage of wings of broiler aged 35 days ranged from 11.53 to 12.58%. Percentage of thighs and drumsticks in this study ranged 18.04-19.11% and 14.50-15.77%, respectively. Average percentage of broiler back aged of 35 days in this study ranged from 23.07 to 23.93%. The percentage value of breast of broiler maintained for 35 days ranged from 28.89-30.75%. Commercial cuts of the breast is part of carcass which contains many muscle tissue so that its development more influenced by protein (Bahij, 1991). The experimental diets did not affect the breast percentage value, this may indicated that the quality and quantity of protein in all experimental diets were no different. In addition, the breast is slowly mature organ, meaning that its growth and weight continue to increase with the age (Muryanto *et al*., 2002).

Effect of treatment on the weight of visceral organs in broiler age of 35 days

The internal organs measured in the study included liver, heart, stomach, pancreas, bile and kidney. The percentage data of internal organs can be seen in Table 4. Treatment does not affect the percentage of internal organs overall.

The liver is an important organ in the metabolic system. The liver plays a role in the metabolism of absorbed nutrients and produces bile acids and salts. The data in Table 4 shows that the liver percentage range was 2.37-2.69%.

Treatment did not affect the percentage of the liver. The normal liver percentage range was 2.64-3.3% (Putnam, 1991). In this study there was no indication of liver enlargement. Enlargement of the liver can occur due to toxins present in the ration (Nabib, 1987). Thus, the JB used in the ration can be said to contain no toxins that may affect the performance of the liver.

The average percentage of broiler heart in this study ranged of 0.57-0.59%. This value corresponds to the normal range according to Putnam (1991), which is 0.42-0.70%. The results of data analysis showed that the treatment did not affect the weight of the heart. The heart is a vital organ that plays a role in the blood circulation. Visually, there is no visible swelling in the heart of broiler. This indicated that the use of

Tabel 3. The effect of treatment on carcass and commercial cuts of 35 day old broiler (%)

Variables	Treatment			
	JB_{0-0}	JB_{50-0}	JB_{50-50}	JB_{0-50}
Carcass (g/chicken)	952.70±53.65	1002.64±81.10	894.45±198.68	808.67±118.08
Carcass (%)	64.08±2.23	65.68±0.71	66.75±2.89	64.18±1.00
Abdominal fat (%)	1.18±0.03	1.27±0.07	1.41±0.53	1.07±0.29
Wings (%)	12.58±0.34	11.59±0.52	11.53±0.29	12.47±3.69
Thigh (%)	19.11±0.64	18.04±0.47	19.07±0.79	18.06±0.84
Drumstick (%)	15.77±0.18	14.50±0.27	15.50±0.36	15.37±0.81
Breast (%)	29.02±1.46	29.60±0.26	30.75±1.29	28.89±1.63
Back (%)	23.64±0.90	23.93±1.37	23.52±0.81	23.07±1.18

JB_{0-0}: starter 0% JB+finisher 0% JB, JB_{50-0}: starter 50% JB+finisher 0% JB, JB_{50-50}: starter 50% JB+finisher 50% JB, JB_{0-50}: starter 0% JB+finisher 50% JB.

Tabel 4. The effect of treatment on internal organ weights of 35 day old broiler (%)

Variables	Ttreatment			
	JB_{0-0}	JB_{50-0}	JB_{50-50}	JB_{0-50}
Liver, %)	2.68±0.20	2.45±0.06	2.69±0.15	2.37±0.58
Heart, %)	0.58±0.09	0.59±0.02	0.57±0.06	0.58±0.09
Gizzard, %)	1.79±0.16	1.80±0.33	1.68±0.21	1.95±0.35
Pancreas, %)	0.32±0.07	0.32±0.05	0.34±0.05	0.30±0.05
Bile, %)	0.07±0.03	0.06±0.04	0.07±0.04	0.09±0.05
Kidney, %)	0.76±0.08	0.69±0.07	0.83±0.07	0.72±0.10

JB_{0-0}: starter 0% JB+finisher 0% JB, JB_{50-0}: starter 50% JB+finisher 0% JB, JB_{50-50}: starter 50% JB+finisher 50% JB, JB_{0-50}: starter 0% JB+finisher 50% JB.

JB at 50% level is still safe to use in diets without inhibiting blood circulation.

Percentage of gizzard broiler aged 35 days in this study ranged from 1.68 to 1.95%. This range is still within the normal range of gizzard according to Sturkie (2000), which is equal to 1.6-2.3%. The results of data analysis showed that the treatment did not affect percentage of broiler gizzard. The 50% JB content in broiler starter and finisher diets did not affect gizzard activity.

The pancreas produces digestive enzymes, such as amylase, lipase, trypsin, kimotripsin, carboxypeptidase, ribonuclease and elastase (Klansing, 2006). The average percentage of broiler pancreas age 35 days in this study ranged from 0.30 to 0.34%. This value is within the range of normal pancreas according to Sturkie (2000), which is 0.25-0.40%. The results of data analysis showed that the treatment did not affect the percentage of pancreas and bile broiler. The mean percentage of broiler bile in this study was 0.06 to 0.10% which is not so different from the results of Hermana *et al*. (2005) that was 0,09 - 0,15%.

Average percentage of kidney broiler in this study was 0.69-0.83%. The results are relatively similar to those reported by Hermana *et al.* (2005) that the percentage of broiler kidney weight ranged from 0.43 to 0.84%. Treatment did not affect the weight of the kidneys. Spector and Spector (1993) reported that abnormalities in the kidneys can be caused by impaired uric acid metabolism characterized by deposition of urate salts in the kidney in the form of white crystalline materials. In this study, no such abnormalities were found.

Effect of treatment on the weight of immune organ of broiler aged 35 days

Weight percentage of immune organ is presented in Table 5. The percentage range of spleen in this study was 0.09-0.12%. The treatment did not affect the weight percentage of the spleen. This means that the use of JB in broiler ration did not affect the spleen whose job is related to blood circulation (Card and Nesheim, 1972). The spleen is the largest lymphoid organ in the body. Most of the blood flows into the spleen and blood that may contain harmful agents is filtered by relying on a filter system of macrophages (Butcher, 2005).

In this study, the weight percentage of the thymus ranged from 0.10 to 0.36% (Table 5). Based on the result of the analysis of variance, all the treatments gave significant effect ($P<0.05$) on the decrease of thymus weight. According to Toghyani *et al*. (2010), the thymus weight is about 0.48% of body weight. The use of JB in the starter phase alone, finisher alone, or sustained from the starter to the finisher phase, has a lower thymus weight than the control treatment. This indicates that the use of JB is less able to trigger an increase in the number of T lymphocytes. The thymus will shrink with age and this is a sign of mature development of the immune system in an individual. Thymus deficiency begins to occur during adulthood (Shanker, 2004). The bursa fabricius and thymus are the primary lymphoid organs in poultry that are the site of the development of lymphoid cells (Roitt *et al*., 2000). Primary lymphoid organs serve as a place for growth and maturation of immune cells (Zane, 2001).

The treatment had no significant effect on the percentage of the bursa fabricius. The data show that the range of bursa fabricius percentages was 0.03-0.07%. Meanwhile Toghyani *et al.* (2010) reported that the weight of bursa fabricius for broiler about 0.98% of its body weight.

Conclusions

Jack bean meal protein can replace soybean meal protein up to 50% level in broiler diets maintained for 35 days without affecting production performance, carcass production,

Tabel 5. The effect of treatment on immune organ weights of 35 day old broiler (%)

Variable	Treatment			
	JB_{0-0}	JB_{50-0}	JB_{50-50}	JB_{0-50}
Spleen, %)	0.12±0.01	0.10±0.10	0.09±0.04	0.10±0.06
Thymus, %)	0.36±0.11^{b}	0.10±0.04^{a}	0.23±0.11^{a}	0.19±0.06^{a}
Bursa fabrisius, %)	0.03±0.01	0.04±0.01	0.04±0.02	0.07±0.02

JB_{0-0}: starter 0% JB+finisher 0% JB, JB_{50-0}: starter 50% JB+finisher 0% JB, JB_{50-50}: starter 50% JB+finisher 50% JB, JB_{0-50}: starter 0% JB+finisher 50% JB

Different superscript at the same column indicate significant differences ($P<0.05$).

visceral organ, spleen and bursa fabricius. Method of giving neither jack bean meal is given in starter phase only, in both starter and in finisher phase, nor in the finisher phase only do not give any different results.

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