



## Effects of supplementing broiler diets with a combination of fermented red ginseng marc powder and red-koji on thigh meat quality of broiler chick during storage

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**ABSTRACT.** We assessed the effects of supplementing broiler diets with a combination of fermented red ginseng marc powder and red-koji on thigh meat quality of broiler chick during storage. Broilers ( $n = 120$ ) were randomly assigned to one of two groups: control or treatment with 1% fermented red ginseng marc combined with red-koji. There were four replicates per group, each comprising 15 birds (10 male and 5 female). Neither the dietary supplementation group nor the number of storage days had a significant ( $p > 0.05$ ) effect on meat pH. However, TBARS, a measure of lipid oxidation, was significantly affected ( $p < 0.05$ ) by both the number of storage days and the dietary supplementation, with reduced TBARS activity noted in the treatment group after 7 days of storage. There was no significant impact ( $p > 0.05$ ) on the lightness ( $L^*$ ) of meat in group after 1 and 7 day of storage (included T1 group), or redness ( $a^*$ ) of meat in group at 1 through 7 days of storage, whereas the yellowness ( $b^*$ ) of meat in both groups increased significantly ( $p < 0.05$ ) with an increase in storage duration. Our results suggest that supplementing broiler diets with fermented red ginseng marc combined red-koji powder does not affect meat color, even after storage. We conclude that dietary supplementation with 1% fermented red ginseng powder combined with red-koji can reduce lipid oxidation in broiler thigh meat after 7 days of storage.

**Keywords:** fermented red ginseng marc, red-koji, pH, TBARS, meat color, thigh meat.

## Efeitos de dietas suplementadas para frangos de corte acrescentadas de pó de ginseng vermelho fermentado e koji vermelho sobre a qualidade de carne da coxa durante armazenamento

**RESUMO.** Avaliamos os efeitos de dietas de frango de corte suplementadas por pó de ginseng vermelho fermentado e koji vermelho sobre a qualidade de coxa de frango de corte durante armazenamento. Os frangos de corte ( $n = 120$ ) foram distribuídos aleatoriamente em dois grupos, controle e tratamento com 1% ginseng vermelho fermentado acrescentado de koji vermelho, com quatro repetições por grupo, cada qual com 15 aves (10 machos e 5 fêmeas). Não houve efeitos significativos ( $p > 0.05$ ) sobre pH da carne no grupo com suplementação nem no número de dias de armazenamento. TBARS, a medida de oxidação de lipídios, foi afetada significativamente ( $p < 0.05$ ) pelo número de dias de armazenamento e pela suplementação, com decréscimo de TBARS no grupo tratamento após 7 dias de armazenamento. Não houve impacto significativo ( $p > 0.05$ ) sobre a brancura ( $L^*$ ) da carne após 1 e 7 dias de armazenamento (inclusive grupo T1), ou cor vermelha ( $a^*$ ) na carne no grupo entre 1 e 7 dias de armazenamento, enquanto a cor amarela ( $b^*$ ) da carne nos dois grupos aumentou significativamente ( $p < 0.05$ ) com o aumento do período de armazenamento. Os resultados sugerem que as dietas suplementadas por ginseng vermelho fermentado e pó de koji vermelho não alteram a cor da carne após armazenamento. Podemos concluir que a suplementação dietária com 1% de ginseng vermelho fermentado e pó de koji vermelho pode reduzir a oxidação de lipídios na carne da coxa de frangos de corte após 7 dias de armazenamento.

**Palavras-chave:** ginseng vermelho fermentado, koji vermelho, pH, TBARS, cor da carne, carne da coxa.

### Introduction

Red ginseng is fresh ginseng that is harvested after six years, then processed by steaming with water at 98–100°C followed by drying (Kim & In, 2010). Consequently, red ginseng undergoes certain

biochemical changes and has pharmacological properties, including antioxidant, anti-aging, and hepatoprotective effects (Bak, Hong, Lee, & Jeong, 2012). Red ginseng marc is a by-product generated after hot water extraction of red ginseng and is often

discarded as a waste product. Recently, the benefits of red ginseng marc have been studied. These benefits may be linked to the presence of bioactive components such as saponins, polysaccharides, and alkaloids, which are retained in red ginseng marc after extraction. A previous study found that supplementing the diet of laying hens with Korean ginseng root extract had no adverse effects on either egg quality, or productivity (Yildirim, Şekeroglu, Eleroglu, Şen, & Duman, 2013). Kim, Lee, and Choi (2014) explored the antioxidant effects of red ginseng marc, as a dietary supplement, on meat quality of broilers.

Red-koji (red yeast rice) has been used traditionally for centuries to improve digestion, revitalize the blood, or as a food preservative to help maintain the taste and color of meat and fish (Fujimoto et al., 2012). A fermented product of rice and red yeast (*Monascus purpureus*), red-koji has scarlet to purple red grains, which have a rice-grain structure (Erdogru & Azirak, 2004). Several studies have demonstrated that the bioactive components present in red-koji include monacolin K,  $\gamma$ -aminobutyric acid (Gaba), and dimerumic acid, which are thought to possess anti-hypercholesterolemic, anti-inflammatory, and antioxidant properties, and may help in the treatment of hypotension (Aniya et al., 2000; Su, Wang, Lin, & Pan, 2003).

To improve of meat quality as animal diets, other strategies have focused on using the combination of fermented red ginseng and red-koji prepared from *Monascus* species. For example, the meat industry is interested in the potential economic advantages of using a blend, rather than a single compound (Nanari, Hewavitharana, Becu, & Jong, 2004). Therefore, the impact of blends such as the combination of red ginseng marc powder and red-koji on meat quality still needs to be investigated before they can be successfully used in the poultry meat industry. This study aimed to determine the effects of supplementing broiler diets with a combination of fermented red ginseng marc powder and red-koji on thigh meat quality of broiler chick after storage.

## Material and methods

### Birds and diets

Fermented red ginseng marc and red-koji were prepared from Ginseng Organic Co. (Seoul, Korea). The rate at which fermented red ginseng marc and red-koji are mixed is 9:1 as a weight. The animal experimentation protocols were performed

according to the Guidelines for the Care and Use of the Dansan Farm (Yeongju, South Korea). 120 broiler chicks (80 male and 40 female, Arbor acres, 1 day old) were distributed into 2 groups with 4 replicates 15 birds (10 male and 5 female) each housed in 8 pens. Each pen was used as the experimental unit. Dietary groups consisted of a basal diet (control) and basal diet with 1% fermented red ginseng marc combined with red-koji (T1). The birds were fed the experimental diets for 4 weeks during the starter phase (1-21 days, 12.97 MJ kg<sup>-1</sup> ME, 22 crude protein, 6 crude fat, 7 crude fiber, 10 crude ash, 0.9 Ca, and 1% P) and finisher phase (22-28 days, 12.97 MJ kg<sup>-1</sup> ME, 19 crude protein, 6 crude fat, 7 crude fiber, 10 crude ash, 0.8 Ca, and 0.9% P). Birds were raised in an environmentally controlled room with *ad libitum* access to feed and water throughout the experimental period. Birds are also maintained under a light:dark schedule of 14:10. Pens (1.1 × 1.2 m) were equipped with one tube feeder and one hanging bell drinker. An approximately 6 cm layer of bedding materials in poultry litter included wood shavings and rice hulls. Ventilation was automatically regulated according to the birds' age and weight. The temperature was maintained at 35°C during the first 1 week and then decreased gradually to 24°C until 4 weeks. At the end of the experimental period, birds were fasted for 6 hours. Three birds chosen from each pen were moved to the slaughterhouse and sacrificed according to conventional slaughter procedures. After electrically stunning, birds were bled out—with a full ventral neck cut and exsanguinated. Thigh meat from all carcasses were then skinned and deboned for the determination of meat quality. All thigh meats were then packed in zip-sealable plastic bags and analyzed after 1, 3 and 7 day storage at 4°C.

### Measurement of meat quality

#### pH

The pH of the thigh meat was measured by homogenizing a 10 g sample with 90 mL of distilled water for 1 min using a blender (HM-3000, Hyundai Electronic Industry Co., Incheon, South Korea). The pH was then determined using a digital pH meter (691 pH meter, Metrohm, Swiss) with a two-point method against standard buffers of pH 4.0 and pH 7.0.

#### TBARS

The amount of thiobarbituric acid reactive substances (TBARS) was measured to assess changes in lipid oxidation in the thigh meat, following the

methods described by Sinnhuber and Yu (1977). A combination of 3 mL of 1% trichloroacetic acid solution, 0.3% NaOH solution, 17 mL of 0.25% trichloroacetic acid solution and 3.6 mM of HCl solution, was added to a 0.5 g sample of broiler breast meat. This mixture was heated in a 98°C water bath for 30 min and then cooled for 15 min in ice water. After being transferred to a glass test tube, 3 mL of chloroform was added to the mixture, which was then centrifuged at 3500 rpm for 30 min to separate the layers. Finally, the absorptivity of the supernatant was determined using an UV-Visible spectrophotometer (UV-24D, Shimadzu, Tokyo, Japan) at a wavelength of 532 nm. TBARS values were calculated as follows Equation 1:

$$\text{TBARS (mg of malondialdehyde [MA] kg}^{-1} \text{ of sample)} = \frac{[\text{absorbance sample} - \text{absorbance blank}] \times 46}{(\text{meat sample weight [g]} \times 5)} \quad (1)$$

#### Meat color

Color measurements of the thigh meat were recorded using a Minolta colorimeter (Minolta Co. CR 301, Japan), which was calibrated using a standard white plate (reference number 12633117,  $Y = 93.5$ ,  $x = 0.3132$  and  $y = 0.3198$ ). The color values of lightness ( $L^*$ ), redness ( $a^*$ ) and yellowness ( $b^*$ ) were measured on the surface of the meat sample.

#### Statistical analysis

All measurements were performed in triplicate. We used the analysis of variance (ANOVA) option of the general linear models procedure in Statistical Analysis System (SAS, 2002). We then used paired t-tests (the difference between groups) and Duncan's multiple range comparisons (the difference among storage day) to find significant differences ( $p < 0.05$ ).

#### Results and discussion

##### pH and TBARS

The pH and TBARS values of the broiler meat on storage days 1, 3, and 7 are presented in Table 1. Overall, neither treatment group nor the storage duration had a significant ( $p > 0.05$ ) effect on pH. Therefore, these results suggest dietary supplementation with the combination of fermented ginseng marc and red-koji had no impact on meat pH.

**Table 1.** Effect of dietary fermented red ginseng marc combined red-koji to poultry diets on pH and TBARS in broiler thigh meat during storage.

Item	Storage day	Groups <sup>1</sup>		Significance
		Control	T1	
pH	1	6.32±0.13 <sup>aA</sup>	6.31±0.22 <sup>aA</sup>	NS
	3	6.45±0.18 <sup>aA</sup>	6.29±0.16 <sup>aA</sup>	NS
	7	6.45±0.24 <sup>aA</sup>	6.38±0.16 <sup>aA</sup>	NS
	Significance	<sup>2</sup> NS	NS	
TBARS (mg MA 100 g <sup>-1</sup> )	1	0.16±0.10 <sup>bb</sup>	0.31±0.05 <sup>ab</sup>	*
	3	0.41±0.06 <sup>aA</sup>	0.48±0.08 <sup>aA</sup>	NS
	7	0.54±0.06 <sup>aA</sup>	0.38±0.11 <sup>baB</sup>	*
	Significance	*	*	

<sup>a, b</sup>Means in the same row with different superscripts are significantly different ( $p < 0.05$ ); <sup>A, B</sup>Means in the same column with different superscripts are significantly different ( $p < 0.05$ ); Mean values are expressed as means ± SEM; <sup>1</sup>Control: no treatment; T1: 1% fermented red ginseng marc with red-koji; <sup>2</sup>NS: not significant.

The amount of TBARS was significantly affected ( $p < 0.05$ ) by both the number of days in storage, and by treatment group. However, after 3 days of storage, no significant difference in the amount of TBARS was observed in the two groups. TBARS levels were significantly lower in the meat samples from the group fed the 1% fermented red ginseng marc combined with red-koji (T1) compared with that in the control group after 7 days of storage (but not after 1 or 3 days). This result is similar to that of Kim et al. (2014), who showed the addition of red ginseng marc to broiler diets had an antioxidant effect (it reduced lipid oxidation, as measured by TBARS) in chicken thigh meat. They also suggested that the antioxidant activity of red ginseng marc could be attributed to the high level of saponins (ginsenoside) present in red ginseng marc and its ability to serve as an efficient free radical scavenger. In our study, we evaluated the effect of the addition of 1% fermented red ginseng marc combined with red-koji powder to broiler diets, on lipid oxidation (TBARS) after meat storage. It is unknown whether red-koji (*Monascus* species) could act as an antioxidant during meat storage if added to broiler diets. Red-koji has been used in clinical therapy to lower blood cholesterol (Arunachalam & Narmadhapriya, 2011). Man, Lynn, and Cheung (2002) suggested that red-koji could inhibit the activity of the rate-limiting step of hepatic cholesterol biosynthesis in a dose-dependent manner. Furthermore, meat pH is known as an important determinant of meat quality with respect to lipid oxidative processes. These, in turn, can cause meat products to deteriorate or change in flavor, color, or texture (Zanardi, Dorigoni, Badiani, & Chizzolini, 2002). However, in our study, the decrease in TBARS activity after day 7 of storage was not associated with a decrease in thigh meat pH.

### Meat color

Table 2 summarizes the color of the thigh meat after days 1, 3, and 7 of storage. The L\* and a\* values of thigh meat samples differed between groups with or not 1% fermented red ginseng marc combined with red-koji or among storage days ( $p < 0.05$ ). However, there was no significant impact ( $p > 0.05$ ) on the L\* of group after 1 and 7 day of storage (included T1 group), or a\* of group at 1 through 7 days of storage. In addition, the b\* value of the meat was influenced in both treatment groups and the storage duration ( $p < 0.05$ ). In spite of statistically significance, our results suggest that supplementing broiler diets with a combination of 1% fermented red ginseng marc and red-koji powder did not have an effect on meat color after storage. This is similar to the results of Kim et al. (2014), which showed that supplementing broiler diets with red ginseng powder did not affect the color of thigh meat. Color is important to consider, because consumers associate it with the product's freshness and will choose poultry products that have an appetizing color or appearance. Other factors that affect meat color are pH and myoglobin concentration (Fletcher, 1999). Therefore, it is possible that the decrease in L\* value observed or the increase in a\* observed is related to the presence of antioxidant agents that could retard metmyoglobin formation in meat and decrease the activity of free radicals (Fernandez-Lopez, Zhi, Aleson-Carbonell, Perez-Alvarez, & Kuri, 2005). However, due to the lack of studies that evaluate the use of different types of red ginseng marc and red-koji in broiler diets, it is difficult to compare results across studies that assess the dietary inclusion of these supplements.

**Table 2.** Effect of dietary fermented red ginseng marc combined red-koji to poultry diets on color in broiler thigh meat during storage.

Item	Storage day	Groups <sup>1</sup>		Significance
		Control	T1	
L* (lightness)	1	52.67±3.58 <sup>aA</sup>	54.25±2.60 <sup>aA</sup>	<sup>2</sup> NS
	3	49.22±3.85 <sup>bB</sup>	55.30±4.39 <sup>aA</sup>	*
	7	54.08±2.83 <sup>aA</sup>	53.76±3.56 <sup>aA</sup>	NS
	Significance		NS	
a* (redness)	1	11.71±1.86 <sup>bB</sup>	12.69±2.37 <sup>aAB</sup>	NS
	3	14.22±2.19 <sup>aA</sup>	13.77±4.02 <sup>aA</sup>	NS
	7	11.92±2.01 <sup>aB</sup>	11.60±2.06 <sup>aB</sup>	NS
	Significance		*	
b* (yellowness)	1	7.37±1.71 <sup>bB</sup>	10.32±1.62 <sup>aB</sup>	*
	3	7.37±1.38 <sup>bB</sup>	10.27±2.26 <sup>aB</sup>	*
	7	9.49±1.50 <sup>bA</sup>	11.70±2.42 <sup>aA</sup>	*
	Significance		*	

<sup>a, b</sup>Means in the same row with different superscripts are significantly different ( $p < 0.05$ ); <sup>A, B</sup>Means in the same column with different superscripts are significantly different ( $p < 0.05$ ); Mean values are expressed as means ± SEM; <sup>1</sup>Control: no treatment; T1: 1% fermented red ginseng marc with red-koji; <sup>2</sup>NS: not significant.

### Conclusion

Our research showed there was no impact of supplementing broiler diets with a combination of fermented red ginseng marc powder and red-koji on the pH or color of thigh meat after storage. However, after 7 days in storage, there was less TBARS activity (a measure of lipid oxidation) in the thigh meat of broilers fed the fermented red ginseng marc combined with red-koji when compared to those fed a standard diet.

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