The effect of Kelor (Moringa oleifera) seed meal on productive performance, carcass traits, and meat cholesterol of broiler chickens

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Abstract. Kelor seed meal has been believed to be rich in protein and available in many tropical countries. A study was conducted to determine the effect of kelor seed meal on productive performance, carcass traits, and meat cholesterol of broiler chickens. The study used a total of 100 day-old-unsexed Cobb broiler chicks. The birds were distributed into 5 brooders for one week. On day 3, the chicks were vaccinated against New Castle diseases. On days 7, the chicks were transferred into 20 pens. The birds were fed 5 experimental diets throughout the study according to a completely randomized design. The experimental diets were 0, 2, 4, 6, and 8% kelor seed meal, respectively. The diets and water were supplied ad-libitum. Parameters measured were feed intake, body weight gain, FCR, meat cholesterol, carcass and non-carcass percentage. The data found in this study were subject to the analysis of variance. The differences detected in the analysis of variance were further tested with the Tukey test. The results of the study showed that supplementation of the diets with kelor seed meal did not affect (P>0.05) feed intake, percentages of the carcass, meat, and bone. Bodyweight gain, FCR, meat, and abdominal fat and meat cholesterol were significantly (P<0.05) affected by the treatments. In conclusion, the addition of 2% to 8% kelor seed meal in the diet increased body weight gain with the highest body weight gain of birds fed the 6% and 8% kelor seed meal. Percentages of fat and cholesterol were lower in birds fed the diets containing kelor seed meal.

1. Introduction

Moringa oleifera (kelor) is a tropical plant that could grow well in dry areas. Palu City and its surroundings are areas where the dry season is longer than the rainy season. Accordingly, this plant can easily grow in the city of Palu and its surroundings. One of the favorite menus that are often present at various traditional party events in Palu is vegetables deriving from this plant. The part of the plant that is mostly used for human consumption in Central Sulawesi is from its leaves. The pods containing seeds are scarcely utilized for human food and thus this part of the plant was thrown away as waste.

The poultry industry has been growing so fast over the last three decades. This condition triggers the increased need for raw materials of feed. Efforts to obtain local non-conventional feed raw materials have been done, particularly from agricultural by-products such as copra meal [1], rice bran [2], and palm kernel meal [3]. Technologies of enzyme application [3] and fermentation [4] have been applied to improve the quality of agricultural by-products, but with limited success. Finding out a prospective high-quality feedstuff becomes a must to meet the increasing demand for feedstuffs for poultry. Moringa pods can be used as an alternative raw material for feed because their use as food is hardly utilized in...
Central Sulawesi. Studies on the use of kelor as poultry feed rely more on the use of its leaves than pods. This is understandable because the availability of kelor leaves is much more abundant than kelor pods. Research on the use of kelor pods as poultry feed is still relatively few.

Researches on the use of kelor pods for poultry are more directed to function as a feed additive used with small concentrations in feed [5]. This is understandable because the use of kelor pods either for humans and animals is still directed towards health, such as prebiotics [6], immune modulators, and antioxidants [7]. There has not been much research to use kelor pods as a feed ingredient, even though the nutritional content of kelor seeds is very good. According to Ashour et al. (2020), kelor seeds contain about 39.5% protein, 39.4% ether extract, and only 4.9% crude fiber [5]. This high nutrient content indicates that the use of kelor seeds as a feed ingredient is very prospective. Accordingly, a study on the use of kelor seeds has been carried out.

2. Materials and methods

2.1. Kelor seed meal

The kelor pods were locally collected. The pods were peeled and the seeds were taken out. The seeds were sun-dried for 3 consecutive days until the colour of the seeds got brown. The dried kelor seeds were ground to pass through 1–2 mm screen size. The finely ground kelor seed meal was analyzed for proximate fractions [8] and calcium and phosphorous contents. The ground kelor seed meal was used as a feed ingredient.

2.2. Experimental broilers and cages

A total of 100-day old chicks obtained from PT Charoen Pokphand Makassar were purchased and individually weighed and used in this study. The freshly arrived chicks were immediately given sugar water to recover the lost energy during transport. The chicks were then offered commercial multivitamins to minimize transportation stress. The birds were distributed into 20 pens with slat floor with a size of 1.0×1.0×0.5 m³ each pen. A total of 5 chicks were allocated in each pen. During the first week, the pen was heated using a 60-watts bulb. After a week in the heater or brooder, the temperature was decreased by changing the 60-watts bulb to a 40-watt bulb which only functions as lighting. A plastic feeder and plastic drinker were placed inside each pen. New Castle diseases vaccination was administered through eye drops when the birds were 3 days old and it was repeated at days 21 through mouth drops. The broiler chickens were kept for 6 weeks. The pens, the drinkers, and surroundings were regularly cleaned.

2.3. Diets and feeding

All the feed ingredients were purchased from the local poultry shop. The experimental diet was formulated by using UFF software [9]. The feed ingredients were mixed by using a horizontal feed mixer. A single formulated diet with 20% protein and 3,000 kcal/kg metabolizable energy was used throughout the study. The birds were fed with the same diet without differentiating the growth phase. The experimental diets (see table 1) were 100% control diet (R0), 98% control feed + 2% kelor seed meal (R1), 96% control feed + 4% kelor seed meal (R2), 94% control feed + 6% kelor seed meal (R3) and 92% control feed + 8% kelor seed meal (R4). The experimental diets were offered ad-libitum. Drinking water for the birds was provided at all times.

2.4. Parameters measured

The parameters measured in this study were feed consumption (g), body weight gain (g), feed conversion ratio, carcass (%), components of the carcass (%), percentages of meat, bone and fat, cholesterol content, abdominal fat and meat fat. At the end of the experiment, the birds were slaughtered, plucked and eviscerated after the removal of internal organs, shank, and head [10]. The carcasses were individually weighed and dissected for the measurement of the carcass components (breast, thigh, drumstick, and wings). After weighing all the parts of the chicken, a separation between the meat and bone was done.
to measure the weight and percentages of bone and meat. The meat was analyzed for fat content based on AOAC (1990) [8] method to have data on total fat content.

| Feed ingredients (%) | Treatments |
|----------------------|------------|
|                      | R0         | R1         | R2         | R3         | R4         |
| Maize                | 55.0       | 55.0       | 55.0       | 55.0       | 55.0       |
| Rice bran            | 6.0        | 6.0        | 6.0        | 6.0        | 6.0        |
| Copra meal           | 10.0       | 8.0        | 6.0        | 4.0        | 2.0        |
| Full fat soybean meal| 15.0       | 15.0       | 15.0       | 15.0       | 15.0       |
| Fish meal            | 13.0       | 13.0       | 13.0       | 13.0       | 13.0       |
| Premix               | 1.0        | 1.0        | 1.0        | 1.0        | 1.0        |
| Kelor seed meal      | 0.0        | 2.0        | 4.0        | 6.0        | 8.0        |

Calculated nutrients

| Protein (%)         | 20.15      | 20.29      | 20.44      | 20.58      | 20.73      |
| Lipid (%)           | 5.34       | 5.21       | 5.08       | 4.95       | 4.82       |
| Metabolizable energy| 3032       | 3028       | 3010       | 3009       | 3009       |
| Crude fibre (%)     | 4.46       | 4.23       | 4.01       | 3.78       | 3.56       |
| Ca (%)              | 0.61       | 0.71       | 0.82       | 0.92       | 1.03       |
| P (%)               | 0.35       | 0.39       | 0.43       | 0.47       | 0.51       |

2.5. Data analysis
The study used a completely randomized design, 5 treatments with 4 replications and 5 chickens in each cage. Data were analyzed by analysis of variance [11], if there are any differences among treatments, The least significant difference test was applied by using the Minitab statistical program [12].

3. Results and discussion

3.1. Results
The results of proximate and mineral analyses were that kelor seed meal contained 28.27% protein, 5.18% crude fiber, 5.21% lipid, 5.48% Calcium, and 2.66% phosphorous. Data on feed intake, body weight gain, feed conversion ratio, carcass percentage, and the component of the carcass are presented in table 2. Data on percentages of meat, bone, lipid, meat cholesterol, and abdominal fat are shown in table 3. Analysis of variance indicated that body weight gain, feed conversion ratio, fat percentage, cholesterol content, and abdominal fat were significantly affected (P<0.05) by the treatment diets. Feed intake, components of carcass, and percentages of meat and bone were not statistically affected (P>0.05) by the treatments.

3.2. Discussions
Kelor (Moringa oleifera) seed meal used in this study contains 28.27% protein concentration. This figure seems to be lower than reported by Anwar and Rashid (2007) and NRC (1994) that the protein content of kelor seed meals was 31.7 and 36.7%, respectively [13,14]. This difference in protein content of kelor seed meal might be due to the plant origin and the nitrogen concentration of the soil. The most striking difference was the lipid content. Two previous studies indicated that the lipid content of kelor seed meal was 39.4% [5] and 34.8% [13]. The lipid content of kelor seed meal used in this present study (5.2%) was far below the lipid content reported by Ashour et al (2020) and Anwar and Rashid (2007) [5,13]. The calcium (5.48%) and phosphorous (2.66%) contents of kelor seed meals were relatively high. These minerals concentration can meet the requirements of calcium and phosphorous for poultry at any growth and production phase [14].
Studies of the use of kelor seed meal on the growth performance of broiler chickens have been done by several researchers [15,16]. Abbas and Ahmed (2012) found that the addition of kelor seed meals could not increase the body weight gain of broilers, even a decreased body weight gain was found in the starter period [16]. However, different results were found in this current study. Supplementation of the diet with between 2% and 8% kelor seed meal increased body weight gain significantly. The increase in body weight gain due to the supplementation of kelor seed meal might be due to the fact that this feedstuff is rich in amino acids [17]. The high concentration of antioxidants such as ascorbic acids, carotenoids, and flavonoids [13,18] might add up the efficacy of using this feedstuff in poultry diets. The increased body weight gain of broilers due to the increasing level of kelor seed meal reached the maximal inclusion of 6% in the diet. Increasing the inclusion level to 8% in the diet, body weight gain remained stagnant to the same level of body weight gain of birds fed the 6% kelor seed meal in the diet. The increased body weight gain of broilers was nothing to with feed intake as feed intake was statistically the same among all treatments. Since the chickens consumed feed to fulfill their energy requirements, the same metabolizable energy content of the diets might be the main reason for the unimproved feed intake. The feed intake of broilers in this current study ranged from 3,671 to 3,700 g/broiler. A study of Elbushra et al [19] indicated that feed intake of broilers fed the diets supplemented with kelor seed meal decreased. The authors speculated that the decreased feed intake might be due to the presence of saponins causing a bitter taste of kelor seed meal. The feed conversion ratio of birds fed the diets supplemented with kelor seed meal was better than the control birds because of the better growth rate. The feed conversion ratio of birds fed the kelor-supplemented diets decreased by between 7.1% and 14.3%.

Although the carcass percentage of the experimental broiler was not significantly affected by the treatment diets in this present study, the broiler chickens fed the diets supplemented with 6 and 8% kelor seed meal had bigger breasts. This might indicate that muscle development in the broilers fed the 6 and 8% kelor seed meal underwent good growth rather than bone development. This speculation was based
on the fact that the main component of the breast is muscles, while the other parts of the carcass had a significant portion of the bone. The results of this study were contrary to the study of Elbushra et al (2019), who found that carcass percentage was heavier in birds fed the diets supplemented with kelor seed meal [19].

Proportions of meat and bone of the broilers in this study were not significantly affected by the treatment diets. The percentage of meat was between 60.3% and 61.4% while the bone percentage of the experimental broilers was between 14.93% and 15.95%. The total fat, on the other hand, was affected by the treatment diets. The total fat decreased linearly over the increased kelor seed meal in the diet. The higher concentration of the kelor seed meal was the lower total fat content. This might indicate that kelor seed meal could bind fat and bring the fat out of the digestive tract. This speculation needs to be verified by measuring the fat digestibility. Accordingly, a study is needed to prove the speculation.

A study on the effect of kelor seed meal on blood cholesterol of laying hens has been done by Ashour et al [5]. The authors found that blood cholesterol dropped significantly due to the addition of kelor seed meal in the diets. The low level of blood cholesterol found in the study of Anshour et al (2020) might take place in the birds used in this present study and thus produce a lower level of meat cholesterol [5]. The modus operandi of decreased cholesterol meal due to kelor seed meal addition is not yet clear. It might be through two mechanisms. First, the specific fiber from kelor seed meal possibly binds cholesterol. Because of the indigestibility of the fiber, the bound cholesterol flows out the digestive tract along with the fiber of kelor seed meal. According to Supadmo (1997), the addition of fibrous feedstuffs could bind bile salt which contains cholesterol and is excreted through the excreta [20]. Second, kelor seed meal probably increased the population of beneficial bacteria such as Lactobacillus. The antibiotic properties of kelor seed meal have been reported by Abbas (2013) [21] due to the presence of phenolics and flavonoids contents [13]. The increased population of lactobacillus in the digestive tract of broilers fed the diets supplemented with kelor seed meal led to a decreased pH of the digestive tract. The acid condition of the tracts could decrease cholesterol concentration [22]. The mechanism for reducing cholesterol occurs because lactic acid bacteria degrade cholesterol to become coprostanol. Coprostanol is a substance that cannot be absorbed by the intestine, then coprostanol and the remaining cholesterol can be excreted with feces [23].

Meat fat and abdominal fat of experimental broilers in this current study were about 4.98 to 26.7% and 1.07 to 2.42% respectively. The lower content of meat fat and abdominal fat of broilers fed the kelor seed meal diet than the control birds were probably due to the same mechanisms of the decreased cholesterol concentration. The decreased cholesterol, meat fat and abdominal fat due to kelor seed meal supplementation can be an indicator that this feedstuff is the potential to be used to produce healthy poultry meat.

4. Conclusion
The addition of 2% to 8% kelor seed meal in the diet increased body weight gain with the highest body weight gain of birds fed the 6% and 8% kelor seed meal. Percentages of fat and cholesterol were lower in birds fed the diets containing kelor seed meal.

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