ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2017.233.237

Research Article
Economic Analysis of Male Broiler Chickens Fed Diets Supplemented with *Salvinia molesta*

Siswanto Imam Santoso, Siti Susanti and Agus Setiadi

Faculty of Animal Science and Agriculture, Diponegoro University, Tembalang Campus, 50275 Semarang, Indonesia

Abstract
Background and Objective: *Salvinia molesta* is an aquatic plant that grows well in Rawa Pening, Central Java, Indonesia but it is invasive and typically causes environmental problems. Therefore, the government of Central Java is interested in reducing *Salvinia* in Rawa Pening. Based on a laboratory analysis, *Salvinia* contains 32% crude protein; thus, it may be used as broiler chicken feed. However, *Salvinia molesta* has not commonly been used in this way in Indonesia. The aim of this study was to determine the profitability of using *S. molesta* leaf meal in the diets of male broiler chickens. **Methodology:** One hundred male broiler chickens were divided into the following 4 treatments with 5 replicates each and 5 male broilers were reared in each replicate: T0 (0% *S. molesta* in the diet), T1 (6% *S. molesta*), T2 (12% *S. molesta*) and T3 (18% *S. molesta*). **Results:** The body weights of the chickens fed T_1 did not differ in comparison to T0 and the FCRs of the birds fed T2 and T3 were similar to those of the birds fed T0. The feed consumption was similar among all treatments and no deleterious effects were observed during the experiment. Among the treatments, the T3 birds exhibited the most profitability. Therefore, *Salvinia molesta* can be used as broiler chicken feed at up to 6% of the diet. **Conclusion:** Incorporating *Salvinia molesta* at up to 6% of the diet may reduce feeding costs and thus increase profit.

Key words: *Salvinia*, Rawa Pening, profitability, broiler chicken

Received: February 10, 2017 Accepted: April 26, 2017 Published: May 15, 2017

Citation: Siswanto Imam Santoso, Siti Susanti and Agus Setiadi, 2017. Economic analysis of male broiler chickens fed diets supplemented with *Salvinia molesta*. Int. J. Poult. Sci., 16: 233-237.

Corresponding Author: Agus Setiadi, Faculty of Animal Science and Agriculture, Diponegoro University, Tembalang Campus, 50275 Semarang, Indonesia

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

Chicken meat is a source of protein for humans and increasing demands for meat have contributed to an increase in chicken production in Indonesia. However, chicken production is expensive and one problem with the chicken-rearing system is the cost of feed, which is high due to the many ingredients in commercial feed. In particular, Indonesian chicken production faces high feed costs because almost all of the important ingredients are imported from other countries. Therefore, using local resources is necessary to rear chickens. Reducing the cost of feed may increase income and ultimately render the chicken-rearing business profitable. A greater profit margin will attract other people to engage in this business. Aquatic plants are abundant in Indonesia and are already used as non-conventional feed in certain instances. For example, duckweed is an aquatic plant that is rich in plant protein and polyunsaturated fatty acids (PUFA)[1] and is used as animal feed[2,3].

Aquatic plants are abundant and are the cheapest sources of protein for animals; hence, incorporating them into diets can reduce feed cost[2]. Furthermore, using *Azolla* at 10% of the diet for laying chickens may improve their performance. *Salvinia* contains 32% crude protein and 42% crude fibre. The high fibre content of certain ingredients is major factor in their use in conventional feed[4]. Alalade and Iyayi[2] found no deleterious effects of including aquatic plants in the diet of laying hens and Khatun *et al.*[3] incorporated aquatic plants at up to 20% of the diet, which yielded the best performance.

Salvinia molesta is an aquatic plant that grows rapidly and it has been used in animal feed[5]. Experiments have been conducted to determine the performance of broilers fed certain ingredients in their feed[6,7] but efforts to use *S. molesta* as unconventional feed are not yet common in Indonesia. Mukherjee *et al.*[1] stated that *Salvinia molesta* is an important protein source. Based on their study, *Salvinia molesta* may be used as a low-cost chicken feed. This study sought to determine the profitability of using *Salvinia molesta* in the feed of male broiler chickens.

MATERIALS AND METHODS

The study was carried out at the Faculty of Animal Science and Agriculture, Diponegoro University, Semarang, Indonesia. *Salvinia molesta* leaves were harvested from Rawa Pening Lake in Semarang Regency, Central Java. One hundred male broiler chickens were used in the study and were divided among 4 treatments that varied in the percentage of *S. molesta* leaf meal in the diet: T0 (0%), T1 (6%), T2 (12%) and T3 (18%). The chickens were divided into 4 groups of 25 birds each in a completely randomized design and each diet replicate contained 5 birds. The room temperature ranged from 23-38°C. The diet compositions during the starting and finishing periods are shown in Table 1 and 2, respectively.

Table 1: Diet compositions during the starter period

	Diets			
Ingredients	T0	T1	T2	T3
Corn (%)	52.1	52.3	51.0	51.8
S. molesta leaf meal (%)	21.3	17.0	14.0	10.8
Rice bran (%)	16.8	15.9	15.1	11.8
Salvinia molesta (%)	0.0	6.0	12.0	18.0
Fish meal (%)	5.0	5.0	5.0	5.0
Coconut oil (%)	1.2	1.2	1.3	1.3
$CaCO_3$ (%)	0.8	0.7	0.4	0.4
Premix (%)	0.8	0.7	0.4	0.3
Methionine (%)	1.0	0.6	0.4	0.3
Lysin (%)	1.0	0.6	0.4	0.3
Total (%)	100.0	100.0	100.0	100.0
Nutritional analysis				
Energy (kcal kg^{-1})	2900.710	2900.840	2900.310	2900.800
Crude protein (%)*	20.320	20.040	20.270	20.330
Fat (%)*	5.040	4.940	4.910	4.680
Crude fibre (%)*	6.220	8.360	10.570	12.100
Methionine (%)**	1.260	0.970	0.870	0.850
Lysin (%)**	1.550	1.420	1.470	1.610
Ca (%)**	1.240	1.770	2.100	2.730
P (%)**	0.720	1.050	1.390	1.700
Diet cost (IDR)	6.776	5.970	5.427	5.016

*Proximate analyses were conducted at the Faculty of Animal Science and Agriculture of Diponegoro University, **Feed Ingredient Composition Table by Amrullah[8]

Table 2: Diet compositions during the finisher period

	Diets			
Ingredients	T0	T1	T2	T3
Corn (%)	54.0	52.9	52.6	52.5
Soybean meal (%)	19.3	16.5	12.7	9.4
Rice bran (%)	17.7	17.6	16.4	14.6
S. molesta leaf meal (%)	0	6.0	12.0	18.0
Fish meal (%)	4.0	3.5	3.5	3.5
Coconut oil (%)	1.2	1.1	1.2	1.0
$CaCO_3$ (%)	1.0	0.7	0.4	0.2
Premix (%)	1.0	0.5	0.4	0.2
Methionine (%)	0.9	0.6	0.4	0.2
Lysin (%)	0.9	0.6	0.4	0.2
Total (%)	100.0	100.0	100.0	100.0
Nutritional analysis				
Energy (kcal kg^{-1})	2902.620	2901.510	2901.970	2902.100
Crude protein (%)*	19.020	19.140	19.030	19.120
Fat (%)*	5.090	4.910	4.870	4.710
Crude fibre (%)*	6.310	8.680	10.750	12.680
Methionine (%)	1.140	0.940	0.840	0.730
Lysin (%)	1.420	1.390	1.440	1.490
Ca (%)	1.360	1.650	1.980	2.410
P (%)	0.680	1.020	1.350	1.680
Diet cost (IDR)	6.572	5.855	5.309	4.761

*Proximate analyses were conducted at the Faculty of Animal Science and Agriculture of Diponegoro University

Feed consumption: Feed consumption during the treatments was measured by weighing the feed offered and then subtracting the weight of the unconsumed feed daily and it was reported in grams per week. Feed consumption was measured using the following formula:

$$\text{Feed consumption} = \frac{\text{Total amount of feed consumed}}{\text{Total birds}} \quad (1)$$

Feed conversion ratio: The Feed Conversion Ratio (FCR) was calculated by comparing the rations consumed to the resulting weight gain over time and it was reported in the same unit as body weight. The feed conversion ratio value was calculated as follows:

$$\text{FCR} = \frac{\text{Amount of feed consumed}}{\text{Body weight gain}} \quad (2)$$

Feed costs: Calculation of the feed costs were started when the broilers were 4 weeks old and continued throughout the experiment until 10 weeks of age. Feed costs were obtained based on the price of feed per kilogram, which was multiplied by the daily consumption and expressed as IDR per head per day. The feed price was obtained by multiplying the price of each component by its proportion in the diet and expressed as IDR kg^{-1}. However, the price of *Salvinia molesta* was obtained by calculating wages divided by the number of person-days for production, which was added to the cost of converting the crop from its wet form to its dry ingredients plus the cost of transportation and milling to a powder; the price was expressed in IDR kg^{-1}.

Income over feed cost: Income over feed cost was obtained using the difference between income and the cost of feed, which was expressed as IDR per head. Then, income over feed cost was calculated using the following formula[9]:

$$\text{IOFC} = \frac{\text{BB} \times \text{Price of chicken}}{\text{kg live}} - \frac{\Sigma\ \text{feed intake} \times \text{Feed cost}}{\text{kg}} \quad (3)$$

Profitability: Profitability was obtained by dividing the IOFC by the feed cost and assuming the other costs were *ceteris paribus*. The profitability of using *Salvinia molesta* as a broiler chicken feed is the percent increase in profit obtained from broiler chicken rearing using *Salvinia molesta* relative to the control.

Analysis of meat quality: The protein content of the broiler meat was analysed using the Kjeldahl method[10], which involves destruction, distillation and titration stages. The destruction phase is stopped when the extract turns into a clear solution and is followed by a distillation process that ends when the green solution is entirely clear. The sample is then distilled and titrated with 0.1 M HCl until it changes into a purple liquid. The protein content was then calculated using the standard formula.

The fat content was determined using the Soxhlet method[10]. Filter paper (11.7×14.5 cm) was oven-dried at 100-105°C for 1 h and cooled in a desiccator for 15 min, after which the filter paper was weighed. Each sample was weighed and placed in the middle of the filter paper, which was folded and the samples in filter paper were oven-dried at 100-105°C for 4-6 h, weighed and then repeatedly dried to a constant weight as described above. Once the constant weight was reached, the sample was placed in the desiccator for 15 min and weighed again. The sample was then inserted into the Soxhlet apparatus with the inclusion of fat solvents at as much as ±2.5-3 times the volume of the extraction flask. This process was repeated for ±6 h, after which the samples were removed from the apparatus and aerated for ±30 min in the open air, reinserted into the oven for ±1 h, placed in a desiccator for 15 min and then weighed again. The weight was considered constant when the difference did not exceed 0.2 mg.

The cholesterol content was measured using a modified saponification process[11]. Approximately 2 g of each sample was saponified with 4 mL (50%) potassium hydroxide and 6 mL (95%) absolute ethanol, heated to complete solubilization at 40°C and then heated again for 10 min at 60°C. Next, 5 mL of water was added and the samples were cooled. The non-saponifiable fraction was extracted three times using 10 mL hexane and aliquots of the hexane extracts (3 mL) were dried under a nitrogen flow. After saponification, the samples were analysed using enzymatic methods[12]. The extract was diluted in 0.2 mL isopropyl alcohol and analysed using an enzymatic kit (Merck® Diagnostica, Darmstadt, Germany).

Statistical analysis: The data were statistically analysed using the General Linear Model (GLM) procedure of SPSS 16.0. Least Squares Means (LSMs) were calculated and the differences among treatment means were analysed using the Duncan multiple range test[13].

RESULTS AND DISCUSSION

The feed consumption, final body weight and FCR are shown in Table 3. No significant differences ($p \geq 0.05$) in feed

Table 3: Feed consumption, body weight gain and FCR

	Diets			
Parameters	T_0	T_1	T_2	T_3
Feed consumption (g per bird)	2,962.12[a]	2,949.48[a]	3,105.29[a]	2,910.35[a]
Final body weight (g per bird)	1,739.99[a]	1,628.10[a]	1,409.10[b]	1,337.99[b]
FCR	3.79[a]	3.76[a]	3.76[a]	4.06[b]

Different columns followed by same letter are statistically significant at p<0.05, FCR: Feed conversion ratio

Table 4: Feed cost. revenue and income over feed cost (IOFC)

	Diets			
Constituents	T_0	T_1	T_2	T_3
Feed cost (IDR per bird)	25.481	22.448	20.405	20.306
Revenue (IDR per bird)	31.302	29.304	25.362	24.066
IOFC (IDR per bird)	5.821	6.856	4.957	3.760
Profitability (%)	22.840	30.550	24.290	18.510

IOFC: Income over feed cost

Table 5: Fat, cholesterol and protein contents of broiler chicken meat

	Diets			
Parameters	T_0	T_1	T_2	T_3
Fat (%)	3.20[a]	2.90[a]	2.80[a]	2.77[a]
Cholesterol (mg/100 g)	62.00[a]	58.00[a]	58.00[a]	57.50[a]
Protein (%)	12.70[a]	12.90[a]	12.80[a]	12.60[a]

Different columns followed by same letter are statistically significant at p<0.05

consumption were observed among the different treatments, which indicates that all the birds consumed the same amount of feed. This result agrees with the finding of Naghshi *et al.*[14], who reported that the inclusion of 5-15% *Azolla* did not significantly affect feed consumption. The final body weights of the birds fed T1 were the same as those of the broilers fed the control diet (p>0.05) but they were better than those fed T2 and T3 (p<0.05), which might be due to reduced feed conversion because of the high fibre in the ration. The reduction in body weight due to higher proportion of aquatic plants (*Azolla*) might be due to higher levels of NDF and lignin[15,16]. The FCR did not differ among the birds fed T0, T1 and T2 (p>0.05) but they exhibited better values than the birds fed T3 (p<0.05). The FCRs of the birds fed T1 and T2 were similar to those of the birds fed the control diet. The poor performance of the birds fed T3 might be due to the fibre content in *Salvinia*. Consistent with previous reports, broiler body weight gain was reduced with higher concentrations of high-fibre dietary ingredients, which also result in reduced palatability[17-19]. *Salvinia* has a high fibre content but incorporating it at up to 6% of the diet yielded a lower FCR compared with the birds fed the control diet. Thus, broilers can use the plant proteins in *Salvinia* for growth. The results are consistent with Alalade and Iyayi[2], who used the aquatic plant *Azolla* in the diets of laying hens and observed the best performance when the chickens were fed up to 10% *Azolla*.

Table 4 shows that, feed costs were reduced when *Salvinia* was incorporated at 6% of the broiler diet. However, the feed cost and profit of the birds fed T3 were lowest and similar results were observed by Ara *et al.*[19], who reported that the reduction in net profit per bird could be due to reduced body weights. *Salvinia* was the cheapest ingredient for broiler feed because it is abundant in Rawa Pening and has not yet been used by farmers. Additionally, using *Salvinia molesta* from Rawa Pening Lake as chicken feed would reduce the environmental problems in the lake.

Using *Salvinia molesta* as a chicken feed is not yet common in Indonesia but the plant is abundant. Based on this research, incorporating *Salvinia* at up to 6% of the broiler chicken diet could provide the best IOFC and profitability. Ara *et al.*[19] reported that replacing the protein source in the diets of broiler chicken with an aquatic plant had a better economic outcome than the control group. These findings agree with the results of Dhumal *et al.*[20] and Santoso and Setiadi[9], who observed higher returns with a chicken fed ration in which 5% of the protein source was replaced by *Azolla*. Incorporating *Salvinia molesta* in the diet of broiler chickens could reduce feed costs and improve the FCR.

No significant differences (p>0.05) in the fat, cholesterol and protein contents of the broiler meat were observed among the dietary treatments. Fat, cholesterol and protein contents were not influenced by the inclusion of *S. molesta* in the diet (T1-T3) compared with the control diet (T0) (Table 5).

CONCLUSION

Incorporating *Salvinia molesta* at up to 6% of the diet yielded the greatest profitability for the broiler-rearing system because it reduced the feed cost and increased the income over feed cost and the profitability. Additionally, the fat, cholesterol and protein contents of the meat did not significantly differ among the treatments. However, further research is necessary to determine the effects of incorporating *Salvinia molesta* in chicken diets in pellet form as well as the effects on the quality of broiler chicken meat.

ACKNOWLEDGMENT

This project was supported by the Indonesian General Directorate of Higher Education through the Master Plan for the Acceleration and Extension of Indonesian Economic Development research grant program.

REFERENCES

1. Mukherjee, A.K., P. Kalita, B.G. Unni, S.B. Wann, D. Saikia and P.K. Mukhopadhyay, 2010. Fatty acid composition of four potential aquatic weeds and their possible use as fish-feed nutraceuticals. Food Chem., 123: 1252-1254.
2. Alalade, O.A. and E.A. Iyayi, 2006. Chemical composition and the feeding value of *Azolla* (*Azolla pinnata*) meal for egg-type chicks. Int. J. Poult. Sci., 5: 137-141.
3. Khatun, A., M.A. Ali and J.G. Dingle, 1999. Comparison of the nutritive value for laying hens of diets containing *Azolla* (*Azolla pinnata*) based on formulation using digestible protein and digestible amino acid versus total protein and total amino acid. Anim. Feed Sci. Technol., 81: 43-56.
4. Dwiloka, B., A. Setiadi, S.I. Santoso, E. Suprijatna and S. Susanti, 2015. Effects of duck feed supplemented with invasive giant *Salvinia* (*Salvinia molesta*) on duck meat characteristics. Turk. J. Vet. Anim. Sci., 39: 668-675.
5. Leterme, P., A.M. Londono, J.E. Munoz, J. Suarez, C.A. Bedoya, W.B. Souffrant and A. Buldgen, 2009. Nutritional value of aquatic ferns (*Azolla filiculoides* Lam. and *Salvinia molesta* Mitchell) in pigs. Anim. Feed Sci. Technol., 149: 135-148.
6. Amerah, A.M., A. Quiles, P. Medel, J. Sanchez, M.J. Lehtinen and M.I. Gracia, 2013. Effect of pelleting temperature and probiotic supplementation on growth performance and immune function of broilers fed maize/soy-based diets. Anim. Feed Sci. Technol., 180: 55-63.
7. Hamilton, R.M.G. and F.G. Proudfoot, 1995. Ingredient particle size and feed texture: Effects on the performance of broiler chickens. Anim. Feed Sci. Technol., 51: 203-210.
8. Amrullah, I.K., 2004. Seri Berternak Mandiri: Nutrisi Ayam Boiler. Lembaga Satu Gunung Budi, Bogor.
9. Santoso, S.I. and A. Setiadi, 2016. Profitable utilization of giant salvinia, *Salvinia molesta*, as local duck feed. Int. J. Poul. Sci., 15: 121-125.
10. Joseph, J.D. and R.G. Ackman, 1992. Capillary column gas chromatographic method for analysis of encapsulated fish oils and fish oil ethyl esters: Collaborative study. J. AOAC Int., 75: 488-506.
11. Holland, B., A.A. Welch, I.D. Unwin, D.H. Buss, A.A. Paul and D.A.T. Southgate, 1998. McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry, Cambridge, pp: 8-9.
12. Soeparno, 2009. Ilmu dan Teknologi Daging. Gadjah Mada University Press, Yogyakarta, Indonesia.
13. Steel, R.G.D. and J.H. Torrie, 1995. Prinsip dan Prosedur Statistika. PT. Gramedia, Jakarta, pp: 168-170.
14. Naghshi, H., S. Khojasteh and M. Jafari, 2014. Investigation the effect of different levels of *Azolla* (*Azolla pinnata*) on performance and carcass characteristics of cobb broiler chicks. Int. J. Farming Allied Sci., 3: 45-49.
15. Tamany, Y., G. Samanta, N. Chakraborty and L. Mondal, 1992. Nutritive value of *Azolla* (*Azolla pinnata*) and its potentiality of feeding in goats. Environ. Ecol., 10: 755-756.
16. Parthasarathy, R., R. Kadirvel and V. Kathaperumal, 2002. *Azolla* as a partial replacement for fish meal in broiler rations. Indian Vet. J., 79: 144-146.
17. Loar, R.E., J.S. Moritz, J.R. Donaldson and A. Corzo, 2010. Effects of feeding distillers dried grains with solubles to broilers from 0 to 28 days posthatch on broiler performance, feed manufacturing efficiency and selected intestinal characteristics. Poult. Sci., 89: 2242-2250.
18. Lumpkins, B.S. and A.B. Batal, 2005. The bioavailability of lysine and phosphorus in distillers dried grains with solubles. Poult. Sci., 84: 581-586.
19. Ara, S., S. Adil, M.T. Banday and M.A. Khan, 2015. Feeding potential of aquatic fern-*Azolla* in broiler chicken ration. J. Poult. Sci. Technol., 3: 15-19.
20. Dhumal, M.V., M.F. Siddiqui, M.B.A. Siddiqui and P.E. Avari, 2009. Performance of broilers fed on different levels of *Azolla* meal. Int. J. Poul. Sci., 44: 65-68.