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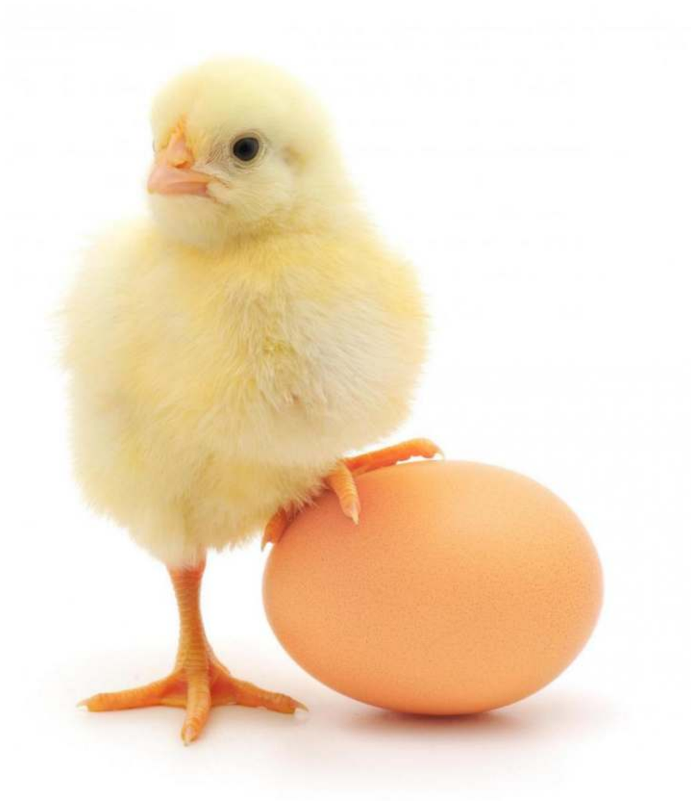

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Research Article
Substituting Soybean Meal with Fermented Leaves and Seeds of Rubber Trees (*Hevea brasiliensis*): Effects on Carcass Percentage, Abdominal Fat Percentage and Meat-to-Bone Ratio in Broiler Chickens

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Abstract
Objective: This study aimed to reduce the use of imported feed ingredients and those competing with human food resources by using local conventional feed. **Materials and Methods:** This study included 480 day-old caged broiler chicks of the Cobb strain. Chicks were housed in colonies in wire cages. Each cage unit was equipped with a feeding area, a drinking area and an incandescent lamp. A completely randomized design with 6 treatments and 4 replications was employed. The data obtained were analysed using ANOVA and differences between treatments were tested by Duncan's multiple range test (DMRT). Treatments included a group fed control rations as well as groups fed FLSRT as a replacement for specific percentages (0, 20, 40, 60, 80 and 100%) of soybean meal. The observed variables included body weight gain, carcass percentage, meat-to-bone ratio, percentage of abdominal fat, percentage of ventricular weight and thickness of broiler chicken intestine. **Results:** The results showed that replacement of up to 80% of soybean meal protein with processed rubber leaves and seeds in broiler rations had no significant effect ($p>0.05$) on body weight, carcass percentage, or meat-to-bone ratio. However, measurements of these parameters under replacement with 100% processed rubber leaves and seeds differed significantly ($p<0.01$) from other treatments. **Conclusion:** Replacement of up to 80% of soybean meal with FLSRT resulted in increased body weight, higher carcass percentage and meat-to-bone ratio and a lower percentage of abdominal fat in comparison to replacement at the 0% concentration.

Key words: Abdominal fat, broiler rations, dietary protein, rubber leaves and seeds, soybean meal

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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

Broiler chickens have been bred as a source of dietary protein. The broiler is the fastest growing variety of chicken livestock because it is a result of cultivation using advanced technology; thus, it has profitable economic properties. According to Amrullah[1], within 6-7 weeks, the broiler will grow to 40-50 times its initial weight.

A problem that often occurs at broiler farms, especially in Indonesia, is dependence on imported raw feed material, which is limited in supply and relatively expensive to procure. According to a report by the Directorate General of Animal Husbandry[2], corn feed material imported in 2004 reached 988,500 t, soybean meal amounted to 1,779,470 t and meat and bone meal amounted to 226,900 t. Food prices therefore tend to be expensive, although Indonesia still has potential natural resources. The challenge in using local raw materials is noncontinuous availability due to poor management of raw materials after harvest. To meet this challenge, we need a new breakthrough in the livestock industry, especially the poultry industry, to supply feed that is available continuously without competing with food resources for humans. One candidate source of raw feed material that can be used includes the leaves and seeds from rubber trees (*Hevea brasiliensis*).

Leaves and seeds of rubber trees in Indonesia are still by-products that are not yet well utilized because only a small proportion of the seeds are used. Each tree is expected to produce 5,000 seeds per year[3]. According to Syahruddin *et al.*[4] and Giok *et al.*[5], rubber leaves include 14.60% crude protein, 8.98% crude fat, 17.81% crude fibre and 963 ppm hydrogen cyanide (HCN). Wizna *et al.*[6] and Toh and Chia[7], stated that rubber seeds contain 19.20% crude protein, 47.2% crude fat, 6.00% crude fibre and 573.72 ppm HCN. Its use in poultry rations is limited (5%) because of its high HCN content and bitter taste[8-10].

Processing using fermentation technology is one way to improve the nutritional value and treatment by soaking and boiling can reduce the content of HCN and coarse fibres in rubber leaves and seeds to increase quality. Wiseman[11] suggested that a fungus of the genus *Trichoderma spiralis* produces a more complete cellulose-breaking enzyme than any other mould. Fati[12] reported that rice bran fermentation with *T. spiralis* could increase crude protein from 8.74-14.66% and decrease crude fibre from 18.90-12.81%.

Broiler chickens are in great demand because their meat is tender but broiler chicken meat also has a high fat content; thus, some people fear consuming broiler chickens because fat accumulation in the body can lead to heart disease, stroke, obesity and other diseases. Thus, another benefit of rubber leaves and seeds, in addition to the utilization of plantation waste, is providing meat with a favourable content of crude fibre to reduce fat levels and prevent a decrease in consumption of broiler chickens caused by fear of the undesirable effects of broiler meat fat.

Therefore, research on feeding fermented leaves and seeds of the rubber tree (FSLRT) to broiler chickens is needed to understand the extent to which these resources can replace soybean meal and the effects of this substitution on measurable characteristics of meat.

MATERIALS AND METHODS

Research methods: The study took place over two years. During year 1: The best substrate to be used in broiler chicken rations was determined and During year 2: Observations were made on body weight gain, carcass percentage, meat-to-bone ratio, abdominal fat percentage, percentage of ventriculus by weight and intestinal thickness of broiler chickens fed rations containing selected FLSRT.

Research materials: This experiment was conducted for 8 weeks using 480 day-old broiler chicks of the Cobb strain. Chicks were housed in colonies in wire cages and each cage unit was equipped with a feeding area, a drinking area and an incandescent lamp.

The feed ingredients used for preparing the rations included fermented leaf powder and seeds fermented with *Trichoderma spiralis*, soybean meal, fish meal, yellow corn, fine bran, bone meal and premix A. All ration treatments were isocaloric and equal in protein content but differed in the percentage of each ingredient.

The composition of feed rations for livestock in Table 1 and the nutritional and energy content of rations in Table 2.

Research methods: The experiment on the chicken livestock rations was performed using a completely randomized design with 6 treatments and 4 replications.

The treatments were as follows:

- R0 0% FLSRT (control ration with no replacement of soybean meal)
- R1 replacement of 20% soybean meal protein with FLSRT
- R2 replacement of 40% soybean meal protein with FLSRT
- R3 replacement of 60% soybean meal protein with FLSRT
- R4 replacement of 80% soybean meal protein with FLSRT
- R5 100% replacement of soybean meal protein with FLSRT

Table 1: Composition of rations

	Experimental treatments					
Ingredients	R0	Rl	R2	R3	R4	R5
Corn	50	49.13	48.26	47.39	46.52	45.65
Soybean meal	20	16.00	12.00	8.00	4.00	0.00
FLSRT	0.0	5.87	11.74	17.61	23.48	29.35
Fine rice bran	15.5	14.50	13.50	12.50	11.50	10.50
Fish meal	13.5	13.50	13.50	13.50	13.50	13.50
Bone meal	0.5	0.50	0.50	0.50	0.50	0.50
Top mix	0.5	0.50	0.50	0.50	0.50	0.50
Total	100	100.00	100.00	100.00	100.00	100.00

Table 2: Nutritional and metabolic energy contents of the experimental rations

Components	R0	Rl	R2	R3	R4	R5
Crude protein (%)	21.680	21.590	21.490	21.400	21.310	21.210
Fat (%)	3.910	3.900	3.890	3.880	3.870	3.860
Crude fibre (%)	4.780	5.170	5.560	5.950	6.340	6.730
Ca (%)	1.230	1.210	1.290	1.220	1.200	1.180
P total (%)	0.680	0.690	0.700	0.710	0.720	0.730
ME (kcal kg^{-1})	2942.800	2940.300	2937.800	2935.300	2932.800	2930.300
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

Results of the calculations

Processing and analysis of data: All data obtained were analysed using analysis of variance (ANOVA) with a completely randomized design as described by Steel and Torrie[13]. Differences between treatments were tested by Duncan's multiple range test (DMRT).

Parameters observed: The parameters measured were weight gain, carcass percentage, meat-to-bone ratio, percentage of abdominal fat, percentage of ventriculus by weight and thickness of broiler chicken intestine.

RESULTS AND DISCUSSION

Effect of treatment on body weight increase, carcass percentage and meat-to-bone ratio of broiler chickens: The average weight gain, carcass percentage and meat-to-bone ratio of broiler chickens fed rations containing processed rubber leaves and seeds in lieu of soybean meal protein can be seen in Table 3. Body weight gain ranged from 2551.47-2665.68 g $head^{-1}$, carcass percentage ranged from 68.92-70.68% and the meat-to-bone ratio ranged from 2.19-3.11.

The results of ANOVA showed that replacement of up to 80% of soybean meal protein with processed rubber leaves and seeds in broiler rations had no significant effect ($p>0.05$) on body weight, carcass percentage, or meat-to-bone ratio. However, measurements of these parameters under replacement with 100% processed rubber leaves and seeds differed significantly ($p<0.01$) from other treatments.

Table 3 shows that the higher levels of processed rubber leaves and seeds substituted for soybean meal protein in the ration caused a highly significant decrease in broiler body weight gain that was maintained until 8 weeks of age ($p<0.01$). Furthermore, the DMRT results showed that measurements from treatment groups R0, R1, R2, R3 and R4 were not significantly different ($p>0.05$) but were significantly ($p<0.01$) higher than those from treatment group R5. Treatment groups R0, Rl, R2, R3 and R4 showed uniform ($p>0.05$) weight gain due to the same feed intake at each treatment, resulting in the same weight gain at the end of the study. In addition, similar weight gain in each treatment group was also due to the processed rubber leaves and seeds having optimal digestibility from fermentation processing; thus, leaf protein and processed rubber seeds can be used instead of soybean meal protein in the ration. In addition, the rate of growth is also determined by the degree of nitrogen retention of the material or ration given due to high protein digestibility; therefore, nitrogen retention will also be high[14]. Rough protein digestibility and nitrogen retention in leaf and processed rubber products used in this ration test were 76.77 and 74.19% and critical amino acids were methionine and lysine (0.365 and 1.33%), respectively.

The low weight gain of the R5 treatment group compared with other treatment groups is due to the presence of more processed leaves and seeds (29.35%), resulting in an increase in the amount of nucleic acid content in the ration[15]. High nucleic acid content would affect the need for Se in the body because some Single Cell Proteins have low Se content[16],

Table 3: Average weight gain, carcass percentage and meat-to-bone ratio during the study

Treatments	Increase in body weight	Carcass percentage (%)	Meat-to-bone ratio
R0	2665.22[a]	70.65[a]	2.94[a]
R1	2665.68[a]	70.68[a]	3.11[a]
R2	2665.48[a]	70.60[a]	3.07[a]
R3	2665.37[a]	70.55[a]	3.08[a]
R4	2665.21[a]	70.33[a]	3.06[a]
R5	2551.47[b]	68.92[b]	2.19[b]
Average	2641.08	70.864	2.91

Different letters in the columns indicate significant effects ($p<0.01$)

consequently making the ration deficient in Se. The alleged deficiency in Se in treatment R5 is supported by Succi *et al.*[17], who reported that the substitution of soybean meal with yeast PST without Se supplementation showed very slow chicken growth at 21 days. In addition, the low body weight gain with the use of 29.35% processed rubber leaves and 100% substitution of soybean meal protein with rubber in the ration is due to an increase in the crude fibre content of the ration, which was 6.73%. According to Soeharsono[18], to obtain optimal results, the coarse fibre content in broilers aged 8 weeks should not exceed 5.5%.

The carcass percentage measured in this study was higher than that reported by Kompiang *et al.*[19] (64.7-66.2%) and is in the range of carcass percentage of ready-to-cut broiler chickens, which is from 65-75%[20]. The R5 treatment had a highly significant effect ($p<0.01$). Carcass weight in this study shows different results due to different cut weights. A heavy carcass is strongly influenced by the live weight before the cut; the higher the live weight is before the cut, the higher the weight of the carcass produced. Nurhayati *et al.*[21] also noted that carcass production is closely related to the live weight or cutting weight; heavier livestock increases the carcass yield.

Feeding 23.48% FLSRT yielded equivalent chicken carcass percentages compared with feeding 0% FLSRT. This finding is seen in the higher average carcass percentages for the R0, R1, R2, R3 and R4 groups (70.65, 70.68, 70.60, 70.55 and 70.33%, respectively) compared to that for the R5 group. This observation is because the ration consumption in treatment groups R0, R1, R2, R3 and R4 was higher than that in group R5, resulting in a deficiency of nutrients needed for growth. In accordance with the opinion of Rasyaf[22], chickens consumed little ration and the nutrients received by the body were also low; thus, chickens will have nutrient deficiencies affecting their growth. The results of this study were higher than those of Ketaren *et al.*[23] showing that fermentation of palm kernels resulted in broiler chicken carcass percentages of 65.19-66.08%.

Meat-to-bone ratio: In general, a low percentage of meat is associated with a high percentage of bone and a high percentage of meat indicates a low percentage of bone. Meat-to-bone ratios produced by poultry greatly influenced carcass weight and other measures of body weight[24]. As shown in Table 3, the meat-to-bone ratio of the R5 treatment group (2.19: 1) was lower than that of the R0 (2.94: 1), R1 (3.11: 1), R2 (3.07: 1), R3 (3.08: 1) and R4 (3.06: 1) groups. This result is due to the consumption of rough fibres in different chicken rations in each treatment, affecting the growth of meat and bone. Soeparno[25] stated that during growth, bone grows continuously at a relatively slow rate, while muscle growth is relatively faster, so the ratio of muscle to bone increases during growth.

This difference in outcomes is likely to vary with different rough nutrient fibre rations; thus, the growth and development of different body components are also different. This result is in accordance with the opinion of Widodo *et al.*[26], who stated that every component of the body has a speed or development that varies due to the influence of nutritional rations. The use of a ration with a DBKF concentration of up to 23.48% promotes a better meat-to-bone ratio compared to a ration with a concentration of 29.35%.

Solangi *et al.*[27] stated that a nutritious ration is very important for the growth of muscle, which is the largest part of the carcass. Large quantities of meat showing high levels of protein metabolism in the body are better. The average meat-to-bone ratio in this study ranged from (2.19: 1) to (3.11: 1). Qotimah *et al.*[28] studied the effect of protein levels and katuk leaf supplementation on the meat-to-bone ratio, which ranged from (2.5: 1) to (4.7: 1).

Effect of Treatment on Percentage of Abdominal Fat, Percentage of Ventriculus by Weight and Intestinal Thickness. The average percentage of abdominal fat, percentage of ventriculus by weight and intestinal thickness in broiler chickens fed rations containing processed rubber leaves and seeds in lieu of soybean meal protein can be seen in Table 4. Abdominal fat percentage ranged from 1.69-1.83 g head^{-1}, percentage of ventricular weight ranged from 2.20-2.24% and intestinal thickness ranged from 0.310-0.312.

The results of ANOVA showed that the replacement of soybean meal protein with processed rubber leaf and

Table 4: Mean influence of treatment on percentage of abdominal fat (%), percentage of ventricular weight (%) and intestinal thickness (g cm^{-1}) of broiler chickens

Treatments	Percentage of abdominal fat (%)	Percentage of ventricular weight	Thickness of intestine
R0	1.83[a]	2.23[a]	0.310[a]
R1	1.83[a]	2.20[a]	0.312[a]
R2	1.82[a]	2.21[a]	0.311[a]
R3	1.82[a]	2.20[a]	0.312[a]
R4	1.81[a]	2.21[a]	0.311[a]
R5	1.69[b]	2.24[a]	0.312[a]
Average	1.80	2.22	0.311

Different letters in the columns indicate highly significant effects (p<0.01)

processed beans up to 100% in the broiler ration had no significant effect (p> 0.05) on ventricular weight and intestinal thickness but that substitution had a highly significant effect (p<0.01) on percentage of abdominal fat.

Percentage of abdominal fat: The data for percentage of abdominal fat in chickens fed FLSRT can be seen in Table 4.

FLSRT products in the diet resulted in lower percentages of abdominal fat (1.83, 1.83, 1.82, 1.82, 1.81 and 1.69%). These results are consistent with coconut cake fermentation research reports, which also indicate the possibility of lipase activity during the fermentation process that inhibits fat accumulation in the body[29].

Likewise, increasing levels of FLSRT products in the diet resulted in lower abdominal fat levels. Similarly, Maurice and Jensen[30] reported a decrease in fatty liver content from including granulated fermented residue products in laying hens' rations. When compared with control rations, abdominal fat content decreased in chickens fed 29.35% FLSRT.

Increased levels of FLSRT in the ration automatically increased the levels of crude fibre, causing a decrease in abdominal fat content in chickens that consumed the ration with an FLSRT content of 29.35%. Jorgensen *et al.*[31] suggested that increased consumption of fibre by broilers causes the retained energy from feed to be more widely used for protein formation than stored as fat. Other researchers have also reported that elevated levels of dietary fibre may cause decreases in blood and plasma lipid levels in broiler liver[32]. This result is because the fibre that comes from the food binds the bile acids in the digestive tract. Before assisting in the absorption of fat, bile acids that have been bound by the fibres are removed by the body in the form of impurities. To replace lost bile acids, the fat in the body will be overhauled such that a greater amount of fibre removes more bile acids, resulting in more fat being removed from the body; thus, the fat content in the body will decrease[33,34].

The results of this study were higher than those of Ketaren *et al.*[23] who used fermented palm kernel cake and found that the average abdominal fat of broiler chickens ranged from 1.61-1.30%.

Ventricular weight percentage data of broiler chickens fed FLSRT can be seen in Table 4.

The result of the diversity analysis showed that the FLSRT treatment had no significant effect (p>0.05) on the percentage of ventricular weight and that the ration treatment had no significant effect (p>0.05), meaning that 29.35% FLSRT with 6.73% crude fibre can still be tolerated by the ventriculus. In accordance with the research of Febriyenti[35], the use of 25% fermented tofu dregs (FTDs) with 7.23% crude fibre can still be tolerated by the ventriculus. The results of this study are still consistent with those of Putnam[36], who showed that the percentage of the ventricular weight is 1.6-2.3% of the live weight. Data on the thickness of the small intestine of broiler chickens treated with FLSRT can be seen in Table 4.

The result of the diversity analysis showed that the FLSRT ration had no significant effect (p>0.05) on the thickness of the small intestine, meaning that up to 29.35% FLSRT in the ration did not affect or cause damage to the small intestine. The coarse fibres contained in the 29.35% FLSRT ration can still be tolerated, so as not to damage the small intestine and fibre is needed to improve the absorption of nutrients by decreasing the mucous in the small intestine.

The use of up to 29.35% FLSRT with 6.73% crude fibre in rations can still be tolerated. This result is in accordance with a study by Febriyenti[35], which showed that the use of up to 25% fermented sago hampas with 7.23% crude fibre in the ration did not cause thinning of the mucous wall of the small intestine because certain crude fibres are required by poultry to expedite the elimination of undigested food. The results of this study are still in accordance with Syahruddin[37] on the influence of various crude fibres in the ration at levels of 0.31, 0.29 and 0.27 g cm^{-1}.

CONCLUSION

Broiler chicken production, especially body weight increase, carcass percentage, meat-to-bone ratio, percentage of abdominal fat, percentage of ventriculus weight and broiler intestinal thickness, is not substantially influenced by the use of up to 29.35% FLSRT in feed rations. Fermented rubber leaves and fermented seeds of *Trichoderma spiralis* can replace up to 80% of soybean meal as a protein source in broiler chicken rations.

SIGNIFICANCE STATEMENT

This study found that in order to improve the quality of broilers and ducks, substituting rubber leaves and seeds processed by microbes for soybean meal (imported commodities) can be beneficial as a feed ingredient in the preparation of chicken and duck rations.

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