

« Research Note »

A Study on Growth Performance of Ducks Fed Diets with Different Types of Sipjeondaebo-Tang Byproduct Meal and Red Ginseng Marc with Fermented Red Koji and Ammonia Fluxes in Duck Litter using Alum or Aluminum Chloride

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The aims of the present study were to investigate the growth performance of ducks fed diets with different types of Sipjeondaebo-tang (ST) byproduct meal and red ginseng marc with fermented red koji (RGMK), and to investigate ammonia (NH₃) fluxes from duck litter treated with alum or aluminum chloride (AlCl₃). A total of 270 1-d-old ducks (180 males and 90 females) were allotted in a completely randomized design with 6 treatments and 3 replicates of 15 birds per pen. The six diet treatments were: basal diet, pelleted 1% ST byproduct powder, pelleted 1% RGMK, 1% blends (a mixture of ST byproduct and RGMK) powder, 1% pelleted blends, and coated pellets of 1% blends. The six litter treatments with 6 diet treatments were: no treatment, 50, 100, or 200 g alum/kg duck litter, and 100 g or 200 g AlCl₃/kg duck litter (treatments T1, T2, T3, T4, and T5, respectively). During days 10 to 40, ducks fed the 5 experimental diets had significantly different ($p < 0.05$) weight gains and feed conversion ratios compared with those fed the control diet, but initial body weight, final body weight, feed intake, and mortality were not affected. There were significant differences ($p < 0.05$) in NH₃ fluxes among treatments over the 6 weeks of the study, except for week 0. The relative NH₃ losses at week 6 were lower by 25.6, 45.3, 45.6, 46.7, and 48.6% than those in the controls in T1, T2, T3, T4, and T5 respectively. In conclusion, feeding pellets or coated pellets of ST and RGMK and using alum or AlCl₃ in the litter at the same time improves weight gain and feed conversion ratio performance and reduces mortality and NH₃ losses in ducks.

Key words: alum, aluminum chloride, ammonia, fermented red koji, growth performance, sipjeondaebo-tang

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Introduction

Animal diets are often supplemented with plant-derived materials or natural products from plants that have biological activities. Such supplementation provides unlimited opportunities for discovery of new feed additives because of the unmatched availability of chemical diversity, a lack of side effects, and economic viability. In poultry, the benefits of supplementation have been investigated intensively and confirmed repeatedly (Kim and In, 2010; Yildirim *et al.*, 2013). Supplements that have been studied include Sipjeondaebo-

tang and red ginseng marc.

Sipjeondaebo-tang contains 10 different crude natural herbs and is extensively used in Asian countries to cure atopic dermatitis, anemia, and fatigue (Kogure *et al.*, 2005). Various biological activities (with anti-inflammatory and immunomodulatory effects) have been reported for Sipjeondaebotang (Kamiyama *et al.*, 2005; Nakamoto *et al.*, 2008).

Red ginseng marc is a water-insoluble byproduct of the extraction and processing of fresh ginseng (Lim *et al.*, 2004). Byproducts of the feed industry are gaining attention for use in animal nutrition. Red ginseng marc has been of particular interest due to its positive effects on growth performance and meat quality, and it has gradually been accepted as an animal feed (Ao *et al.*, 2011a; Kim *et al.*, 2014).

Another interesting feed additive might be red koji (*Monascus* spp.), which has medicinal properties, especially a serum lipid-lowering effect that is likely due to monacolin K (Arunachalam and Narmadhapiya, 2011). Animal feed-

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ing experiments have been limited to broilers (Chung and Choi, 2016), and its effects on duck production have not been studied.

However, Sipjeondaebo-tang byproduct and red ginseng marc are usually simply discarded rather than used in animal feed, even though they contain large amounts of bioactive materials (Lim *et al.*, 2004). Thus, other strategies to utilize these ingredients include using them as feed additives for ducks in the form of pellets or coated pellets either singly or blended together.

Additionally, one of the main problems in the livestock industry is the control of ammonia (NH₃) released from poultry litter or poultry facilities. In general, NH₃ fluxes from poultry litter may lead to reduced air quality with high levels of atmospheric NH₃, which is very hazardous to the health of both birds (which negatively affects poultry performance) and workers (Kristensen *et al.*, 2000). Various methods to reduce the amount of NH₃ produced from poultry litter have been reported (Patterson and Adrizal, 2005; Ullman, 2005). Among these methods, chemical (alum or aluminum chloride) applications onto poultry litter are the most efficient at inhibiting NH₃ production, even when the litter is applied at recommended rates; in an on-farm comparison of alum's effects, Moore *et al.* (2000) reported that during the first 4 weeks, using alum in litter significantly reduced NH₃ fluxes from the litter by as much as 99%. Consequently, using both feed additives and chemical litter additives in duck facilities at the same time can be a useful method for improving duck production and reducing the negative environmental impact. The aim of this study was to evaluate the growth performance of ducks fed diets with different types of Sipjeondaebo-tang byproduct meals, red ginseng marc with fermented red koji, or both, and to evaluate NH₃ fluxes in duck litter with added alum or aluminum chloride.

Materials and Methods

Preparation of Feed Additives

To make feed additives with different types of Sipjeondaebo-tang (ST) byproduct powder and red ginseng marc with fermented red koji (RGMK), these materials were prepared and obtained from Yusim Co. (Yeongju, South Korea). First, pellets with ST byproduct powder or RGMK were made using a pellet machine (Model 400, Kumkang Eng., Daegu, South Korea). Next, blend powders were manufactured by mixing in a 1:1 ratio of ST byproduct powder and RGMK. After that, the blended powders were pelleted using the pellet machine. To make coated pellet blends, canola oil was sprayed on the surface of pelleted blends using a small hand pump to coat and pellets were dried for 3 days. All feed additives were placed into plastic bags and refrigerated at 4°C until the experiment started.

Animals and Diets

All experimental procedures of the present study were approved by the Gilhong Farm Committee for Animal Use and performed according to the animal care guidelines of the animal policy at Gilhong Farm (Geochang, South Korea). A

total of 270 one-d-old ducks (180 males and 90 females) were allotted in a randomized complete block design with 6 treatments and 3 replicates of 15 birds per pen. Treatments consisted of 6 groups: basal diet (Control); basal diet + pelleted 1% ST byproduct powder (T1); basal diet + pelleted 1% RGMK (T2); basal diet + 1% blends powder, a mixture of ST byproduct powder and RGMK (T3); basal diet + pelleted 1% blends, a mixture of ST byproduct powder and RGMK (T4); and basal diet + coated pellets of 1% blends, a mixture of ST byproduct powder and RGMK (T5). Ducks were fed a starter diet for the first 21 days, which contained 21% crude protein, 2.5% crude fat, 8% crude fiber, 9% crude ash, 0.40% Ca, and 1.50% P, and a finisher diet from days 22 to 40, which contained 17% crude protein, 2.5% crude fat, 8% crude fiber, 9% crude ash, 0.40% Ca, and 1.0 % P. Diets and water were supplied *ad libitum* during the duration of the study. Ducks were housed in pens (2.5 m × 2.0 m, with a tube feeder and an automatic bell drinker) that had concrete floors and an approximately 8-cm deep litter containing a mixture of wood shavings, rice hulls, and duck manure. Temperature, lighting, and ventilation could be automatically controlled to suit the ducks. For the lighting program, ducks were maintained in a standard light/dark cycle (14 h light/10 h dark). Room temperature was kept at 35°C during the first week, and was gradually decreased by 3°C/week until it reached 20°C. For determination of growth performance, initial and final body weights were measured at 10 and 40 d of age and weight gain was calculated as the difference between initial and final body weights. Feed intake was determined as the difference between feed disappearance and feed wastage, and the feed conversion ratio was calculated as the ratio of feed intake to weight gain. Mortality was calculated as the total number of live birds minus the number of deceased birds.

Chemical Treatments and NH₃ Gas Measurements

The chemical treatment was a randomized complete block design with 6 treatments and 3 replication pens per treatment at the same pens for feeding trial as experimental unit. These materials were applied by top-dressing onto the surface of the duck litter. The six treatments were: no treatment (Control), 50 g alum/kg duck litter (T1), 100 g alum/kg duck litter (T2), 200 g alum/kg duck litter (T3), 100 g aluminum chloride/kg duck litter (T4), and 200 g aluminum chloride/kg duck litter (T5). The alum (aluminum sulfate, Al₂(SO₄)₃·14~18H₂O) and aluminum chloride (AlCl₃·6H₂O) used in this experiment were purchased from Daejung Chemical & Metals CO (Siheung, South Korea). Alum is a dry acid salt that neutralizes alkalinity, and aluminum chloride is a form of acid that includes a small amount of liquid with aluminum and chloride and is sold commercially as Hyper Ion. NH₃ fluxes from duck litter were measured weekly at 5 random locations in each pen using a Gas-Tech (Gas Tech Corporation, Fukaya, Ayase, Japan) with an NH₃ kit at the workers' height.

Statistical Analysis

Growth performance and NH₃ fluxes were statistically analyzed according to a randomized complete block design, using the GLM procedure of SAS (SAS Institute, 2002) with

the pen as the experimental unit. Significant differences between treatment means were separated by Tukey's honest significant difference test at $p < 0.05$.

Results and Discussion

Table 1 shows the growth performance of ducks fed diets with different types of ST byproduct meal, RGMK, or both for 40 days. During days 10 to 40, ducks fed the five different experimental diets had significantly ($p < 0.05$) different weight gains (WG) and feed conversion ratios (FCR) from those fed the control diet. However, no differences were observed in initial body weight (IBW), final body weight (FBW), feed intake, or mortality for any diets during the experimental period. In addition, WG was the highest in T2 (pelleted 1% RGMK) when compared with other treatments, followed by T1, T3, T4, and T5 in that order. For FCR, only T3 (1% blends powder, a mixture of ST byproduct powder and RGMK) was better than the control, as there were no remarkable changes with the other treatments with different types of ST byproduct meal and RGMK. Research on feeding blends to poultry was first carried out by Chung and Choi (2016) who showed that 1% fermented red ginseng marc combined with red koji (RGMK) led to better weight gain ($p < 0.05$) than did other treatments. At the same time, they reported that broilers fed diets with fermented red ginseng marc powder combined with red koji did not influence FBW, feed intake, or FCR. Ao *et al.* (2011b) reported that growth performance of broilers was not affected by fermented red ginseng marc extract. In contrast, Jang *et al.* (2007) suggested an increase in egg production for laying hens using fermented wild ginseng culture byproduct, along with an improvement in the health status of birds fed diets with ginseng. These discrepancies may be a result of using different types of feed and sources of ginseng or herbal medicine. In general, growth performance is dependent on feed type. As an example, feeding pellet-type feeds increases average daily gain (ADG) and improves FCR, as demon-

strated by several authors (Amerah *et al.*, 2007; Abdollahi and Ravindran, 2013; Serrano *et al.*, 2013). In the current study, the improvements observed for WG and FCR might be due to the decrease in feed wastage or difference in feed types. In other words, fine particles that pass rapidly through the gizzard into the small intestine have minor effects or are retained to a lower extent in the gizzard than coarse particles (Amerah *et al.* 2007; Svihus, 2011; Abdollahi *et al.*, 2013). Pellet or coated pellet structures increase quantity of fine particles in the gizzard once the bird has consumed the feed. Consequently, beneficial effects of pellet feed or coated pellet feed on gastrointestinal tract development and growth are based on particle size distribution (Abdollahi *et al.*, 2013).

Although treatment with different types of ST byproduct powder and RGMK had no effect on mortality, these supplements play important roles in enhancing immune function. In this respect, the lowest mortality (0%) was observed in T2 (1% fermented RGMK), T4 (1% pelleted blends), and T5 (1% coated blends), followed by T1 (1% pelleted Sipjeondaebotang byproduct powder) and T3 (1% blends powder) at 2.22%; however, the control had the highest mortality (4.44%). Presumably, this reduction in mortality is the result of the addition of Sipjeondaebotang (which has 10 different crude components) and red ginseng marc (saponin) with fermented red koji (monacolin K) to the diet, as these are considered to be the principal bioactive ingredients with respect to the immune system and can act as immune modulators (Kamiyama *et al.*, 2005; Ao *et al.*, 2011b). This observation supports the findings of Kim *et al.* (2014), who observed markedly decreased mortality using 3% red ginseng marc in broiler diets. In addition, Chung and Choi (2016) reported that 1% fermented red ginseng combined with red koji had a marked effect on mortality, which was 0% at day 28. This means that these two feeding strategies to improve growth performance might counteract each other when used in combination. Yet, the mechanisms by which ST and RGMK, or a

Table 1. Growth performance of ducks fed diets with Sipjeondaebotang byproduct powder and fermented red ginseng marc powder with red koji for 40 days

Parameter	Treatment ¹						SEM ²	p-value
	Control	T1	T2	T3	T4	T5		
Initial body weight (10 d, g)	479.00	484.00	503.67	492.00	498.00	488.33	3.70	0.7684
Final body weight (40 d, g)	3173.33	3312.67	3369.78	3319.89	3303.78	3226.67	110.51	0.0786
Weight gain (g)	2694.33 ^c	2828.67 ^{ab}	2866.11 ^a	2827.89 ^{ab}	2805.78 ^{ab}	2738.33 ^{bc}	26.28	0.0306
Feed intake (g)	5612.44	5575.33	5660.67	5550.67	5586.89 ^a	5462.00	27.22	0.1048
Feed conversion ratio (g feed/g gain)	2.08 ^a	1.97 ^b	1.98 ^b	1.96 ^b	1.99 ^b	1.99 ^b	0.02	0.0438
Mortality (%)	4.44	2.22	0.00	2.22	0.00	0.00	0.74	0.6564

^{a-c} Means in the same row with different superscript letters are significantly different ($p < 0.05$).

¹ Control: basal diet + no alum and aluminum chloride; T1: (basal diet + pelleted 1% Sipjeondaebotang byproduct powder) + 50 g alum/kg duck litter; T2: (basal diet + pelleted 1% red ginseng marc with fermented red koji) + 100 g alum/kg duck litter; T3: (basal diet + 1% blend powder, a mixture of Sipjeondaebotang byproduct powder and red ginseng marc with fermented red koji) + 200 g alum/kg duck litter; T4: (basal diet + pelleted 1% blend, a mixture of Sipjeondaebotang byproduct powder and red ginseng marc with fermented red koji) + 100 g aluminum chloride/kg duck litter; T5: (basal diet + coated pellets of blend, a mixture of Sipjeondaebotang byproduct powder and red ginseng marc with fermented red koji) + 200 g aluminum chloride/kg duck litter.

² Values are expressed as means \pm standard errors.

Table 2. Effects of adding alum and aluminum chloride to duck litter on NH₃ flux as a function of time

Week	Treatment ¹						SEM ²	P-value
	Control	T1	T2	T3	T4	T5		
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—
1	1.00 ^a	0.13 ^b	0.00 ^b	0.07 ^b	0.00 ^b	0.00 ^b	0.16	P<0.0001
2	3.20 ^a	1.10 ^b	1.10 ^b	0.83 ^b	1.00 ^b	1.00 ^b	0.37	0.004
3	6.93 ^a	4.67 ^b	2.07 ^c	1.17 ^c	1.23 ^c	1.90 ^c	0.94	P<0.0001
4	16.27 ^a	10.47 ^b	9.00 ^{bc}	4.87 ^d	7.47 ^c	5.13 ^d	1.73	P<0.0001
5	18.00 ^a	15.67 ^{ab}	10.73 ^c	11.87 ^c	12.73 ^{bc}	9.87 ^c	1.27	P<0.0001
6	24.27 ^a	18.00 ^b	13.27 ^c	13.20 ^c	12.93 ^c	12.47 ^c	1.90	P<0.0001

^{a-d} Means in the same rows with different superscript letters are significantly different ($p < 0.05$).

¹ Control: basal diet + no alum and aluminum chloride; T1: (basal diet + pelleted 1% Sipjeondaabo-tang byproduct powder) + 50 g alum/kg duck litter; T2: (basal diet + pelleted 1% red ginseng marc with fermented red koji) + 100 g alum/kg duck litter; T3: (basal diet + 1% blend powder, a mixture of Sipjeondaabo-tang byproduct powder and red ginseng marc with fermented red koji) + 200 g alum/kg duck litter; T4: (basal diet + pelleted 1% blend, a mixture of Sipjeondaabo-tang byproduct powder and red ginseng marc with fermented red koji) + 100 g aluminum chloride/kg duck litter; T5: (basal diet + coated pellets of blend, a mixture of Sipjeondaabo-tang byproduct powder and red ginseng marc with fermented red koji) + 200 g aluminum chloride/kg duck litter.

² Values are expressed as means \pm standard errors.

blend of the two, affect growth performance are unknown, and to our knowledge there has been no prior report on growth performance of duck fed diets with these ingredients, either singly or blended.

NH₃ fluxes obtained from litter with alum or aluminum chloride (AlCl₃) added for 6 weeks are summarized in Table 2. There were significant differences ($p < 0.05$) in NH₃ fluxes among treatments for all 6 weeks except for week 0. In all treatments, NH₃ fluxes were under 3.20 ppm up to week 2, then increased at weeks 3 through 6. NH₃ fluxes were further reduced by higher levels of alum and AlCl₃ as time increased. In particular, relative NH₃ losses at week 6 were reduced by 25.6, 45.3, 45.6, 46.7, and 48.6%, compared with the controls, for T1, T2, T3, T4, and T5, respectively. The reductions in NH₃ fluxes with 100 g and 200 g of alum or AlCl₃/kg of litter were the same or only slightly different from each other, but 50 g of alum/kg of litter had a smaller reduction. In the present study, the observed decreases in NH₃ fluxes were likely responsible for improvements in duck growth performance. Similar results were reported by Moore *et al.* (1999) and Choi and Moore (2008) who found clear signs of improved growth performance in birds and reduced NH₃ fluxes when alum and liquid AlCl₃ were applied to litter. Therefore, they concluded that the growth performance of birds and NH₃ fluxes were both clearly improved by the application of alum and AlCl₃ to litter.

In summary, feeding pellets and coated pellets of different types of ST byproduct powder and RGMK at rates of 1% improved WG and FCR and reduced mortality compared with controls. At the same time, use of alum and AlCl₃ litter amendments decreased NH₃ fluxes. These two strategies might be effective management practices to decrease NH₃ levels, which in commercial duck facilities should translate to improved growth production as measured by feed intake, weight gain, and mortality.

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