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Optimization of Noni Fruit Addition to "Cinnamononi" Extract Formula on Protein Efficiency Ratio, Nitrogen Retention, and Metabolic Energy in Broiler Chickens

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Abstract | This study aimed to evaluate the effect of increasing the proportion of noni fruit in the composition of Cinnamononi extract raw materials (a mixture of cinnamon leaves, noni leaves, and noni fruit) on protein efficiency ratio, nitrogen retention, and metabolic energy in broiler chickens. The study used 24 broiler chickens aged 5 weeks with an average body weight of 1.721±118.51 g/bird. The study used a completely randomized design with four treatments and five replicates. Treatments consisted of P1 (Bravo 512 commercial feed without extract), P2 (basal feed + Cinnamononi extract with composition 1:2:2), P3 (basal feed + Cinnamononi extract with composition 1:2:4), and P4 (basal feed + Cinnamononi extract with composition 1:2:6). Parameters observed included protein efficiency ratio, nitrogen retention, and apparent metabolic energy. The results showed that increasing the proportion of noni fruit in Cinnamononi extract did not have a significant effect ($P > 0.05$) on nitrogen retention and metabolic energy but demonstrated a trend towards a significant effect ($P < 0.10$) on protein efficiency ratio. In conclusion, the addition of noni fruit up to 6 parts in the raw material composition of Cinnamononi extract through drinking water is able to match the protein efficiency ratio, nitrogen retention, and metabolic energy of broiler chickens fed commercial rations.

Keywords | Broiler chickens, Cinnamononi extract, Protein efficiency ratio, Nitrogen retention, Metabolic energy, Herbs

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INTRODUCTION

Indonesia has a tropical climate (rainy and dry season). These seasonal differences create significant variations in temperature and humidity, which have a major impact on broiler production and health, especially in the open-house rearing system widely used by smallholder farmers. Environmental stress in open-house rearing system, including exposure to pathogenic microbes, has the potential to reduce broiler productivity. So far, the use of antibiotics as feed additives has been a common method to reduce negative environmental impacts and protect broilers from disease. However, since 2018, the Indonesian government has banned the use of antibiotics as feed additives. This ban is due to the potential for antibiotic residues in livestock products to endanger human health and increase the resistance of pathogenic microorganisms to antibiotics (Mund *et al.*, 2017; Mehdi *et al.*, 2018; Widiasih *et al.*, 2019). Therefore, it is necessary to find alternative materials to replace antibiotics by using herbal

plants. Some herbal plants that have been studied for their benefits and content are cinnamon leaves, noni leaves, and noni fruit (Yuniza and Rizal, 2015).

Noni fruit (*Morinda citrifolia*), a tropical plant commonly found in Southeast Asia and the Pacific Islands, has gained attention for its pharmacological properties. Traditionally used in herbal medicine, noni fruit contains various bioactive compounds, including proxeronine, scopoletin, and flavonoids. These compounds have been reported to exhibit antimicrobial, antioxidant, anti-inflammatory, and immunomodulatory activities (Ali *et al*., 2016). Bioactive compounds in plants have the potential to replace antibiotics. Yuniza and Yuherman (2015) reported that the extraction of a mixture of cinnamon leaf meal, noni leaf meal, and noni fruit meal in a ratio of 1:2:1 produced a product called "Cinnamononi extract". Research shows that Cinnamononi extract can inhibit the growth of Escherichia coli and Salmonella bacteria, as well as inhibit the development of nematodes in chickens (Yuniza and Yuherman, 2015). One of the main compounds in noni fruit extract is xeronine, along with its precursor, proxeronine (Ali *et al*., 2016; Muspita *et al*., 2023). Xeronine has important roles in protein metabolism, such as activating inactive proteins, repairing the structure and function of damaged cell proteins, activating protein-forming enzymes, and increasing the efficiency of protein absorption in the digestive tract (Mushawwir *et al*., 2019; Muspita *et al*., 2023). Thus, the use of this compound is expected to increase nutrient absorption, digestibility of food substances, and body metabolism in broiler chickens.

Yuniza and Rizal (2021) considered changing the composition of Cinamononi extract raw materials from a ratio of 1:2:1 to 1:2:2 by increasing the proportion of noni fruit to maximize the amount of xeronine that can be absorbed by the animal's body. Giving Cinnamononi extract 1:2:2 through limited drinking water after a 90-minute fast can increase the live weight (slaughter weight) of 4-week-old broilers to 846.25 g/head (Yuniza and Rizal, 2021). However, this achievement is still lower than the weight of broilers reared on commercial rations, which at 4 weeks of age can reach 1,476 g/head (Charoen Phokphand Indonesia, 2006). One factor that is thought to affect these results is the duration of drying the macerated solution (by oven at 50 °C) which takes quite a long time, namely 4-5 days. The long drying process is thought to damage proxeronin and several other phytochemicals contained in Cinnamononi extract.

The use of a rotary evaporator is potentially a solution to the problem of drying duration, as this method shortens the drying time to 4-6 hours. However, the amount of xeronine produced from Cinnamononi extract is thought to still be insufficient to produce growth responses equivalent to broilers fed commercial rations. Therefore, increasing the proportion of noni fruit in the raw material composition of Cinnamononi extract needs to be considered. With the ability of xeronine to increase protein synthesis and body metabolism, it is expected that this study can improve protein efficiency ratio, nitrogen retention, and metabolic energy in broiler chickens. Therefore, this study aimed to evaluate the effect of increasing noni fruit in the raw material composition of cinnamononi extract on protein efficiency ratio, nitrogen retention, and metabolic energy of broiler.

MATERIALS AND METHODS

Animal, design and diet

All research procedures involving animals were carried out in accordance with ethical guidelines and regulations applicable to animal research. This study used 24 broilers platinum MB 202 (Japfa Comfeed Indonesia) aged 5 weeks with body weight 1721±118.51 g/bird. The design used was a completely randomized design with 4 treatments and 5 replications (4 birds per replication), consisting of P1 (Commercial ration without Cinnamononi extract), P2 (Basal ration + Cinnamononi extract composition 1:2:2), P3 (Basal ration + Cinnamononi extract composition 1:2:4), and P4 (Basal ration + Cinnamononi extract composition 1:2:6). Feed was prepared for grower-phase broilers based on the National Research Council (1994), which has been modified for the tropics with an energy content of 3000 Kcal/kg with a crude protein of 20%. Feed ingredients and feed composition of the treatments are presented in Table 1.

Preparation of cinnamononi extract

Cinnamononi extract raw materials consist of cinnamon leaves, noni leaves, and noni fruit. The leaves and fruit are obtained in fresh condition from cinnamon and noni plants that grow around the Universitas Andalas. The leaves and fruit are then washed, and then each is cut. The pieces of leaves and fruit are then dried in the sun for 30 hours at a temperature of 40°C to 50°C. The dried leaves and fruits are then pulverized into meal.

The extraction of cinnamon leaf meal, noni leaves, and noni fruit was carried out by multistage maceration using water solvent. A mixture of cinnamon leaf meal, noni leaves, and noni fruit (according to the composition) of 150 grams was dissolved in 750 ml of water (1:5 ratio), then allowed to stand for 24 hours, then filtered with a filter (first extraction). The dried residue was redissolved in water, and a second extraction was carried out. The filtrate obtained from both extractions was heated using a rotary evaporator at 40–50 °C to form a paste.

Table 1: Feed ingredient and nutrient content of feed.

Ingredients	%
Corn	60.00
Rice bran	5.00
Fish meal	12.00
Soybean meal	19.00
Palm oil	2.50
Bone meal	1.00
Top Mix[1]	0.50
Total	100
Metabolizable Energy, (Kcal/kg)	3000.00
Crude Protein, (%)	20.00
Crude Fibre, (%)	5.00
Crude Fat (%)	6.00
Methionine (%)	0.49
Lysine (%)	1.39
Available Phosphorus, (%)	1.10
Calcium (%)	0.55

[1]Provides per kilogram of diet = Vitamin A 12.000 IU; Vitamin D3 2.000.000 IU; Vitamin E 8.000 IU; Vitamin K_3 2.000 mg; Vitamin B_1 2000; Vitamin B_2 5.000 mg; Vitamin B_6 500 mg; Vitamin $B1_2$ 1.200 µg; Vitamin C 25.000 mg; Ca-D-Pathotenate 6.000 mg; Niacin 40.000; Cholin Chloride 10.000 mg; Lysine 30.000 mg; Methionine 30.000 mg; Manganese 120.000 mg; Iron 20.000 mg; Zinc 100 mg; Iodine 200 mg; Cobalt 200 mg; Copper 4.000 mg; Santoquin 10.000 mg; Growth promoter 1.300.000

Variables measured

Protein efficiency ratio: This variable was calculated based on the formula from Scott *et al.* (1982), namely: Body weight gain (g/bird)/protein consumption (g/bird); Nitrogen retention: The nitrogen content of excreta from each bird was assessed by proximate analysis (AOAC, 2005). Nitrogen retention was determined using the methodology established by Sibbald (1985). Apparent metabolizable energy: The assessment of energy metabolism was conducted utilizing the methodology established by Sibbald (1985).

Statistical analysis

Data were processed with analysis of variance (ANOVA). If there are significantly different results, it is continued with Duncan's multiple range test. Data analysis used SPSS software version 22.

RESULTS AND DISCUSSION

Protein efficiency ratio

The effect of increasing noni fruit in the composition of cinnamononi extract raw materials on protein efficiency ratio in each treatment during the study can be seen in Table 2. The average protein efficiency ratio of broiler chickens during the study ranged from 3.06 to 3.33. The results of the analysis of variance showed that the provision of cinnamononi extract through limited drinking water had no significant effect ($P > 0.05$) on protein efficiency ratio. After tested on F. Table 10% showed a tendency of increasing noni fruit in the composition of cinnamononi extract raw materials affect the protein efficiency ratio ($P < 0.10$). The DMRT test results on protein efficiency ratio showed that P1 treatment was not significantly different ($P > 0.05$) from P3 and P4 treatments but tended to be significantly different ($P < 0.05$) from P2.

Table 2: The average protein efficiency ratio of treatment during the study.

Treatment	Protein efficiency ratio
P1	3.33[a]
P2	3.06[b]
P3	3.21[ab]
P4	3.23[ab]
SE	0.07

[a,b]Different superscripts showed the tendency to have a significant effect ($P < 0.10$). P1 (Commercial ration without cinnamononi extract), P2 (Basal ration + cinnamononi extract composition 1:2:2), P3 (Basal ration + cinnamononi extract composition 1:2:4), and P4 (Basal ration + cinnamononi extract composition 1:2:6). SE (Standard Error).

The protein efficiency ratio of P1 tends to be significantly different ($P < 0.05$) from P2 due to the composition of noni fruit raw materials in P2, which is still low so that it cannot match the protein efficiency ratio of chickens fed commercial feed. This is in accordance with the opinion of Adriani *et al.* (2015), who stated that one of the main compounds found in noni fruit extract is xeronine, whose precursor is proxeronine (Ali *et al.*, 2016; Muspita *et al.*, 2023). This compound has many functions in protein metabolism, including activating inactive proteins, improving the structure and function of abnormal cell proteins, activating protein-forming enzymes, synthesizing proteins in the body of living things, and accelerating the process of protein absorption in the digestive tract (Mushawwir *et al.*, 2019; Muspita *et al.*, 2023). Noni fruit is a type of fruit that is low in protein but has sufficient protein supply, namely isoleucine, glutamate, and aspartate (Palioto *et al.*, 2015; Santoso and Fenita, 2017). Amino acids are compounds that become the basic unit of protein and energy formation in the body.

Different ($P > 0.05$) P2 against P3 and P4 on protein efficiency ratio because cinnamon in cinnamononi extract raw materials contains essential oils that function to regulate the secretion of gastric pH so as not to be excessive, which causes the contents of the stomach to not be too acidic, so

that if the food that enters the stomach can be forwarded to the small intestine to be absorbed (Muliani, 2015). Smooth regulation of HCl secretion will cause digestion and absorption of food substances to also be smooth so that an increase in the emptiness of the stomach will affect feed consumption and body weight growth (Gustina *et al*., 2022).

The results of this study had the highest average of 3.23, indicating that increasing noni fruit in the composition of cinnamononi extract raw materials and improving drying techniques using rotary evaporators can increase protein efficiency ratio so that it can match chickens fed commercial rations. The high amount of protein digested and absorbed in the body of livestock will result in a higher amount of protein that can be utilized by livestock so that it is expected that the need for optimal growth can be achieved.

Nitrogen retention

The effect of increasing noni fruit in the composition of cinnamononi extract on nitrogen retention in each treatment during the study can be seen in Table 3. The average nitrogen retention of broiler chickens during the study ranged from 71.91% to 73.68%. The results of the analysis of variance showed that increasing noni fruit in the composition of cinnamononi extract raw materials through limited drinking water had no significant effect (P > 0.05) on nitrogen retention.

Table 3: The average nitrogen retention of treatment during the study.

Treatment	Nitrogen retention (%)
P1	73.68
P2	71.91
P3	72.58
P4	72.90
SE	4.27

No significant differences were observed (P > 0.05). P1 (Commercial ration without cinnamononi extract), P2 (Basal ration + cinnamononi extract composition 1:2:2), P3 (Basal ration + cinnamononi extract composition 1:2:4), and P4 (Basal ration + cinnamononi extract composition 1:2:6). SE (Standard Error).

Increasing noni fruit in the composition of cinnamononi extract in limited drinking water had no significant effect on nitrogen retention. This proves that the content of substances in the composition of the treatment feed has a high digestibility because it contains good quality feed ingredients such as commercial rations so that it is more easily digested. This is because the increase in noni fruit in the composition of cinnamononi extract raw materials can match the results of nitrogen retention in chickens fed commercial rations. Adriani *et al*. (2015) stated that one of the main compounds found in noni fruit extract is xeronine, whose precursor is proxeronine (Ali *et al*., 2016; Muspita *et al*., 2023). This compound has many functions in protein metabolism, including modifying inactive proteins, improving the structure and function of abnormal cell proteins, activating protein-forming enzymes, and accelerating the process of protein absorption in the digestive tract (Sanni *et al*., 2017; Mushawwir *et al*., 2019; Muspita *et al*., 2023). So that it can increase protein digestibility by increasing its bioavailability and functionality in metabolic processes, positive nitrogen retention indicates that the protein needs of livestock are met and can increase livestock weight gain. Maximum protein digestibility can increase nitrogen retention.

The results of this study have a high average of 72.90% compared to previous research conducted by Widyanti (2014) using cinnamononi extract composition 1: 2: 2 with oven drying techniques in broiler chickens resulting in a nitrogen retention value of 71.37%. This proves that the improvement of drying techniques using rotary evaporators and the increase of noni fruit in the composition of cinnamononi extract raw materials shows a positive response in broilers to the amount of nitrogen retained.

Apparent metabolizable energy

The effect of increasing noni fruit in the composition of cinnamononi on extract on metabolic energy in each treatment can be seen in Table 4. The average metabolic energy of broiler chickens during the study ranged from 3001.24 to 3035.99 kcal/kg. The results of the variance analysis showed that the increase of noni fruit in the composition of cinnamononi extract raw materials had an effect that was not significantly different (P > 0.05).

Table 4: The average metabolizable energy of treatment during the study.

Treatment	Metabolizable energy (kkal/kg)
P1	3035.99
P2	3016.84
P3	3001.67
P4	3001.24
SE	28.45

No significant differences were observed (P > 0.05). P1 (Commercial ration without cinnamononi extract), P2 (Basal ration + cinnamononi extract composition 1:2:2), P3 (Basal ration + cinnamononi extract composition 1:2:4), and P4 (Basal ration + cinnamononi extract composition 1:2:6). SE (Standard Error).

Increasing noni fruit in the composition of Cinnamononi extract in limited drinking water did not significantly affect metabolic energy. The treatment of giving Cinnamononi

extract through limited drinking water can match chickens fed commercial rations. This proves that the content of substances in the composition of the treatment feed has a high digestibility because it contains good quality feed ingredients such as commercial rations so that it is more easily digested. Nida *et al.* (2022) reported that adding cinnamon extract to drinking water could increase the efficiency of energy and protein utilization efficiency in poultry production, especially broilers. Nath *et al.* (2023) reported that cinnamon oil also provided better growth performance and feed conversion ratio and showed improved energy metabolism.

The effect of giving Cinnamononi extract through limited drinking water that can match chickens given commercial rations is that Cinnamononi extract contains several phytochemical compounds. Baskara *et al.* (2021) reported that bioactive compounds from cinnamon extract are efficacious in slowing down digestion in the small intestine so that the efficiency of nutrient utilization can increase. Cinnamon bark has antimicrobial effects, lowers cholesterol and immunity, and improves digestibility (Li *et al.*, 2016; Paranagama *et al.*, 2020; Liyanage *et al.*, 2021). Djunadi and Natsir (2003) stated that the more food substances in the body caused by increased absorption of food substances would be more effectively converted into energy.

CONCLUSION

The incorporation of noni fruit at levels of up to 6 parts in the raw material composition of Cinnamononi extract administered through drinking water demonstrated comparable effects to commercial rations in terms of protein efficiency ratio, nitrogen retention, and metabolisable energy in broiler chickens. These findings suggest that Cinnamononi extract enriched with noni fruit has the potential to serve as an effective alternative or supplement to commercial feed in broiler nutrition.

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NOVELTY STATEMENT

We investigated the use of a mixture of cinnamon leaves, noni leaves, and noni fruit extracts as feed additives in broiler rations.

AUTHOR'S CONTRIBUTION

AY: Conceptualization, methodology, data curation, supervision, writing-reviewing.
NS: Formal analysis data, data curation, writing-original draft.
M: Supervision, writing-reviewing.
Y: Supervision, writing-reviewing.
RKR: Writing-original draft, validation, writing-reviewing.

Generative AI and AI-assisted technology statement

No AI tools were used in this article.

Conflict of interest

The authors have declared no conflict of interest.

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