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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Research Article

Effects of Replacing Soybean Meal with Fermented Leaves and Seeds of the Rubber Tree (*Hevea brasiliensis*) on the Production and Egg Quality of Kamang Laying Ducks

[1]Erman Syahruddin, [2]Rita Herawaty and [1]Azhar

[1]Department of Animal Production, Faculty of Animal Sciences, Andalas University, Kampus Limau Manis, Padang 25163, West Sumatra, Indonesia
[2]Department of Animal Nutrition and Feed Technology, Faculty of Animal Sciences, Andalas University, Kampus Limau Manis, Padang 25163, West Sumatra, Indonesia

Abstract

Background and Objective: This study aimed to reduce the use of imported feed ingredients and feed ingredients that are competitive with human needs through a transition to local conventional feed. Thus, the potential of fermented leaves and seeds of the rubber tree (FLSRT) as a substitute for soybean meal in Kamang laying duck rations without adverse effects on Kamang laying duck production was assessed. **Methodology:** This experiment used 240 Kamang laying ducks aged 20 weeks. A completely randomized design with four replications was used and the six treatments replaced 0, 20, 40, 60, 80 and 100% of soybean meal with FLSRT. The variables measured were feed intake, feed conversion and income over feed cost (gross profit), as well as variables related to egg production (hen-day production and egg weight) and egg quality (eggshell thickness and yolk color index). The data were analyzed statistically using analysis of variance (ANOVA) and if the result showed a marked influence, then Duncan's multiple range test (DMRT) was applied. **Results:** The performance of Kamang laying ducks was not affected significantly by substituting FLSRT for soybean meal. Feed intake, feed conversion and egg production were also not altered. **Conclusion:** FLSRT can be substituted for up to 100% of soybean meal in the diet of Kamang laying ducks.

Key words: Fermented leaves, fermented seeds, rubber tree, hen-day production, egg quality, Kamang laying duck

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Corresponding Author: Erman Syahruddin, Department of Animal Production, Faculty of Animal Sciences, Andalas University, Kampus Limau Manis, Padang 25163, West Sumatra, Indonesia

Competing Interest: The author has declared that no competing interest exists.

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

INTRODUCTION

Soybean meal is a source of vegetable protein in poultry rations. It contains high protein levels and a more complete amino acid profile than other vegetable feed ingredients. Unfortunately, its availability is sometimes limited. The demand for soybean meal is constantly increasing along with the development of poultry farming. The demand for soybean meal in Indonesia is met almost entirely with imports, which totaled approximately 1,968,049 million tons in 2016[1]. To reduce the dependency on imported feed ingredients such as soybean meal, an alternative raw-material feed is necessary. A potential food source that has not been widely used is the leaves and seeds of the rubber tree (*Hevea brasiliensis*), which are agricultural waste products. This plant has high adaptability and can grow at elevations of 0-1500 meters. The rubber plant is a plantation crop. According to the Central Bureau of Statistics[1], extensive rubber plantations (18,898,217 ha) make Indonesia the global leader in rubber production. One hectare on a rubber plantation grows 200-300 trees[1].

The low nutrient content and the presence of antinutritional substances in the rubber plant have resulted in its minimal use as feed. The leaves and seeds of the rubber tree contain 26.70-28.62% crude protein, 5.60% fat, 1762.95-2301.64 kcal kg^{-1} metabolizable energy, 53.42-71.19% nitrogen retention and 25.73-28.62% crude fiber (Poultry Laboratory). According to Oluyemi *et al.*[2], the metabolizable energy of rubber tree leaves and seeds is approximately 4,835 kcal kg^{-1}. Rubber tree leaves and seeds also contain various amino acids, such as aspartic acid 10.25%, glutamic acid 14.73%, lysine 2.55%, arginine 7.23%, methionine 0.92% and threonine 2.65 Orok and Bowland[3]. The main obstacle to the use of rubber tree leaves and seeds as animal feed is their high levels of cyanide (HCN). According to Giok *et al.*[4], the HCN content of the leaves and seeds of fresh rubber is 325 mg/100 g. However, according to Syahruddin and Herawaty[5], the HCN content of rubber tree leaves and seeds can be reduced or eliminated by storage, extraction, drying, soaking in water or boiling. Soaking the leaves and seeds of the rubber plant for 24 h can reduce HCN levels, while boiling the leaves and seeds at 160°C can eliminate toxic HCN[6]. Syahruddin and Herawaty[5] showed that using the leaves and seeds of fresh rubber plants as more than 9% of the diet of broiler chickens could reduce weight gain and feed intake. Thus, processing must be performed to increase the quality of rubber tree leaves and seeds. One preparation process is fermenting the leaves and seeds of the rubber tree with the microbe *Trichoderma spiralis*, which can increase the percentage of crude protein to 33.85%, according to Syahruddin and Herawaty[7]. The present study was designed to determine the effectiveness of using rubber leaves and seeds fermented with *Trichoderma harzianum* as feed in biological tests. Fermented leaves and seeds of the rubber tree (FLSRT) were used to substitute for 0, 20, 40, 60, 80% and 100% of protein soybean meal in the rations of native laying ducks[8].

MATERIALS AND METHODS

Biological experiments were used to determine the effect of a 100% replacement of soybean meal protein with FLSRT in the rations of Kamang laying ducks. The study was conducted at the Faculty of Animal Science and alas University, Padang.

Material research: The experiment used 240 Kamang laying ducks aged 20 weeks for 8 weeks in a cage battery. The treatment rations were prepared by adding FLSRT. The rations were composed to supply equal protein and energy across the treatments.

The treatments were as follows:

- **R0:** 0% FLSRT (control diet without replacement of soybean meal)
- **R1:** Replacement of 20% protein soybean meal with FLSRT
- **R2:** Replacement of 40% protein soybean meal with FLSRT
- **R3:** Replacement of 60% protein soybean meal with FLSRT
- **R4:** Replacement of 80% protein soybean meal with FLSRT
- **R5:** Replacement of 100% protein soybean meal with FLSRT

The diet composition for each animal can be seen in Table 1 and the nutrient and metabolic energy contents are presented in Table 2.

Processing and data analysis: All data were analyzed using one-way analysis of variance (ANOVA) of a completely randomized design according to Steel and Torrie[9]. Differences between treatments were tested with Duncan's multiple range test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Effect of treatments on consumption, hen-day egg production, egg weight and feed conversion of Kamang laying duck: The average feed consumption, hen-day egg production, egg weight and feed conversion per head per week during the study are presented in Table 3.

Table 1: Composition of rations for Kamang laying ducks (CP 17% and ME 2800 kcal kg^{-1})

	Percentage					
Ingredients	R0	R1	R2	R3	R4	R5
Corn	50.0	49.13	48.26	47.39	46.52	45.65
Soybean meal	20.0	16.00	12.00	8.00	4.00	0.00
FLSRT	0.0	5.87	1174.00	17.61	23.48	29.35
Fine rice bran	15.5	14.50	13.50	12.50	11.50	10.50
Fish meal	6.0	6.00	6.00	6.00	6.00	6.00
Bone meal	1.5	1.50	1.50	1.50	1.50	1.50
Flour shells	4.0	4.00	4.00	4.00	4.00	4.00
Coconut oil	2.5	2.50	2.50	2.50	2.50	2.50
Top mix	0.5	0.50	0.50	0.50	0.50	0.50
Total	100.0	100.00	100.00	100.00	100.00	100.00

Table 2: Nutrient content of the tested rations

Components	R0	R1	R2	R3	R4	R5
Crude protein (%)	17.680	17.590	17.490	17.400	17.310	17.210
Fat (%)	3.910	3.900	3.890	3.880	3.870	3.860
Crude fiber (%)	4.780	5.170	5.560	5.950	6.340	6.730
Ca (%)	3.030	3.010	2.990	2.920	2.900	2.880
P total (%)	0.680	0.690	0.700	0.710	0.720	0.730
ME (K kal kg^{-1})	2842.800	2840.300	2837.800	2835.300	2832.800	2830.300
Methionine	0.296	0.295	0.293	0.291	0.290	0.289
Lysine (%)	1.110	1.053	0.990	0.930	0.870	0.820

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Table 3: Average feed consumption, hen-day egg production, egg weight and feed conversion of Kamang laying duck per week

Treatments	Feed consumption (g/head/week)	Hen-day egg production (%)	Egg weight (g/head/week)	Feed conversion ratio
R0	856.30	63.76	98.76	4.41
R1	862.36	64.09	101.30	4.34
R2	866.65	63.06	102.23	4.33
R3	869.05	63.74	99.84	4.48
R4	865.05	63.10	96.60	4.61
R5	862.89	62.38	96.48	4.60
Average	863.72	63.50	99.20	4.46

The ANOVA showed that the substitution of soybean meal protein with protein from FLSRT at proportions up to 100% in the diet of Kamang laying ducks did not have significant (p>0.05) effects on feed consumption, hen-day egg production, egg weight or feed conversion.

Table 3 shows that the feed intake levels obtained during the study with FLSRT ranged from 856.30-869.05 g/head/week or from 122.33-124.15 g/head/day. The average feed intake in this study was higher than that reported by Nurtini[10], which was 90-100 g/head/day and that by Cresswell and Gunawan[11] at 88 g/head/day. According to Mansjoer[12], the feed consumption of laying hens aged 25-70 weeks is 115 g/head/day.

The non-significance of the differences in feed consumption may be due to the fermentation process, which appropriately improves the quality of the rubber leaves and seeds and gives them a palatability similar to that of soybean meal. Consequently, the use of FLSRT for up to 29.35% of the ration for Kamang laying ducks, equal to a 100% soybean meal substitution, had no effect on feed intake. Moreover, non-significant effect on feed consumption was also due to the contents of metabolizable energy, protein and other nutrients being similar in each treatment.

There was a non-significant effect (p>0.05) of the treatment on hen-day egg production (Table 3). The lack of significant differences was due to the feed conversion, the protein and energy contents of the rations (17% and 2800 kcal kg^{-1}) and the availability of other food substances in accordance with the needs of the Kamang laying duck. Thus, the treatments resulted in the same egg production as well as the same maintenance and management of the environment. Nurtini[10] and Akter *et al.*[13] stated that the factors affecting egg production are genetics, management and feed. In addition to ration quality, factors that affect egg production are age, maintenance, environment, management, disease and quantity of food[14].

In general, hen-day egg production in this study ranged from 62.38-64.09%, or an average of 63.50% which is higher than the results of Kingston[15], who showed that the hen-day egg production of native laying ducks in Indonesia was 41.3%. Low hen-day egg production is due to the genetic traits of the ducks; that is, some ducks do not produce eggs every day. According to Kingston[15] and Anderson *et al.*[16], egg production is influenced by genetic factors, management and feeding. Specifically, egg production is influenced by the contents of the substances consumed, especially the levels of protein, energy, methionine, lysine, calcium and phosphorus in the rations.

FLSRT can be used up to 29.35% as laying duck food rations, or a 100% substitution of soybean meal protein, with a hen-day egg production of approximately 63.50%. Production at R5 was only 62.48%; however, because of its relatively low cost compared with those of other treatments, this ration can produce a considerable profit. The fermentation process improved the quality of the rubber leaves and seeds, thus affecting the quality of the rations and maintaining egg production. According to Rasyaf[17], FLSRT cannot be fed to native layers as more than 20% of the diet. However, in the current study, FLSRT can be used in the diet at proportions as high as 29.35%, as a 100% replacement for soybean meal protein, without affecting production. Thus, FLSRT can provide greater profits.

Average egg weights are shown in Table 3, they ranged from 96.48-102.23 g/head/week or 37.70-38.94 g/egg. This result is slightly lower than that found by Iskandar[18], who indicated that the egg weights of intensively reared ducks reached 41 g/egg but results of this study (39.96 g/egg) are similar to those reported by Mansjoer[12].

The weights of the eggs produced in this study were not strongly influenced by the level of soybean meal protein substitution with FLSRT. The weights of the eggs produced were very similar because the feed, energy and protein content of the rations as well as those of other food substances consumed were substantially similar in each treatment, due to the processing of the rubber leaves and seeds. According to Romanof and Romanof[19], the level of protein in the diet has a major influence on egg weight. Decreased energy and protein consumption can lead to decreased egg weight[20]. Egg weight and size are also influenced by the contents of methionine, lysine, calcium and phosphorus in the rations. The tested rations had 0.037 g methionine and a lysine content of 0.66 g/head/day, which can produce normal eggs in terms of weight and size. The dietary proportion of calcium needed to produce large eggs is generally 3.7% for 40-week-old laying ducks and the proportion of phosphorus is 0.353%[21]. Methionine consumption in this study amounted to 0.23 g/head/day and lysine consumption ranged from 0.68-0.88 g/head/day.

The average feed conversions during the study are shown in Table 3 and ranged between 4.41 and 4.61. The ANOVA showed no significant effects (p>0.05) of the treatments on feed conversion. This result is because the feed consumption and the weight of eggs produced were the same, as the feed conversion ratio is the amount of feed consumed divided by the weight of eggs produced. These data indicate that fermenting rubber leaves and seeds with the mold *Trichoderma spiralis* for 5 days at a temperature of 30°C can increase their quality as rations. This treatment allows FLSRT to be substituted for 100% of soybean meal content while retaining a conversion rate comparable to that of the control diet.

Effect of the treatment on eggshell thickness, egg color and income over feed cost: Average eggshell thickness, yolk color scores and income over feed cost can be seen in Table 4.

The mean eggshell thickness and the yolk color score ranged from 10.45-11.13 mm and from 0.48-0.50, respectively. The ANOVA for eggshell thickness showed that the treatments had no significant effects (p>0.05). This result was caused by the similar contents of calcium and phosphorus in all ration types, with calcium ranging between 2.88 and 3.03% and phosphorus ranging between 0.66 and 0.73%. These values are consistent with the recommendations of the NRC[14]. The eggshell thickness in this study was the same as that recommended by Stadelman and Cotterrili[22]. Furthermore, the color of the eggshell is caused by the pigment porphyrin

Table 4: Effects of treatment on eggshell thickness, yolk color score and income over feed cost

Treatments	Eggshell thickness (mm)	Yolk color score	Income over feed cost (Rp.)
R0	0.50	10.45	4819.71
R1	0.49	10.51	5149.01
R2	0.50	10.96	5350.11
R3	0.50	11.01	5534.19
R4	0.49	11.13	5719.71
R5	0.48	11.02	5816.02
Average	0.49	10.85	5397.62

deposited on the surface of the egg and its thickness was less than 0.43 mm. According to Mansjoer[12], eggshells of less than 0.31 mm thickness are too thin to be marketed, while satisfactory eggs have a thickness of approximately 0.49 mm.

The yolk color of the eggs produced in this study varied from yellow to orange, with color scores ranging from 10.45-11.13. According to Cresswell dan Gunawan[11], consumers generally favor golden-colored egg yolks, which give an attractive appearance that stimulates appetite or interest. The intensity of the egg yolk color is determined by the concentrations of carotenoid pigments[19]. Anggorodi[23] stated that lutein, zeaxanthin and kryptoxanthin are responsible for egg yolk color and the addition of xanthophylls to poultry feed can increase the egg yolk color score.

The average incomes compared to feed costs in this study are presented in Table 4. The advantage gained during the study ranged from Rp. 4819.71-5819.03, or Rp. 180.33-235.28 per egg. Profits increased with increasing use of FLSRT in the rations, because FLSRT costs less than soybean meal.

CONCLUSION

The use of FLSRT in feed rations had no significant effects on the production performance of Kamang laying duck based on feed intake, feed conversion and egg production. Up to 100% substitution of soybean meal protein with FLSRT can be performed in the diet of Kamang laying duck.

SIGNIFICANCE STATEMENT

This study found that fermented leaves and seeds of the rubber tree can be used as a substitute for soybean meal in Kamang laying duck rations without adverse effects on Kamang laying duck production.

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