Influence of different forms of flavonoid on growth performance and gut morphology of broiler: A meta-analysis

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Abstract. The objective of this study was to determine the effects of different forms of dietary flavonoid on the production performance and intestinal morphology of broiler. A database was built from published literature regarding the various forms of dietary flavonoid. The database contained a total of 103 data points from 39 studies that met the criteria. The different forms of dietary flavonoid were considered as fixed effects, and various studies were treated as random effects, and p-values were used as the model statistics. Results revealed that both dried powders and crude extract of flavonoid increased ($p<0.05$) average daily gain and villus height of ileum but did not give any significant effects on other parameters. Flavonoids can maintain the health of villus, so it provides the increment of absorption of feed and affects average daily gain. The conclusion of this paper is that the different forms of flavonoids have a positive impact on the production performance and gut morphology of broiler. The best form of flavonoid is through the extraction method base on the enhancement of average daily gain and gut morphology conditions.

1. Introduction

Indonesia is well-known as a tropical country that has various types of plants with diverse bioactive substances. With bioactive substances, herbs can be used as traditional drugs for humans [1]. Bioactive substances in plants are secondary metabolites, such as phenolic compounds including flavonoid, quinone, tannin, and saponin [2,3]. Each secondary metabolite has the ability as an antimicrobial, antifungal, antioxidant, immunomodulatory, and hypercholesteremic agent. For animals, herbs can be used as an alternative antibiotic where the poultry industry is very dependent on this to make animals healthy. Herbs as feed additives have a decreasing pathogen bacterium role in the digestive tract, so it's beneficial to increase the growth performance of the animal. Based on fact, the continuous use of an antibiotic can generate danger of resistance to the host and microflora in the intestine [4]. Since January 1st, 2018, the Indonesian government bans the use of antibiotics as feed additives, both in the form of

products and raw materials for animal medicines mixed in feed already. Thus, we need an antibiotic alternative that does not cause microbial resistance; one of the other options is Flavonoid.

Flavonoid is one of the most abundant secondary metabolite compounds in herbs. Several kinds of literature which give flavonoid as feed additives can provide a positive effect on growth performance and digestive tract of broiler [5,6]. From the data which has been collected, there is a different form of flavonoids such as crude extract, dried powder, and control (no flavonoid) as a treatment. Extraction was performed to get pure flavonoids so it can act well. In fact, dry and extract preparation gives more effort (time and cost waste). So, this study aimed to evaluate the different forms of flavonoid to growth performance and gut morphology by a comprehensive study of meta-analysis compared to other treatments.

2. Material and method

A database was collected based on data from various published articles that reported the supplementation of various doses of flavonoid-rich herbs to broiler diets and their response to the performance (body weight, average daily gain, daily feed intake, feed conversion ratio and mortality) and gut morphology (villus height, crypt depth and the ratio of villus height and crypt depth) of the broiler. Journal articles were searched in Scopus, Science Direct and Google Scholar with the keywords of "flavonoid", "herbs" and/or "broiler". All data from articles were included as base construction of this paper even though the articles only had performance or other parameters. After searching with keywords above, 60 papers were found. The next stage was an abstract evaluation and full paper evaluation, which resulted in 50 papers. As indicated in the database, several forms of flavonoid in herbs were applied in control (no addition), in dried powder of herb, and in crude extract. In tabulating data into a database, similar variables were converted to the same measurement units, which would be analysed.

The database had compatible and equal measurement units and was further processed in a statistical meta-analysis based on a mixed model methodology [7]. Different studies were grouped as random effects, and the different forms of flavonoid were grouped as fixed effects. The present meta-analysis used two types of statistical models to determine whether the predictor variables were continuous or discrete. The statistical model used in this study was based on p-values. The criterion for determining the significance of the effect for each variable was a p-value<0.05. If the p-value is between 0.05, the effect is significant. All statistical analyses were carried out by using R 3.60.

3. Results and discussion

The effect of different forms of flavonoid to increase growth performance and gut morphology reported in Tables 1 and 2. The effect of different flavonoid forms on growth performance (Table 1) showed in Table 2. Generally, the flavonoid in different form did not give significant effect ($p>0.05$) on all parameters. Average daily gain is one parameter that had significant effect ($p<0.05$). The flavonoid in crude extracts form had the best value, 57.98 g/bird/d and followed by control and dried powder of herb, 57.66, and 56.89 g/bird/d respectively.

It can be seen that extract form could improve growth performance and gut morphology. This shows the positive effect of the crude extract compared to only dried powder (without extraction). The results of this study (enhancement of growth performance and gut morphology) are in line with previous studies [6]. In general, flavonoids have several actions in increasing performance in broilers. Some examples of the actions of flavonoids have been reported by several previous studies, such as growth hormone stimulation [8] and reducing the effects of stress [9]. In addition, insulin-like growth factor-1 (IGF01), triiodothyronine insulin (T3), and thyroxine (T4) are examples of hormones-like that can produce the effects of flavonoids and could increase the growth of broilers. Flavonoids, as one of the polyphenol compounds, have antioxidant action and could reduce the negative consequences of oxidative stress [10]. Free radicals produced during oxidative stress can be neutralized by the presence of exogenous antioxidants as a defense against stress. Cell components in broilers are protected by antioxidants from damage, thereby reducing the risk of disease [11]. Flavonoids could prevent the chelation of metal ions

and limit the formation of ROS [12]. The combination of the two actions can make broilers have better growth performance than without the supplementation of flavonoids..

Table 1. Influence of flavonoid form in broiler diet on growth performance.

Response parameter	Unit	N	Flavonoid form			p-value
			Control	Dried powder	Crude extracts	
Dose average	g/kg		0	11.9	2.1	
Total phase						
Body weight	g/bird	131	2126	2272	2114	0.505
Average daily gain	g/bird/d	131	56.7a	56.0ab	58.0b	0.024
Daily feed intake	g/bird/d	131	96.8	98.5	93.6	0.111
FCR[a]	g/g	131	1.94	1.72	1.91	0.654

[a] Feed conversion rate

In line with growth performance, gut morphology of broiler (Table 2) with different forms of flavonoid, did not provide any significant effect ($p>0.05$) in general. Villus height on duodenum and ileum is one parameter that had significant effect ($p<0.05$). In the duodenum, crude extract form of flavonoid had the best effect of 1916.17 µm followed by control and dried powder form of flavonoid, 1662.61, and 1531.09 µm, respectively. Different from the duodenum, the highest villus was found in non-flavonoid diet followed by crude extracts and dried powder form of flavonoid in broiler diet.

Table 2. Influence of flavonoid form in broiler diet on gut morphology.

Response parameter	Unit	N	Flavonoid form			p-value
			Control	Dried Powder	Crude extracts	
Dose average	g/kg		0	11.9	2.10	
Duodenum						
Villus height	µm	13	1663b	1531b	1916a	0.025
Crypt depth	µm	13	214.5	81.5	290.3	0.803
VH:CD	µm/µm	13	9.89	18.9	8.03	0.196
Jejunum						
Viilus height	µm	24	1330	995	1464	0.768
Crypt depth	µm	24	159	84.1	194	0.132
VH:CD	µm/µm	24	9.97	11.9	8.96	0.161
Ileum						
Viilus height	µm	19	683	671	674	0.115
Crypt depth	µm	19	118.7a	68.7b	130.1a	0.023
VH:CD[a]	µm/µm	19	6.43b	5.30b	9.82a	0.007

[a] The ratio of villus height with crypt depth

As is known that villus and crypt have a positive effect on digestibility and positively correlated with average daily gain. Villus is an organ in the gut that has an essential task in transporting nutrients to increase the absorptive surface area so that weight gain increases [10]. Whereas crypt indicates a rapid change of villus tissue [5]. The crypt has a role in replacing villus tissue damaged by pathogenic bacteria. Flavonoids help to keep the villus in top condition from several actions, such as protecting the ecosystem on the intestinal surface, so there is a positive correlation between the availability of pathogenic bacteria in the digestive tract and the damage to villus tissue [13]. Flavonoids have antibacterial activity because flavonoids can interfere with cell membrane permeability [14] through their interaction with various macro-molecules, especially protein [3], and interfere with protein synthesis so that pathogenic bacteria

are difficult to live with flavonoid conditions in the digestive tract. The ratio of villus height and crypt depth variable becomes essential because the higher ratio value indicates that the villus is in optimal condition.

Extraction treatment carried out by several researchers made flavonoids to work more towards the target than the flour/not extracted treatment. This is related to the antioxidant state found in flavonoids. Flavonoids are secondary metabolites that have high antioxidant properties. With extraction treatment, plants will produce more hydroxyl groups so that antioxidant and antibacterial activity is higher than without extraction [15]. This is a good thing because antibacterial will be useful in the inhibition of pathogenic bacteria in the digestive tract and antioxidants are useful in reducing the stress experienced by broilers

4. Conclusions

The different forms of flavonoids have a positive impact on the production performance and gut morphology of broiler. The best form of flavonoid is through the extraction method base on the enhancement of average daily gain and gut morphology conditions.

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