Revista Brasileira de Ciência Avícola
ISSN: 1516-635X
revista@facta.org.br
Fundação APINCO de Ciência e Tecnologia Avícolas
Brasil

Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X Oct - Dec 2016 / v.18 / n.4 / 733-738

http://dx.doi.org/10.1590/1806-9061-2015-0191

Technical Note

Growth Performance and Fatty Acid Profiles of Broilers Given Diets Supplemented with Fermented Red Ginseng Marc Powder Combined with Red Koji

■Author(s)

Chung TH[I]
Choi IH[I]

[I] Department of Companion Animal & Animal Resources Science, Joongbu University, Geumsan-gun 32713, South Korea

■Mail Address

Corresponding author e-mail address
H. Choi
Department of Companion Animal & Animal Resources Science, Joongbu University, Geumsan-gun 32713, South Korea
Tel: +82-41-750-6284
Email: wicw@chol.com

■Keywords

Fermented red ginseng marc powder, red koji, red ginseng marc, growth performance, fatty acid.

Submitted: February/2016
Approved: February/2016

ABSTRACT

In this study, 240 one-d-old Arbor Acres broiler chicks (160 males and 80 females) were randomly allocated in a completely randomized design with four treatments and four replicates. Broilers were fed from hatching to 28 d of age four diets: a basal diet (control), 2% red ginseng marc, 1% fermented red ginseng marc with red koji, and 2% liquid red ginseng. Growth performance and fatty acid profiles in broiler were evaluated. Supplementing diets with different types of red ginseng did have significant effects ($p<0.05$) on initial body weight, due to differences in the birth weights of birds, including weight gain, and mortality. However, no significant differences between the treatments ($p>0.05$) were found for final body weight, feed intake, and feed conversion. In addition, supplementing broiler diets with different types of red ginseng did not significantly influence ($p>0.05$) fatty acid profiles in either breast or thigh meats. We concluded that growth performance (weight gain and mortality) was most enhanced in diets supplemented with 1% fermented red ginseng powder combined with red koji.

INTRODUCTION

Antibiotic resistance and antibiotic residues in meat products are two of the most pressing issues in meat production throughout the world. Antibiotics are highly effective for maintaining flock health and are used to improve growth performance and decrease mortality (Yildirim *et al*., 2013). Recent bans on antibiotics are posing major challenges to the poultry industry, and consumers may welcome herbal plant extracts or essential oils as natural alternatives to antibiotics.

Ginseng (*Panax ginseng* Meyer) is a perennial plant that grows in shaded and humid areas throughout Korea, Japan, and China (Eo *et al*., 2014). For thousands of years, ginseng has been used as a medicine, food, and flavoring agent (Choi *et al*., 2011). Ginseng can be divided into five broad categories depending on the manufacturing method: fresh, red, Taegeuk, black, and white ginseng (Kim *et al*., 2010; Lee *et al*., 2012). In order to enhance its safety, preservation, and efficacy, red ginseng is processed by repeatedly steaming fresh ginseng roots over water vapor at 98–100°C, and then drying the roots, giving them a light reddish brown or dark brown color (Lee *et al*., 2008; Ao et al., 2011b). Previous studies indicated that red ginseng presents the most health benefits of all the ginseng categories because of its higher saponin content (bioactive component) (Ko et al., 2003; Kim & In, 2010). Saponins are believed to boost the immune system and to provide pharmaceutical and antioxidant benefits to humans and animals (Ko et al., 2003; Kim & In, 2010; Yildirim *et al*., 2013). Additionally, non-saponin components (phenolic, peptides, and acidic polysaccharides) in red ginseng prevent fatigue and stress (Kim *et al*., 2010a).

The demand for the addition of red ginseng to a variety of food products and the use of various feed additives has recently increased (Chung *et al*., 2014). Red ginseng marc is a water-insoluble by-product remaining after the red ginseng extraction process. The positive effects of red ginseng marc have gained much attention, as shown in two studies that examined the effects of dietary red ginseng marc on the growth and meat quality of pigs and broilers (Ao et al., 2011a; Kim et al., 2014). In Korea, red ginseng marc is unfortunately discarded as a waste material, even though it has many suggested positive uses (Kim & In, 2010).

Furthermore, red koji (*Monascus* spp.) has historically been marketed in Asian countries for its medicinal properties and used as a food preservative to maintain meat flavor and color (Fujimoto *et al*., 2012). It is considered an antioxidant or medicinal agent because of its unsaturated fatty acids may have serum lipid-lowering effects (Wang *et al*., 1997; Arunachalam & Narmadhapriya, 2011).

Considering the benefits of those products, the combination of fermented red ginseng marc powder with red koji has been suggested as a dietary supplement for poultry. However, to our knowledge, this combination was never previously been assessed as a mean to improve poultry production and meat quality. This study evaluated the growth performance and meat fatty acid profile of broilers fed a diet supplemented with fermented red ginseng marc combined with red kojiover a 28-day period.

MATERIALS AND METHODS

Diet and experimental design

Red koji, fermented red ginseng marc, red ginseng marc, and liquid red ginseng were prepared and provided by Ginseng Organic Co. (Seoul, Korea). All samples were used immediately for the experiments. The experimental procedures followed the guidelines on the Ethical Use and Care of Animals approved by the Dansan Farm in Yeongju (South Korea).

A total of 240 one-d-old Arbor Acres broiler chicks (160 males and 80 females) were obtained from Hayang Hatchery, South Korea. Chicks were distributed according to a completely randomized design into four treatments with four replicates each (10 males and 5 females per replicate pen), and reared from 1–28 d of age. The treatments consisted of: (a) Basal diet (CON), (b) Basal diet with 2% red ginseng marc (T1), (c) Basal diet with 1% fermented red ginseng marc combined with red koji (T2), and (d) Basal diet with 2% liquid red ginseng (T3).

Chicks were reared in 1.1 m × 1.2 m pens concrete floor and litter consistent of an approximately 6-cm deep wood-shavings and rice-hulls litter. Each pen was equipped with one tube feeder and one bell drinker. A 14/10-hlight/dark cycle was applied. Ventilation was automatically regulated and the environmental temperature was maintained at 35°C during the first week, and then reduced 3°C weekly until reaching 24°C house temperature in the fourth week.

Birds were fed a starter diet containing 12.97 MJ metabolizable energy (ME)/kg, 22% crude protein, 6% crude fat, 7% crude fiber, 10% crude ash, 0.9% calcium (Ca), and 1% phosphorus (P) from d 1 to 21; and a finisher diet of 12.97 MJ ME /kg, 19% crude protein, 6% crude fat, 7% crude fiber, 10% crude ash, 0.8% Ca, and 0.9% P from d 22 to 28. Both diets were based on wheat, corn, and soybean meal, and feed and water were offered *ad libitum* for the duration of the study.

In order to determine growth performance, body weights were measured at 1 and 28 d of age. Feed intake was determined for each feeding phase. Feed conversion was calculated as the ratio between feed intake and bird weight gain. Mortality was checked daily and calculated as the total number of live birds minus the number of deceased birds.

Slaughter procedure

At the end of the 28-d experimental period, birds were processed in a commercial processing plant in Yeongju (South Korea). Three birds were randomly taken from each pen, and electrically stunned after fasting for 6 h. After stunning, birds were killed severing the jugular vein, and exsanguinated according to conventional slaughter procedures. Each carcass was plucked and manually eviscerated to obtain the breast and thigh muscles. The skin, along with subcutaneous fats and visible connective tissues, were excised from the breast and thigh muscles before analysis. The breast and thigh muscles were immediately packed in sealable plastic bags and stored at 4°C for 1 d before the determination of the fatty-acid profile.

Fatty acid analysis

Lipid was extracted from the muscles using a chloroform:methanol solution (2:1 volume/volume), according to Folch et al. (1957). Fatty acid methyl esters

(FAMEs) were extracted according to the procedure of Peisker (1964). The analyses of FAMEs in total lipid content were conducted using a gas chromatograph (GA-17A, Shimadzu, Tokyo, Japan) fit with a split/splitless injector and flame ionization detector (FID) coupled with a CP-Sil 88 capillary column (100 m × 0.25 mm × 0.2 µm; Chrompack, Middelburg, the Netherlands). The gas chromatography was conducted under programmed temperature conditions. The column temperature was initially set at 180°C and then heated to 230°C at 1.5°C/min, using injector and detector temperatures of 240°C and 260°C, respectively. The injection volume was 0.5 µL and the mode was split (100:1). Nitrogen gas was used as the carrier gas (20 cm/min). Each FAME peak was identified according to the retention time of the corresponding peaks in the standard acquired from Sigma (St. Louis, MO). The identified peaks included fatty acids between 14:0 and 22:5. The percentage of individual FAME was expressed as a percentage of the total area of the chromatogram.

Statistical Analysis

Data were analyzed according to a completely randomized design. Data were submitted to analysis of variance (ANOVA), using the general linear model (GLM) procedure of SAS statistical software (SAS Institute Inc., 2002). The experimental unit was the pen. Means were compared by Duncan's multiple range test at an overall significance level of P = 0.05(Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance

Growth performance results are shown in Table 1. No significant (p>0.05) differences among treatments were detected in final body weight, feed intake, or feed conversion ratio. However, supplementing the diets with different types of red ginseng significantly influenced (p<0.05) initial body weight, weight gain, and mortality when compared with the control diet. In addition, the observed effect on initial body weight may be explained by differences in body weight at hatch.

In the current study, the diet with 1%fermented red ginseng marc combined with red koji (T2) promoted higher weight gain (P<0.05) relative to the other treatments, and suggests that this combination may increase meat production compared with the other treatments. On the other hand, Ao *et al*. (2011b) did not find any effect of feeding fermented red ginseng on broiler performance, or Yildirim *et al*. (2013) on the egg production performance of laying hens fed Korean ginseng root extract. These disparate findings may be a result of differences in analytical and ginseng straining methods.

In the present study, mortality was significantly reduced in the groups fed the herbal supplements. The lowest mortality (0% at 28 d) was observed in the group fed 1% fermented red ginseng combined with red koji (T2), followed by 2% red ginseng marc (T1) and2% liquid red ginseng (T3), with the highest mortality observed in the control group (CON). In particular, the mortality rate of the broilers in control group as very high (above 10%), possibly because of their lower resistance to the high outdoor temperature recorded during the experimental period (summer season) relative to other groups. Adding different types of red ginseng to poultry diets may enhance the immune function by increasing lymphocyte levels, as previously observed in broilers and laying hens (Ilsley *et al*., 2005; Ao *et al*., 2011b). This benefit is primarily due to the specific effects of saponins, which the main bioactive ingredients in red ginseng and fermented red ginseng extract, on the immune system. Kim *et*

Table 1 – Effects of the dietary addition of fermented red ginseng marc with red kojion the growth performance of 1- to 28-d-old broilers

Item	Treatment[1]				SEM[2]	p-value
	CONT	T1	T2	T3		
Initial body weight (1 d, g)	40.65[b]	42.13[a]	41.10[b]	41.00[b]	0.38	0.0415
Final body weight (28 d, g)	1,516.67	1,525.00	1,578.33	1,526.83	8.36	0.0529
Weight gain (g)	1,476.02[b]	1,482.87[b]	1,537.23[a]	1,485.83[b]	10.66	0.0458
Feed intake (g)	2,406.26	2,348.30	2,349.66	2,394.08	45.41	0.8217
Feed conversion ratio (1-28d)	1.63	1.59	1.53	1.61	0.03	0.4754
Mortality (%)	10.98[a]	3.33[b]	0.00[c]	6.65[b]	2.97	0.0499

[a, b,c] Meansin the same row followed by different superscripts are significantly different(p<*0.05*).

[1] CONT: basal diet; T1: basal diet + 2% red ginseng marc; T2: basal diet + 1% fermented ginseng marc with red koji; T3: basal diet + 2% liquid red ginseng.

[2] Values are expressed as means.

al. (2014) also found that supplementing broiler diets with 3% red ginseng marc markedly decreased mortality.

In general, natural plant extracts contain a variety of bioactive ingredients that have intrinsic abilities to improve digestion and stimulate enzyme activity (Platel *et al*., 2002; Rao *et al*., 2003; Saha *et al*., 2011). Therefore, using fermented red ginseng marc powder combined with red koji is considered a key strategy to support gut health and to optimize digestive functions, thereby improving growth performance.

Meat fatty acid profile

The fatty acid profile results obtained in the breast and thigh meats are presented in Tables 2 and 3, respectively. In the breast meat, there were minor differences ($p<0.05$) between the control and the treatment groups for percentages of pentadecanoic acid (C15:0), palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1 n-9), linoleic acid (C18:2 n-6), saturated fatty acid (SFA), and mono unsaturated fatty acid (MUFA). On the other hand, there were no significant differences among treatments for the percentages of myristic acid (C14:0), palmitoleic acid (C16:1), margaric acid (C17:0), heptadecenoic acid (C17:1 n-7), gamma-linolenic acid (C18:3 n-6), alpha-linolenic acid (C18:3n-3), ecosadienoic acid (C20:2 n-6), dihomo-gamma-linolenic acid (C20:3 n-6),arachidonic acid (C20:4 n-6), adrenic acid (C22:4 n-6), docosapentaenoic acid (C24:5 DPA), poly-unsaturated fatty acid (PUFA), or PUFA/SFA and n-6/n-3 ratios ($p>0.05$). The changes in the fatty acid profiles of thigh muscle showed a similar pattern to that of breast meat. Not all of the fatty acids in thigh meat were influenced by the supplementation of broiler diets with different types of red ginseng ($p>0.05$; Table 3). Pentadecanoic acid (C15:0) was the only thigh muscle fatty acid profile that was affected by ginseng supplementation ($p<0.05$). In general, all treatments produced high levels of unsaturated fatty acids (58.23 to 63.86% in breast meat and 58.58 to 64.28% in thigh meat) and low levels of saturated fatty acids (36.14 to 41.77% in breast meat and 35.72 to 41.42% in thigh meat).

Contrary to expectations, higher saturated fatty acid levels and lower of unsaturated fatty acid levels in the breast meat and thigh meats (although not statistically significant in the latter) were obtained with2% red ginseng marc (T1) in comparison with the control, 1% fermented red ginseng with red koji (T2),

Table 2 – Effects of the dietary addition of fermented red ginseng marc with red koji on the fatty acid profile of the breast meat of 28-d-old broilers.

Item	Treatment[1]				SEM[2]	p-value
	CONT	T1	T2	T3		
Myristic acid (C14:0)	0.61	0.71	0.68	0.61	0.154	0.6614
Pentadecanoic acid (C15:0)	0.09^{b}	0.12^{a}	0.15^{a}	0.14^{a}	0.028	0.0002
Palmitic acid (C16:0)	23.70^{b}	26.10^{a}	23.10^{b}	23.10^{b}	1.637	0.0001
Palmitoleic acid (C16:1)	2.22	2.50	2.32	1.68	0.887	0.1690
Margaric acid (C17:0)	0.20	0.34	0.21	0.20	0.178	0.2047
Heptadecenoic acid (C17:1 n-7)	1.08	1.13	1.14	1.27	0.450	0.7780
Stearic acid (C18:0)	12.70^{ab}	14.50^{a}	12.00^{b}	12.90^{ab}	2.151	0.0456
Oleic acid (C18:1 n-9)	24.20^{a}	13.10^{b}	25.20^{a}	22.30^{ab}	8.553	0.0064
Linoleic acid (C18:2 n-6)	19.50^{b}	22.90^{a}	19.80^{b}	20.20^{b}	1.994	0.0007
Gamma-linolenic acid(C18:3 n-6)	0.13	0.13	0.12	0.12	0.025	0.4234
Alpha-linolenic acid (C18:3n-3)	0.28	0.28	0.40	0.30	0.195	0.4080
Ecosadienoic Acid (C20:2 n-6)	0.68	0.74	0.69	0.78	0.248	0.7638
Dihomo-gamma-linolenic Acid (C20:3 n-6)	1.45	1.84	1.34	1.56	0.476	0.0957
Arachidonic acid (C20:4 n-6)	9.61	11.50	9.38	10.81	3.423	0.4115
Adrenic acid(C22:4 n-6)	2.00	2.30	2.05	2.33	0.714	0.5937
Docosapentaenoic acid (C24:5 DPA)	1.55	1.84	1.44	1.75	0.575	0.3392
Saturated fatty acid (SFA)	37.30^{b}	41.77^{a}	36.14^{b}	36.95^{b}	3.113	0.0004
Mono unsaturated fatty acid (MUFA)	27.50^{a}	16.73^{b}	28.66^{a}	25.25^{ab}	8.867	0.0113
Poly unsaturated fatty acid (PUFA)	35.20	41.50	35.20	37.80	6.285	0.0674
PUFA/SFA	0.94	0.99	0.97	1.02	0.124	0.4609
n-6/n-3 ratio	18.23	20.00	18.14	17.46	3.014	0.5552

[a,b]Means in the same row followed by different superscripts are significantly different ($p<0.05$).

[1]CONT: basal diet; T1: basal diet + 2% red ginseng marc; T2: basal diet + 1% fermented ginseng marc with red koji; T3: basal diet + 2% liquid red ginseng.

[2]Values are expressed as means.

Table 3 – Effects of the dietary addition of fermented red ginseng marc with red koji on the fatty acid profile of the thigh meat of 28-d-old broilers

Item	Treatment[1]				SEM[2]	p-value
	CON	T1	T2	T3		
Myristic acid (C14:0)	0.61	0.68	0.66	0.60	0.299	0.9337
Pentadecanoic acid (C15:0)	0.10^{b}	0.12^{ab}	0.15^{a}	0.14^{a}	0.039	0.0111
Palmitic acid (C16:0)	23.66	26.26	23.00	23.50	6.274	0.5796
Palmitoleic acid (C16:1)	2.37	2.81	2.44	1.74	1.452	0.3495
Margaric acid (C17:0)	0.21	0.36	0.21	0.21	0.217	0.2267
Heptadecenoic acid (C17:1 n-7)	1.18	1.23	1.28	1.44	0.520	0.6305
Stearic acid (C18:0)	12.25	14.00	11.70	13.00	2.836	0.2399
Oleic acid (C18:1 n-9)	25.35	13.60	25.50	20.90	16.52	0.2629
Linoleic acid (C18:2 n-6)	19.20	22.80	19.71	20.50	5.104	0.3275
Gamma-linolenic acid(C18:3 n-6)	0.13	0.14	0.12	0.12	0.053	0.8998
Alpha-linolenic acid (C18:3n-3)	0.20	0.16	0.32	0.19	0.336	0.6885
Ecosadienoic acid (C20:2 n-6)	0.63	0.71	0.65	0.75	0.221	0.5029
Dihomo-gamma-linolenic acid (C20:3 n-6)	1.69	2.12	1.62	1.91	0.584	0.1613
Arachidonic acid (C20:4 n-6)	8.79	10.73	8.97	10.62	3.370	0.3442
Adrenic acid(C22:4 n-6)	2.12	2.44	2.21	2.57	0.805	0.5008
Docosapentaenoic acid (C22:5 DPA)	1.51	1.84	1.46	1.81	0.600	0.2840
Saturated fatty acid (SFA)	36.83	41.42	35.72	37.45	8.858	0.4262
Mono unsaturated fatty acid (MUFA)	28.90	17.64	29.22	24.08	15.70	0.2454
Poly unsaturated fatty acid (PUFA)	34.27	40.94	35.06	38.47	7.814	0.1455
PUFA/SFA	0.93	0.99	0.98	1.03	0.141	0.7138
n-6/n-3 ratio	19.04	19.47	18.69	18.24	9.755	0.8359

[a,b] Means in the same row followed by different superscripts are significantly different ($p<0.05$).

[1] CONT: basal diet; T1: basal diet + 2% red ginseng marc; T2: basal diet + 1% fermented ginseng marc with red koji; T3: basal diet + 2% liquid red ginseng.

[2] Values are expressed as means.

and 2% liquid red ginseng (T3) treatments. Moreover, in general, the concentrations of individual and total SFA and USFA (and the ratio of n-6 to n-3 fatty acids) in breast and thigh meat lipids of the control group were not very different from those obtained with the treatment diets. The reason for the presence of similar levels of unsaturated fatty acids in the breast and thigh meat obtained with all red ginseng treatments is poorly understood, as it was expected that saponins would be have much stronger biological effects (Yildirim *et al*., 2013). The levels of all unsaturated fatty acid obtained with the different red ginseng treatments are nutritionally undesirable.

Red ginseng (saponin) may reduce SFA levels in broiler meat either by inhibiting the activity of the desaturase enzyme complex or by reducing the activity of the enzyme that converts SFA into MUFA in the presence of antioxidant supplementation (Chowdhury *et al*., 2002; Sohaib *et al*., 2015). To the best of our knowledge, this is the first study to examine the effects of different types of dietary red ginseng supplements on broiler growth performance and chicken meat fatty acid profile, and therefore, no comparisons could be made with other studies.

CONCLUSIONS

The present study shows that the inclusion of different types of red ginseng in poultry diets may be an effective strategy to improve broiler growth performance. In particular, the dietary supplementation of 1% fermented red ginseng with red koji increased broiler weight gain, improved feed conversion ratio, and reduced mortality to 0%, promoting the best results among the evaluated treatments. Contrary to the expectations, there were no positive effects of different types of red ginseng on the fatty acid profile of breast or thigh meat. Further studies are needed to investigate the mechanisms underlying chicken meat fatty acid profile changes when different types of red ginseng are fed.

ACKNOWLEDGEMENTS

This work was carried out with the support of "Cooperative Research Program for Agriculture

Science & Technology Development (Project title: Development of insect-based aquaculture feed ingredient, Project No: PJ010034)" Rural Development Administration, Republic of Korea and of the Small and Medium Business Administration funded by the Korean Government (grant No. C0150527).

REFERENCES

Arunachalam C, Narmadhapriya D. Monascus fermented rice and its beneficial aspects:a new review. Asian Journal of Pharmaceutical and Clinical Research 2011;1:29-31.

Ao X, Meng QW, Kim IH. Effects of fermented red ginseng supplementation on growth performance, apparent nutrient digestibility, blood hematology and meat quality in finishing pigs. Asian-AustralianJournal of Animal Science 2011a;24:525–531.

Ao X, Zhou TX, Kim HJ, Hong SM, Kim IH. Influence of fermented red ginseng extract on broiler and laying hens. Australian Journal of Animal Science 2011b;24:993–1000.

Choi SY, Hong HD, Bae HM, Choi C, Kim KT. Phytochemical characteristics of coffee bean treated by coating of ginseng extract. Journal of Ginseng Research 2011;35:436–441.

Chowdhury SR, ChowdhurySD, Smith TK. Effects of dietary garlic on cholesterol metabolism in laying hens. Poultry Science 2002;81:1856-1862.

Chung SI, Rico CW, Kang MY. Comparative study on the hypoglycemic and antioxidative effects of fermented paste (Doenjang) prepared from soybean and brown rice mixed with rice bran or red ginseng marc in mice fed with high fat diet. Nutrients 2014;6:4610-4624.

Duncan DB. Multiple range and multiple F-tests. Biometrics 1955;11:1-42.

EoJK, Choi MS, Eom AH. Diversity of endophytic fungi isolated from Korean ginseng leaves. Mycobiology 2014;42:141-151.

Folch J, Less M, Sloane-Stanley GH. A simple method for isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry 1957;226:497-509.

Fujimoto M, Tsuneyama K, Chen SY, Nishida T, Chen JL, Chen YC, et al. Study of the effects of Monacolin K and other constituents of red yeast rice on obesity, insulin-resistance, hyperlipidemia, and nonalcoholic steatohepatitis using a mouse model of metabolic syndrome. Evidence-Based Complementary and Alternative Medicine 2012;1-11.

Ilsley SE, Miller HM, Kamel C. Effects of dietary quillaja saponin and curcumin on the performance and immune status of weaned piglets. Journal of Animal Science 2005;83:82-88.

Kim IC, Yang JH, Hur SS. Characterization of a loess module for manufacturing loess red ginseng. Journal of Ginseng Research 2010;34:282–287.

Kim DC, In MJ. Production of hydrolyzed red ginseng residue and its application to lactic acid bacteria cultivation. Journal of Ginseng Research 2010;34:321–326.

Kim HJ, Chae IG, Lee SG, Jeong HJ, Lee EJ, Lee IS. Effects of fermented red ginseng extracts on hyperglycemia in streptozotocin-induced diabetic rats. Journal of Ginseng Research 2010a;34:104–112.

Kim YJ, Lee GD, Choi IH. Effects of dietary supplementation of red ginseng marc and α-tocopherol on the growth performance and meat quality of broiler chicken. Journal of the Science of Food and Agriculture 2014;94:1816–1821.

Ko SK, Lee CR, Choi YE, Im BO, Sung JH, Yoon KR. Analysis of ginsenosides of white and red ginseng concentrates. Korean Journal of Food Science and Technology 2003;35:536-539.

Lee DM, Yu SG, Jeong JS,Moon JH, Jung GH. Market Segmentation Based on Attributes for the Purchase of Fresh Ginseng. Agribusiness and Information Management 2012;4:1-13.

Lee HC, Vinodhkumar R, Yoon JW, Park SK, Lee CW, Kim HY. Enhanced inhibitory effect of ultra-fine granules of red ginseng on LPS-induced cytokine expression in the monocyte-derived macrophage THP-1 cells. International Journal of Molecular Sciences 2008;9:1379–1392.

Peisker KV. A rapid semi-micro method for preparation of methyl esters from triglycerides using chloroform, methanol, sulphuric acid. Journal of The American Oil Chemists Society 1964;41:87-88.

Platel K, Rao A, Saraswathi G, Srinivasan K. Digestive stimulant action of three Indian spices mixes in experimental rats. Nahrung 2002;46:394-398.

Rao RR, Platel K, Srinivasan K. In vitro influence of spices and spice-active principles on digestive enzymes of rat pancreas and small intestine. Nahrung 2003;47:408-412.

Saha M, Chowdhury SD, Hossain Md E, Islam Md K, Roy B. Organic water additive on growth performances, hematological parameters and cost effectiveness in broiler production. Journal of Animal Science and Technology 2011;53:517-523

SAS. SAS user's guide, Version 9.1. Cary; 2002.

Sohaib M, Butt MS, Shabbir MA, Shahid M. Lipid stability, antioxidant potential and fatty acid composition of broilers breast meat as influenced by quercetin in combination with α-tocopherol enriched diets. Lipids in Health and Disease 2015;14:61.

Wang J, Lu Z, Chi J, Wang W, Su M, Kou W. Multicenter clinical trial of the serum lipid-lowering effects of a Monascus purpureus (red yeast) rice preparation from traditional Chinese medicine. Current Therapeutic Research 1997;58:964–978.

Yildirim A, Şekeroglu A, Eleroglu H, Şen MI, Duman M. Effects of Korean (Panax ginseng C.A. Meyer) root extract on egg production performance and egg quality of laying hens. South African Journal of Animal Science 2013;43:194-207.