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Full Length Research

Addition of *Spirogyra* sp. flour on fat digestibility, fatty meat and carcass weight of broiler chicken

Lilik Krismiyanto[1], Ananta Putra Kanoko[2], Vitus Dwi Yunianto[1] and Mulyono[1*]

[1]Department of Animal Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.
[2]Bachelor Study Program of Animal Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.

*Corresponding author. Email: qmulyo@gmail.com

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ABSTRACT: The study aimed to assess the effect of adding *Spirogyra* sp. flour in the diets on crude fat digestibility, meat fat mass, relative weight of abdominal fat, and carcass weight of broiler chickens. The experimental animals were 200 unsexed Cobb strain broiler chickens aged 11 days with an average body weight of 201.21 ± 6.11 g. The feed used has a metabolic energy of 3,002.74 kcal/kg and a crude protein of 21.12%. *Spirogyra* sp. flour was used as a feed additive. The study was arranged in a completely randomized design with 5 treatments and 4 replicates so that there were 20 units, and each unit contained 10 birds designated as treatments used were T0 (standard feed), T1 (standard feed + 0.5% *Spirogyra* sp. Flour), T2 (standard feed + 1.0% *Spirogyra* sp. Flour), T3 (standard feed + 1.5% *Spirogyra* sp. Flour), and T4 (standard feed + 2.0% *Spirogyra* sp. Flour). Parameters measured included fat digestibility, meat fat mass, abdominal fat relative weight, and carcass weight. Data were processed using analysis of variance and Duncan's test at the 5% error level. The results showed that the addition of *Spirogyra* sp. flour to the diet had a significant effect ($p<0.05$) on the digestibility of crude fat, meat fat mass, relative weight of abdominal fat, and carcass weight. The research concludes that adding *Spirogyra* sp. flour as much as 2.0% in the diet can reduce the digestibility of crude fat, meat fat mass and relative weight of abdominal fat and increase the carcass weight of broiler chickens.

Keywords: Broiler chicken, carcass, fat digestibility, fatty meat, *Spirogyra* sp.

INTRODUCTION

Broiler chickens as a source of animal protein in Indonesia have advantages including fast meat production, high level of ration efficiency and harvest can be achieved in five weeks with a body weight of 1.7 to 2 kg/bird. But behind these advantages, a lot of fat is stored in the form of abdominal fat and meat fat. Salam *et al*. (2013) reported that intensively reared broilers produced a carcass fat content of 18%. Fat accumulation causes a decrease in carcass quality and affects the growth of broilers. Some of the alternatives to reduce fat content in carcasses can be added to broiler feed. Among the alternatives used is an additive obtained from *Spirogyra* sp.

The plant *Spirogyra* is a genus of green algae that lives in freshwater. *Spirogyra* sp. has the potential to be utilized as a livestock supplement. This is because *Spirogyra* sp. contains phytochemical components (alkaloids, steroids, flavonoids, tannins, and terpenoids) that are able to work as pathogenic antibacterials because they can inhibit the growth activity of *Escherichia coli* and *Candida albicans* bacteria (Rutikanga *et al*., 2014). Saragih *et al*. (2019) stated that the addition of *Spirogyra jaoensis* flour at 2.0% in the feed can increase the appearance of the small intestine (villi of each small intestine) and the growth of broiler chickens. Champa *et al*. (2015) reported that

Spirogyra sp. contains gallotannin 2.7 mg/g; saponin 2.5 mg/g; phenol 3.6 mg/g; and flavonoids 3.1 mg/g.

The use of *Spirogyra* sp. flour as a broiler ration additive works by utilizing secondary metabolites or active compounds such as flavonoids. Flavonoids as antibacterials have the ability to inhibit pathogenic bacteria (Gorniak *et al*., 2019). A decreased population of pathogenic bacteria can increase the population of lactic acid bacteria (LAB). High lactic acid bacteria can create low (acidic) pH conditions in the small intestine (Wang *et al*., 2018). This condition on the one hand increases the LAB population by producing the enzyme bile salt hydrolase (BSH), while on the other hand, pathogenic bacteria can be inhibited. The BSH enzyme has the ability to deconjugate bile salts which causes fat not to be emulsified and absorbed so that it comes out through excreta (Dwiputra *et al*., 2020). The resulting weight gain can be accompanied by improved carcass quality and low-fat meat.

Based on the description above, the study aimed to evaluate the effect of *Spirogyra* sp. flour in the ration of broiler chickens on its fat digestibility, meat fat mass, abdominal fat mass, and carcass weight.

Table 1. Composition and nutrient content of research rations.

Feed stuff	Composition ((%)
Yellow corn	51.71
Pollard	15.74
Soybean meal	21.70
Meat Bone meal	10.00
$CaCO_3$	0.30
Premix	0.25
Lysine	0.10
Methionine	0.20
Total	100.00
Nutrient content	
Metabolizable energy (kkal/kg)**	3002.74
Crude protein (%)*	21.12
Crude fat (%)*	4.22
Crude fiber (%)*	4.89
Calcium (%)*	1.07
Phosphorus (%)*	0.73

Source: *Proximate and mineral analysis results at the Animal Nutrition Science Laboratory, Faculty of Animal and Agriculture Sciences, Diponegoro University (2024); ** Metabolizable energy was calculated using the Bolton formula (1967).

MATERIALS AND METHODS

Livestock management

The experimental animals used were 11-day-old *Cobb* strain unsexed broilers with an average body weight of 201.21±6.11 g. *Spirogyra* sp. flour was used as a feed additive. The ingredients of the ration are listed in Table 1 with a metabolic energy content of 3,002.74 kcal/kg and a crude protein content of 21.12%. Materials used in data collection include; Fe2O3 indicators, labels, and 0.2 N HCl while the equipment used during bird management are; the cages, a partition made of bamboo measuring 1 × 1 m, a ration holder, a drink holder, a digital scale with an accuracy of 1 g with a capacity of 10 kg, a 60-watt lamp, a thermo-hygrometer, a disinfectant sprayer, a digital scale with an accuracy of 1 g with a capacity of 10 kg. Data collection equipment includes; excreta containers, battery cages, HCl sprayers and digital scales with an accuracy of 1 g with a capacity of 10 kg.

Experimental procedure and design

Fresh *Spirogyra* sp. was dried in the sun with a protective cloth. The dried *Spirogyra* sp. was pulverized using a grinder with a particle size of 80 mesh.

The cages used were stage cages made from wood as the frame, bamboo splits as the floor, and zinc as the roof. A total of 20 experimental unit cages of size 1 × 1 m were arranged. Cages were first cleaned using running water and detergent. Thereafter, the experimental unit cages were limed and fumigated using formalin and $KMNO_4$.

The research design was a complete randomized design (CRD) with 5 treatments and 4 replicates so that there are 20 units, and each unit is filled with 10 birds. The treatments used are as follows:

T0 = Standard feed
T1 = Standard feed + 0,5% *Spirogyra* sp. flour
T2 = Standard feed + 1,0% *Spirogyra* sp. flour
T3 = Standard feed + 1,5% *Spirogyra* sp. flour
T4 = Standard feed + 2,0% *Spirogyra* sp. flour

The treatments were given every morning by serving 20% of the ration consumption, the basal ration was served daily when the experimental feeds were exusted.

Parameters measured included crude fat digestibility, meat fat mass, abdominal fat weight, and carcass weight. Crude fat digestibility was measured using the total excreta collection method with a combination of Fe_2O_3 indicators for 4 days on days 33 to 36. Chickens used for total collection were taken randomly in each experimental unit based on the average body weight. Chickens on the first and third days were given rations and indicators, then red excreta were collected. Chickens on the second and fourth days were given rations without indicators with the same rations and methods as the first day, with excreta that was not red collected. During containment, excreta was sprayed with 0.2 N HCl every 2 hours to prevent N

volatilization and cleaned of fur and ration contaminants, then weighed as fresh weight. After weighing, the excreta was weighed under the sun with cloth protection to dry and weighed as air-dry weight. The crude fat content of excreta was analyzed in the laboratory. Crude fat consumption data was obtained by calculating the total ration consumed multiplied by the crude fat content of the ration. Crude fat digestibility measurements were calculated using the formula according to Krismiyanto *et al*. (2020) as follows:

$$FD\ (\%)\ = \frac{\textit{Fat intake - Amount of excreta fat}}{\textit{Fat intake}} x\ 100$$

WhereFD = Fat Digestibility

Meat fat mass, abdominal fat weight and carcass weight were measured at 35 days of chicken's age. One chicken was sampled based on the average weight per flock. Chickens were slaughtered by cutting their necks with a sharp knife and the carcasses were de-feathered, thereafter , heads, and digestive organs were removed. Abdominal fat was separated from the abdominal cavity and weighed. Carcasses were weighed using a digital scale as carcass weight. Meat and bones were separated and weighed. The meat obtained was pulverized with a blender and analyzed for crude fat content in the laboratory. Meat fat mass was calculated by the formula according to Krismiyanto et al. (2020) as follows:

$$\text{RWAF} = \frac{\textit{abdominal fat weight}\ (g)}{\textit{live weight (g)}} \times\ 100$$

Meat fat mass (g) = meat fat content (%) x meat weight (g)

Where: RWAF = Relative Weight of Abdominal Fat.

The carcasses measured were chicken body parts without blood, feathers, legs, head, neck and all contents of the abdominal cavity except liver, gizzard and heart. The resulting carcasses were weighed using a digital scale.

Data were analyzed using analysis of variance applying SPSS 16.0 statistical software. Duncan's multiple range tests examined the differences between the treatments′ means at a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Fat digestibility

The addition of *Spirogyra* sp. flour to the ration has a significant effect ($p<0.05$) on the digestibility of crude fat in broiler chickens (Table 2). The treatment of adding *Spirogyra* sp. 1% to 2% (T2, T3, and T4) resulted in a significantly ($p<0.05$) lower crude fat digestibility than without the addition of *Spirogyra* sp. (T0). This may occur because the role of flavonoids in *Spirogyra* sp. can reduce the population of *E. coli*. An increase in the LAB population can result in a decrease in pH, so the higher the concentration of LAB, the lower the pH condition (Cahyaningsih *et al*., 2013). The pH conditions also affect the development of LAB and *E. coli*, so a pH atmosphere that supports an increase in total LAB will cause total *E. coli* in the chicken intestine to tend to decrease (Rahmah *et al*., 2013). The lactic acid bacteria can produce the enzyme bile salt hydrolase (BSH) to deconjugate bile salts in the small intestine of chickens so that they are more easily eliminated with excreta (Cholis *et al*., 2014). An increased LAB population can increase the production of BSH enzymes, resulting in higher bile salt deconjugation in the small intestine (Geng and Lin, 2017). A decrease in bile salts can result in a decreased, amount of emulsified fat and absorbed fat so that it is eliminated with excreta (Leke *et al*., 2019). A decrease in bile salts also decreases the intracellular enzyme activity of bacteria towards bile salts, thus decreasing the permeability of the cell membrane which leads to an increase in LAB population Ridlon *et al*., 2016).

Treatments T2, T3 and T4 produced crude fat digestibility that were significantly different ($p>0.05$) from treatment T1. This could be due to the role of flavonoids in *Spirogyra* sp. at these levels resulting in the same crude fat digestibility. Crude fat digestibility is also influenced by chicken endogenous fat in the form of bile acids. Endogenous fat is produced through fat metabolism in the chicken liver (Geng *et al*., 2022). Bile acids, which are secreted by the liver, also make up a large portion of the endogenous fat in chickens (Tancharoenrat *et al*., 2014).

The T1 treatment produced crude fat digestibility that was not significantly different ($p>0.05$) from the T0 treatment. This is because the role of flavonoids in *Spirogyra* sp. at the level of 0.5% has not been able to significantly reduce crude fat digestibility. This is supported by the population of LAB and *E. coli*, as well as the pH condition of the small intestine of the T1 treatment which is not significantly different ($p>0.05$) with T0. Research conducted by Choi *et al*. (2014) that adding seaweed supplements at a rate of 5 g/kg improved the feed conversion efficiencyt.

Relative weight of abdominal fat

The addition of *Spirogyra* sp. flour to the diet had a significant effect ($p<0.05$) on the relative weight of abdominal fat in broiler chickens (Table 2). Treatments T3 and T4 produced a significantly ($p<0.05$) lower relative weight of abdominal fat than treatments T0, T1, and T2. This may occur because the role of flavonoids in *Spirogyra* sp. can increase the LAB population. Flavonoids act as pathogenic antibacterial so that there is an increase in LAB (Gorniak *et al*., 2019). The LAB populations produce BSH

Table 2. Fat digestibility, meat fat mass, relative weight of abdominal fat and carcass weight.

Treatment	T0	T1	T2	T3	T4
Fat digestibility (%)	85,49±2,26^{a}	82,42±1,74^{ab}	81,38±3,78^{b}	79,41±1,69^{b}	78,50±2,57^{b}
Meat fat mass (mg)	66,19±7,74^{a}	62,17± 8,43^{ab}	53,48±4,86^{bc}	45,65±3,91^{cd}	40,73±6,25^{d}
Relative weight of abdominal fat (%)	1,02±0,13^{a}	0,75±0,09^{b}	0,71±0,06^{b}	0,40±0,07^{c}	0,39±0,03^{c}
Carcass weight (g)	1.048,25±43,18^{c}	1.085,50±73,07^{bc}	1.143,50±75,49^{abc}	1.166,75±56,36^{ab}	1.186,25±50,01^{a}

Different superscripts on mean values indicate significant differences ($p<0.05$).

to deconjugate bile salts so that they are not easily digested into adipose fat (Cholis *et al*., 2014; Jim, 2013). Decreased absorption of fat in the form of bile salts is characterized by decreased fat digestibility at T3 and T4.

The T4 treatment produced the same abdominal fat relative weight ($p>0.05$) as the T3 addition treatment. This may occur due to the role of flavonoids in *Spirogyra* sp. producing the same relative weight of abdominal fat. Fat digestibility presented in Table 2 shows that the T3 and T4 treatments produced the same fat digestibility ($p>0.05$). Fat digestibility is related to fat metabolism that occurs in livestock (Moningkey *et al*., 2019). The level of crude fat digestibility is related to the level of fat absorption in the digestive tract in the form of bile salt micelles which are reabsorbed and channeled to the liver and carcass to be stored in the form of fat deposits and meat fat (Letis *et al*., 2017).

Treatments T1 and T2 produced a significantly ($p<0.05$) higher relative weight of abdominal fat than T3 and T4, but significantly ($p<0.05$) lower than T0. This could be due to the role of flavonoids at different levels of *Spirogyra* sp. administration which resulted in different abdominal fat weights. This is supported by research conducted by Ncube *et al*. (2018) that the role of flavonoids in the inclusion up to 5% had no deleterious effect on growth, carcass yield and meat quality of broiler chicks.

Meat fat mass

The addition of *Spirogyra* sp. flour to the diet had a significant effect ($p<0.05$) on meat fat mass in broiler chickens (Table 2). Treatment T4 produced meat fat mass that was not significantly different ($p>0.05$) from treatment T3. This could be due to the role of flavonoids in *Spirogyra* sp. at these levels which produced the same meat fat mass. This is supported by fat digestibility in T4 also not significantly different from T3 (Table 2). The amount of digested ration fat affects meat fat mass through the exogenous pathway of fat metabolism (Cahaya and Ayu, 2017).

Treatment T4 produced significantly ($p<0.05$) lower meat fat mass compared to treatments T0, T1 and T2. This could be due to the antibacterial role of flavonoids that reduce the population of pathogenic bacteria. The decreased *E. coli* population, increased LAB and decreased pH of the small intestine in treatment T4 compared to T0, T1 and T2 support the antibacterial ability of flavonoids. The LAB population plays a role in producing BSH enzymes in reducing fat absorption (Wahyuni *et al*., 2019). Bile salt hydrolase works to deconjugate bile salts, making them easier to excrete (Horackova *et al*., 2018). Bile salts that are eliminated with excreta result in a reduced amount of fat deposition, resulting in decreased meat fat mass (Ravindran *et al*., 2016). The significant difference in meat fat mass in T4 and T2 was not supported by fat digestibility in Table 2. This could be due to the presence of endogenous fat that contributes to fat digestibility. Endogenous fat is the result of synthesis from several body tissues such as the liver (Putra and Tiring, 2020).

The T3 treatment produced meat fat mass that was not significantly different ($p>0.05$) from the T2 treatment but produced a significantly ($p<0.05$) lower meat fat mass than the T0 and T1 treatments. This is because the role of flavonoids in the T3 and T2 treatments produces the same meat fat mass. The T1 treatment produced meat fat mass that was not significantly different ($p>0.05$) compared to the T0 addition treatment. This can occur because the addition of *Spirogyra* sp. flour at the level of 0.5% has not been able to reduce the fat mass of broiler meat. The high meat fat mass in T0 can be caused by the absence of *Spirogyra* sp. flour. Competition between LAB and pathogenic bacteria is complex and competitive (Wang *et al*., 2017). This has an impact on the high-fat content of meat because the production of BSH from LAB does not increase. Bile salts that are not deconjugated by BSH cause excessive fat to be stored in the body (Jim, 2013).

Carcass weight

The addition of *Spirogyra* sp. flour to the diet had a significant effect ($p<0.05$) on carcass weight in broiler chickens (Table 2). Treatment T4 produced carcass weights that were not significantly different ($p>0.05$) from treatments T2 and T3. This could be due to the role of flavonoids in *Spirogyra* sp. flour at these levels producing

the same carcass weight. Protein absorption has an impact on animal productivity, especially on carcass weight and fat content (Baeza *et al*., 2022). The T4 treatment produced a significantly ($p<0.05$) higher carcass weight than the T0 and T1 treatments. This can be due to the antibacterial role of flavonoids in increasing the LAB population so that nutrient absorption increases as a result of improved digestive tract health (Singh *et al.*, 2019).

The T1 treatment produced carcass weights that were not significantly different ($p>0.05$) from the T0, T2, and T3 treatments. This could be due to the role of flavonoids in *Spirogyra* sp. in treatments T1 to T3 producing the same carcass weight but less than T4. The effectiveness of flavonoids as acidic polyphenolic compounds can be known through the pH condition of the chicken digestive tract, LAB population, and crude protein digestibility. The T0 treatment was significantly ($p<0.05$) lower than the T3 and T4 treatments. This condition was supported by higher fat digestibility, the relative weight of abdominal fat and meat fat mass of broiler chickens.

Conclusion

The addition of *Spirogyra* sp. flour as much as 2% in the diet can reduce the digestibility of crude fat, meat fat mass and relative weight of abdominal fat and increase the carcass weight of broiler chickens.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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