EFFECTS OF THE ADDITION OF AQUEOUS LIQUORICE (*Glycyrrhiza glabra*) EXTRACT TO DRINKING WATER IN THE PRODUCTION PERFORMANCE, CARCASS CUTS AND INTESTINAL HISTOMORPHOLOGY OF BROILER CHICKENS

S.S.M. Beski[1*] N.A. Shekhu[1] S.A.M، Sadeq[1] A.M.AL-Khdri[1],
Lecturer Assist. Lecturer Lecturer Lecturer
N.H.Ramadhan[2] S.H. AL-Bayati[3]
Researcher Prof.
[1]Dept.of Animal Production, College of Agriculture,University of Duhok.
[2]Dept. of Basic Sciences, College of Agriculture, University of Duhok.
[3]Dept. of Community Health, Duhok Polytechnic University.
[*]Corresponding author: Sleman.mohammed@uod.ac

ABSTRACT

This study was undertaken to investigate the effect of aqueous liquorice extract (ALE) on the growth performance, carcass cuts and intestinal histomorphology of broiler chickens between hatch and 35 days of age. A total of 160-d old (Ross 308) broiler chicks were randomly assigned to 4 treatments, each with 4 replicates, 10 birds per replicate. Four different levels of aqueous liquorice (0, 0.5, 0.7 and 0.9g) were administrated to a liter of drinking water and offered to the birds throughout the entire experimental period. Across the 35 days of trial, administration of ALE to the drinking water resulted in higher (P<0.05) body weight and weight gain. While, feed intake, water intake and FCR did not influence by ALE administration. On the other hand, there was no significant effect of the ALE on carcass cuts, visceral organs and intestinal histomorphology. The study demonstrated that ALE could be administrated to the drinking water of broilers between 0.5 and 0.9g/ liter. However, it would be more economical to use the medium level of ALE (0.7g/ liter) to achieve better results.

Keywords: Liquorice, Performance, Carcass, Histomorphology, Broilers.

مجلة العلوم الزراعية العراقية -2019 :50(3):842-849 بيسكي وآخرون

تاثير اضافة مستخلص مسحوق عرق السوس على الاداء الانتاجي و قطعيات الذبيحة و الصفات النسيجية لامعاء فروج اللحم.

سليمان سعيد محمد بيسكي[١] نارين عبدالعزيز شيخو[١] شوكت عبدالرزاق محمد صديق[١] احمد مشيرالخدري[١]
نيجيرفان حسن رمضان[٢] سعد حيدر البياتي[٣].
[١] قسم الانتاج الحيواني ، [٢] قسم العلوم الاساسية –كلية الزراعة– جامعة دهوك –[٣] قسم صحة مجتمع– جامعة دهوك التقنية

المستخلص

اجريت هذه التجربة لمعرفة مدى تاثير اضافة مستخلص عرق السوس الى ماء الشرب في الاداء الانتاجي و قطعيات الذبيحة والصفات النسيجية للامعاء لفروج اللحم خلال الفترة ما بعد الفقس الى عمر 35 يوم. 160 فروج اللحم سلالة Ross وزعت الطيورعلى اربعة معاملات بواقع اربعة مكررات لكل معاملة بمعدل 10 فروج لكل مكرر. اضيف المستخلص بنسب 0.5, 0.9, 0.7 غرام لكل لتر ماء من عمر يوم واحد من عمر الافراخ و لمدة 35 يوما درس خلالها تاثير المستخلص على الاداء الانتاجي و المتضمن وزن الجسم الحي و الزيادة اليومية و كمية العلف المستهلك و معامل التحويل الغذائي كما تم قياس استهلاك الماء. اذ بينت النتائج ان هناك زيادة معنوية في كل من وزن الجسم و الزيادة الوزنية للطيور التي حصلت على مسحوق السوس في عمر 35 يوم مقارنة بمعاملة السيطرة. ولكن معدل استهلاك العلف والماء و كذلك كفاءة التحويل الغذائي ووزن قطعيات الذبيحة و ووزن الاعضاء الداخلية لم تتاثر نتيجة اضافة مسحوق السوس الى ماء الشرب لفروج اللحم. اكددت هذه التجربة انه بالامكان اضافة مسحوق السوس الى مياه الشرب لفروج اللحم ما بين 0.5 الى 0.9 غرام لكل لتر من الماء و لكن اقتصاديا قد يكون المستوى الاوسط 0.7 غرام لكل لترهو الاحسن باعتباره حصل على افضل النتائج

كلمات مفتاحية: الانتاجية, عمر الافراخ, فروج اللحم, الويادة اليومية, التحويل الغذائي.

*Received:21/8/2018, Accepted:19/12/2018

INTRODUCTION

Ross 308 Herbal extracts have got growing attention as possible feed additives for animal production (36). Subsequently, following the restriction use of antibiotic, feed additives particularly that of plant origin (phytogenic) have gained the interest to be used in poultry nutrition. Numerous herbal plants have been intensively studied to be used as possible natural growth and health promotors in poultry nutrition in lieu of antibiotic due to its content of biologically active compounds (21). ===Liquorice (*Glycyrrhiza glabra*) is a perennial plant or sub-shrub rising to a height of 2 m with horizontal underground stem. Liquorice contains numerous active compounds including saponin triterpenes (glycyrrhizin, glycyrrhetinic acid and liquorice acid), flavonoids (liquiritin, isoflavonoids and formononetin) and other components such as coumarins, sugars, amino acids, tannins, starch, choline, ascorbic acid, phytosterols and bitter principles (4, 12, 33). It has been used as a pharmaceutical product in ancient Asia (37). The pharmacological impacts of liquorice and its isolated active compounds on animals have been confirmed by many workers: antimicrobial (14), antihelicobacter (13), antiatherosclerotic (10), antioxidative (35), antifungal (30), antiviral (9), antiinfective (26), and immune stimulator impacts (11). The administration of liquorice extract (LE) to the drinking water, improved the productive performance of broiler chickens challenged with heat stress (2). Nevertheless, the addition of liquorice powder significantly decreased the poisonous effect of aflatoxins contaminated diets on broiler performance (2). However, the impacts of LE supplementation on the Intestinal histomorphological changes of broilers have not been well investigated. Therefore, this study was accomplished to clarify the impact of aqueous extract of liquorice administration through drinking water on the performance, carcass traits and intestinal histomorphology of broiler chickens.

MATERIALS AND METHODS

The study was carried out at the poultry houses of Dept. of Animal Production, College of Agriculture, University of Duhok. One hundred sixty Ross 308 broilers were collected from a local hatchery. Ten birds were selected at random and allocated to each of the 4 single floor-pen replicates of each of the 4 treatments. Replicates of the treatments were randomly assigned to 16 floor pens bedded with softwood shavings. The room and equipment used for the study were thoroughly cleaned and disinfected before the in vivo study commencement. Treatments were allocated to each of the starter, grower and finisher basal diets comprising mainly of wheat, and soybean meal as shown in Table 1. Three phases of feeding were adopted, a starter diet from 1 to 10 d, grower diets from 11 to 24 d, and finisher diets from 25 to 35 d. All diets were formulated to meet the requirements for Ross 308 broiler chickens. Four levels of aqueous liquorice extract were created by soaking four different amounts (0, 0.5, 0.7 and 0.9g) of liquorice root powder into a liter of water. Thereafter, the water was filtrated and the solutions were collected into four plastic bottles and offered to the four different groups of birds for 35 days. All birds had *ad libitum* access to feed and water throughout the study. The room temperature was maintained at 33°C during the first 5 d and then gradually decreased to 23°C by d 24 of age. Birds received continuous light for the first 24 h, then 23L (light)/:1D (darkness) for the first weeks and were then maintained under 16L:8D for the remainder of the study. Birds and feeds in each pen were weighed by the end of each feeding phase and FCR was adjusted for mortality whenever it occurred. All the birds were monitored for general health at least twice a day. The production and maximising return index were calculated as following:

$$\text{Production index} = \frac{\text{Average body weight (g)} \times \text{livability (\%)}}{\text{Number of rearing days} \times \text{feed conversion ratio} \times 10}$$

(Naji *et al.*(25))

$$\text{Maximising return index} \quad \frac{(M \times SR \times L \times LP) - (AFC \times FCR \times M) - (MC) - (CP)}{\text{Age (days)}}$$

M:(Mass kg); SR:(Stocking Rate kg/m^2); L: (Livability %); LP: (Live price R/kg); AFC: (Average Feed Cost); FCR: (Feed Conversion Ratio); MC: (Medication Cost); CP: (Chick price) (20) At day 35, 2 birds were euthanized by cervical dislocation for measuring carcass characteristics and intestinal tissue collected for morphometric analyses. Approximately 1

cm of the jejunum was collected. The intestinal samples were opened and gently flushed clean with phosphate buffered saline (PBS, pH 7.4) and then fixed in 10% buffered formalin for 24 h. Formalin was subsequently replaced by 70% ethanol for storage. Each segment was embedded in paraffin. A 5 (µm) section of each sample was placed on a glass slide and stained with hematoxylin and eosin, and then examined by microscope (27).

Statistical analysis of data

All data were subjected to CRD (Completely Randomized Design) analysis using SAS, 2003) (29). Differences between mean values were determined using Duncan`s multiple range tests (8)

Table 1. Proximate analysis of experimental diets (dry matter basis).

Nutrients %	Starter	Grower	Finisher
Crude protein (Det.*)	24.8	22.50	19.25
ME, kcal/kg (Cal.**)	3,025	3,100	3,150
C:P ratio (Cal.)	121.98	137.78	163.64
Moisture (Det.)	7.61	7.62	7.46
Dry matter (Det.)	92.39	92.38	92.54
Ether extract (Det.)	4.50	4.80	7.10
Ash (Det.)	6.90	5.96	5.40

***Determined,**Calculated**

RESULTS AND DISCUSSION

Growth performance

Over the starter period (1-10 days), the body weight, weight gain and feed intake were not affected when ALE was administrated to the drinking water of broiler chickens. However, FCR was significantly (P< 0.05) in ALE supplemented groups than those of control (Table 2). Whereas, the results were almost same among all experimental groups over the grower period of broiler age (Table 3)

Table 2. Effect of aqueous liquorice extract on growth performance of broiler chickens (1-10) days

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
BW (g)	278.5	287.2	286.5	287.7	1.74
WG (g)	238.6	248.0	248.2	249.0	1.83
FI (g)	268.7	263.7	260.0	269.3	2.65
WI (ml)	775.2	760.7	766.1	825.4	11.74
FCR (g/g)	1.14[a]	1.07[b]	1.08[b]	1.11[ab]	0.01

BW: body weight. BWG: body weight gain. FI: feed intake. WI: water intake. FCR: feed conversion ratio. [a,b] Means within a row with no common superscript differ significantly (P < 0.05).

Table 3. Effect of aqueous liquorice extract on growth performance of broiler chickens (11-24) days

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
BW (g)	1,109.50	1,138.33	1,122.96	1,099.33	11.01
BWG (g)	835.17	851.17	841.96	817.83	10.14
FI (g)	1,074.83	1,114.50	1,116.69	1,080.17	11.00
WI (ml)	2,765.28	2,820.11	2,852.00	2,971.78	37.00
FCR (g/g)	1.35	1.33	1.35	1.36	0.01

BW: body weight. BWG: body weight gain. FI: feed intake. WI: water intake. FCR: feed conversion ratio.

However, over the subsequent finisher period (25-35 days), the BW, BWG and FI were significantly increased (P< 0.05) by rising levels of ALE (Table 4). Neither WI nor FCR were affected by the treatment in the mentioned period. When assessed, over the entire production cycle (1-35) days, there was a significant increase (P <0.05) in BW and

BWG in birds that received ALE in their drinking water (Table 5). Feed intake and FCR were not affected by the treatments. The production index (PI) was significantly higher (P <0.05) in the experimental groups that offered ALE than the control group (Fig. 1). The highest PI (408.88) was recorded for the birds that received 0.7g/ liter of ALE compared to the other experimental groups. The maximising return index was significantly higher in birds that received 0.7 and 0.9g of ALE than those in the control group (Fig. 2).

Table 4. Effect of aqueous liquorice extract on growth performance of broiler chickens (25-35) days

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
BW (g)	1,882.67[b]	2,002.00[a]	2,036.67[a]	1,995.00[a]	22.19
BWG (g)	787.67[b]	870.70[ab]	926.35[a]	895.67[a]	19.06
FI (g)	1,313.50[b]	1,438.00[ab]	1,475.26[a]	1,441.00[ab]	25.95
WI (ml)	3,366.70	3,380.00	3,328.30	3,533.30	41.70
FCR (g/g)	1.67	1.68	1.67	1.64	0.02

BW: body weight. BWG: body weight gain. FI: feed intake. WI: water intake. FCR: feed conversion ratio. [a,b] Means within a row with no common superscript differ significantly (P < 0.05).

Table 5. Effect of aqueous liquorice extract on the accumulative growth performance of broiler chickens (1-35) days

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
BW (g)	1882.7[b]	2002.0[a]	2036.7[a]	1995.0[a]	22.19
WG (g)	1842.7[b]	1963.0[a]	1998.4[a]	1956.7[a]	22.32
FI (g)	2667.3	2836.1	2855.4	2799.8	34.00
WI (ml)	6981.1	6964.4	7004.6	7370.1	82.54
FCR (g/g)	1.46	1.46	1.47	1.46	0.01

BW: body weight. BWG: body weight gain. FI: feed intake. WI: water intake. FCR: feed conversion ratio. [a,b] Means within a row with no common superscript differ significantly (P < 0.05).

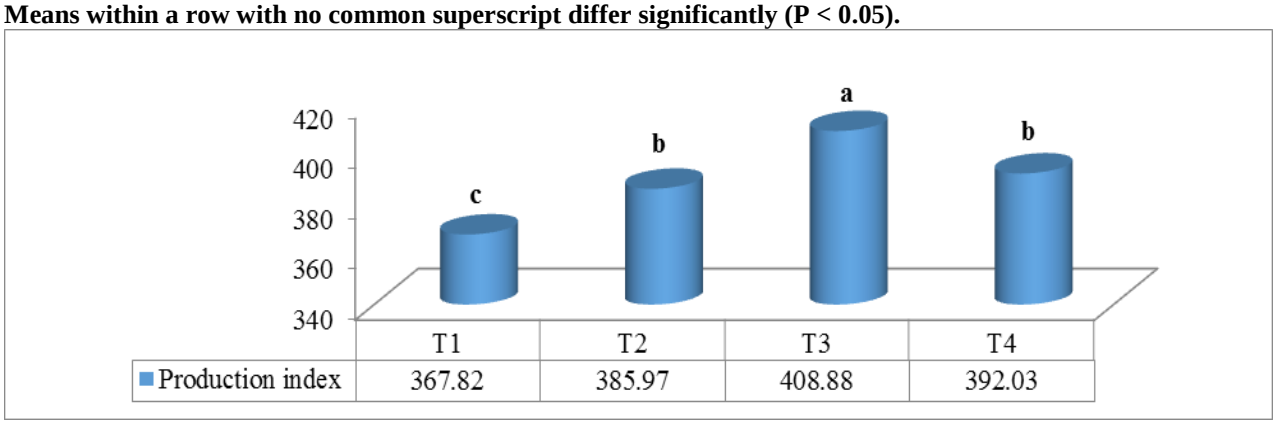

Figure 1. Effects of aqueous liquorice extract on production index of broiler chickens (1-35) days. T1: Control group, T2 (0.5g LE/ liter), T3 (0.7g LE/ liter) and T4 (0.9g LE/ liter). Different letters above each column indicate significant difference between means (P < 0.05).

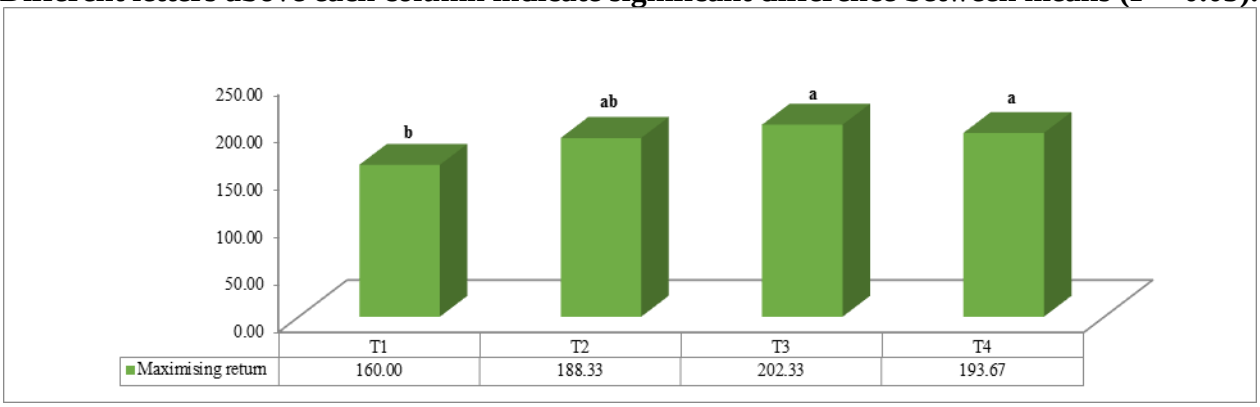

Figure 2. Effects of aqueous liquorice extract on maximizing return index of broiler chickens (1-35) days. T1: Control group, T2 (0.5g LE/ liter), T3 (0.7g LE/ liter) and T4 (0.9g LE/ liter). Different letters above each column indicate significant difference between means (P < 0.05).

Administration of ALE improved the FCR, BW and BWG. The positive effect of ALE on the broiler performance could be due to the improvement in the intestinal health and digestion functions. The beneficial effects of phytogenic extracts on the growth performance of poultry, arises from its ability to promote the digestibility, improve the gut microflora and increase the secretion of endogenous digestive enzymes (28). In addition, these extracts found to stimulate appetite and digestion (6, 36). Furthermore, Grieve (17) stated that liquorice is acting as appetite and digestion stimulators. It also raised blood flow through mucous membranes of gut increasing the utilization efficiency of nutrients. The results were in line with the findings of (2, 3, 28) who found that delivering the liquorice via feed or drinking water, significantly improved the growth performance of broiler chickens. The presence of active compounds especially those belong to isoflavonoid class of chemicals, liquorice may have the ability to improve the function of immune system (1, 7, 32). This could be the only explanation of low mortality rate in ALE supplemented group in the current study. This was in accordance with the findings of (34) who showed that the survival rate increased after intraperitoneal administration of liquorice active compound (glycyrrhizin) 0.2 ml of a saline solution/mouse 1 day before infection and 1 and 4 days post infection in mice infected with 20 and 10 LD50s of influenza virus (H2 N2). In contrast (23, 24, 31) stated that using LE as a dietary supplementation or via drinking water had no significant effects on the performance and immunological parameters of broiler chickens and Japanese quails.

Carcass cuts

There was no significant effects of the ALE administration on the dressing percentage and the relative weight of carcass parts (Table 6). However, although not significant, the dressing percentage and the relative weight of breast percentages were numerically higher ALE supplemented birds than those in control. Similar results have been obtained by (31) when licorice extract was included to the broiler diets. The carcass yield in broilers were mainly influenced by genetic factors than nutritional ones (16). In contrast, (2, 3) stated that the addition of liquorice extract (LE) to the aflatoxin contaminated diets significantly eliminated the negative effect of aflatoxin on the carcass characteristics of broiler chickens. Furthermore, the dressing percentage significantly improved when LE was administrated into the drinking water of broiler chickens.

Table 6. Effect of aqueous liquorice extract on carcass cuts of broiler chickens at 35 days of age

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
Dressing %	73.1	73.7	74.1	75.0	0.36
Breast	36.5	38.7	38.7	38.5	0.43
Thighs	15.5	15.0	14.6	15.4	0.18
Drumsticks	12.8	12.8	13.5	13.2	0.15

SEM=standard error of means

The relative weight of visceral organs

In general, the effect of ALE administration was not significant on the relative weight of internal organs (including liver, heart, bursa and pancreas) except for the relative weight of spleen which was significantly ($P < 0.05$) lower in ALE supplemented groups than those of control (Table 7). In this study, the relative weights of visceral organs were not affected by the administration of ALE to the drinking water of broiler chickens. Except for the spleen weight which was decreased in ALE supplemented groups. This is in agreement with (23, 24, 31) who found no influence of liquorice on these organs in broilers and quails. Also Al-Daraji (3) reported a significant decrease in the relative weight of spleen as a result of ALE administration to the broiler drinking water. However, Salary *et al.*(28) found a significant increasing in pancreas percentage in broilers when introduced to LE.

Intestinal histomorphology

The effect of the ALE administration on the jejunum histomorpholoy is presented in table 8. Villus height (VH), crypt depth (CD) and villus height/crypt depth (VH/CD) were not affected by the administration of ALE to the drinking water or broiler chickens. However, in general VH and VH/CD were higher in birds that received the medium level ALE (0.7g/liter) than other experimental groups.

Table 7. Effect of aqueous liquorice extract on visceral organs of broiler chickens at 35 days of age

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
Liver	3.63	3.59	3.88	3.81	0.05
Heart	0.93	0.91	0.89	0.87	0.03
Bursa	0.147	0.176	0.179	0.153	0.016
Spleen	0.184[a]	0.132[b]	0.108[b]	0.109[b]	0.011
Pancreas	0.232	0.252	0.229	0.210	0.009

[a,b] **Means within a row not sharing the same superscript are significantly different (P < 0.05). SEM=standard error of means**

The critical digestive organ which involved in the absorption of nutrients is a small intestine. Therefore, any improvement of this part is very important for the performance and health status of broiler (19). Villus hight (VH) and crypt depth (CD) became a popular measurement in supporting the impacts of nutrition on the physiology of alimentary canal. Nevertheless, the positive correlations between the improvement of performance and VH and CD have been documented (18). The increasing in VH and VH: CD ratio lead to better absorption of nutrients, consequently, has positive effect on the growth performance (5, 22). Additionally, using phytogenic extracts in poultry causes increasing in height of villus due to decline of harmful bacteria in the intestinal wall, therefore minimizing the byproducts of these bacteria such as toxic compounds which negatively effect on the epithelial cells of intestine and finally inhibit villus destruction and minimizes repairing of the lumen (15).

Table 8. Effect of aqueous liquorice extract on intestinal histomorphology of broiler chickens at 35 days of age

Response	Liquorice level				SEM
	0	0.5	0.7	0.9	
VH (µm)	1320.0	1207.7	1367.6	1325.9	38.15
CD (µm)	206.3	211.4	209.9	215.4	6.41
VH/CD ratio	7.00	6.11	7.39	6.57	0.26

VH: villus height. CD: crypt depth, VH/CD= villus height/crypt depth, SEM=Standard error of means

The results of this experiment provides evidences of the positive effects of the administration of ALE to the drinking water on the performance of broiler chickens. The outcomes achieved in this study suggest that ALE would be more beneficial if used at a medium level (0.7g/liter) throughout the broiler production cycle.

REFERENCES

1-Adam L. 1997. In vitro antiviral activity of indigenous glycyrrhizin, licorice, glycyrrhizic acid (sigma) on Japanese encephalitis virus. J. Com. Dis. 29: 91–99

2-Al-Daraji H.J. 2012a. The protective effect of liquorice against carcass traits changes induced by aflatoxin in broilers. J. Anim. Sci. 1: 18–23

3-Al-Daraji H.J. 2012b. The use of liquorice , probiotic , potassium chloride and sodium bicarbonate to counteract the detrimental effects of heat stress on performance of broilers. Glob. Adv. Res. J. Agri. Sci. 1: 127–135

4-Arystanova T.P., M.P. Irismetov, and A. O. Sopbekova. 2001. Chromatographic determination of glycyrrhizinic acid in

Glycyrrhiza glabra preparation. Chem. Nation. Compd. 37: 89–90.

5-Awad W., K Ghareeb, and J Böhm. 2008. Intestinal structure and function of broiler chickens on diets supplemented with a synbiotic containing Enterococcus faecium and oligosaccha-rides. Int. J. Mol. Sci. 9: 2205–2216

6-Cabuk M., A Alcicek, M Bozkurt, and N Imre. 2003. Antimicrobial properties of essential oils isolated from aromatic plants and using possibility as Alternative Feed Additives. Nation. Anim. Nutr. Congress. 11: 184–187

7-Duke J. 1985. CRC Handbook of Medicinal Herbs. Doi:10.1097/00004850-199001000-00014

8-Duncan, D.B. 1955. Multiple F and multiple "F" test. Biometrics, 11, 1955

9-Fiore C., M Eisenhut, R Krausse, E Ragazzi, D Pellati, D Armanini, and J Bielenberg. 2008. Antiviral effects of Glycyrrhiza species. Phyther. Res. 22: 141–148. doi:10.1002/ptr.2295

10-Fuhrman B., N Volkova, M Kaplan, D Presser, J Attias, T Hayek, and M Aviram. 2002. Antiatherosclerotic effects of licorice extract supplementation on hypercholesterolemic patients: Increased resistance of LDL to atherogenic modifications, reduced plasma lipid levels, and decreased systolic blood pressure. Nutr. 268–273.

11-Fujioka T., R Kondou, and A Fukuhara. 2003. Efficacy of glycyrrhizin suppository for treatment of chronic hepatitis C: a pilot study. Hepat. Res. 26: 103–117

12-Fukai T., B.S. Cai, K Maruno, Y Miyakawa, M Konishi, and T Nomura. 1998. An isoprenylated flavanone from Glycyrrhiza glabra and rec-assay of licorice phenols. Phytochem. 49: 2005–2013.

13-Fukai T., A Marumo, K Kaitou, T Kanda, S Terada, and T Nomura. 2002. Anti-Helicobacter pylori flavonoids from licorice extract. Life Sci. 71: 1449–1463.

14-Fukai T., A. Marumo, K. Kaitou, T. Kanda, S. Terada, and T. Nomura. 2002. Antimicrobial activity of licorice flavonoids against methicillin-resistant Staphylococcus aureus. Fitoterapia. 73: 536–539

15-Garcia V., P. Catala-Gregori, F. Hernandez, M.D. Megias, and J. Madrid. 2007. Effect of formic acid and plant extracts on growth, nutrient digestibility, intestine mucosa morphology, and meat yield of broilers. J. Appl. Poult. Res. 16: 555–562.

16-Gong J., R.J. Forster, H. Yu, J.R. Chambers, P.M. Sabour, R. Wheatcroft, and S. Chen. 2002. Diversity and phylogenetic analysis of bacteria in the mucosa of chicken ceca and comparison with bacteria in the cecal lumen. FEMS Microbiol. Letter. 208: 1–7

17-Grieve, M.M. 1995. A Modern Herbal. *Botanical.com*, Rosmarinus Officinale.doi:http://www.botanical.com/botanical/mgmh/a/artic066.html

18-Hashem S., I. Zulkifli, H. Davoodi, M. Hair Bejo, and T.C. Loh. 2014. Intestinal histomorphology changes and serum biochemistry responses of broiler chickens fed herbal plant (*Euphorbia hirta*) and Mix of Acidifier. Iran. J. Appl. Anim. Sci. 4: 95–103

19-Kawalilak L.T., M. Ulmer Franco, G.M. Fasenko. 2010. Impaired intestinal villi growth in broiler chicks with unhealed navels. Poult. Sci. 89: 82–87.

20-Klein R. 2013. Chicken Nutrition: A guide for nutritionists and poultry professionals. Leicestershire, England: Context Products Ltd

21-Lee K.W., H. Everts, H.J. Kappert, K.H. Yeom, and A.C. Beynen. 2003. Dietary carvacrol lowers body weight gain but improves feed conversion in female broiler chickens. J. Appl. Poult. Res. 12: 394–399.

22-Montagne L., J. Pluske, and D. Hampson. 2003. A review of interactions between dietary fibre and the intestinal mucosa, and their consequences on digestive health in young non-ruminant animals. Anim. Feed. Sci. Tech. 108: 95–117.

23-Moradi N., S. Ghazi, T. Amjadian, H. Khamisabadi, and M. Habibian. 2014. Performance and some immunological parameter responses of broiler chickens to licorice (*Glycyrrhiza glabra*) Extract administration in the drinking water. Annual. Res. Rev. Biol. 4: 675–683

24-Myandoab M., and N. Mansoub. 2012. Comparative effect of liquorice root extract medicinal plants and probiotic in diets on performance, carcass traits and serum

composition of Japanese quails. Global Vet. 8: 39–42

25-Naji S.A.H., G.A. Al-Kaissy, N.N.A. Al-Hjo, and and R.A. Al-Khalidi. 2007. Poultry meat production and technology. Baghdad: Ministry of higher education and scientific research. University of baghdad

26-Nowakowska, Z. 2007. A review of anti-infective and anti-inflammatory chalcones. Europe J. Med. Chem. 42: 125–137

27-Sakamoto K., H. Hirose, A. Onizuka, M. Hayashi, N. Futamura, Y. Kawamura, and T. Ezaki. 2000. Quantitative study of changes in intestinal morphology and mucus gel on total parenteral nutrition in rats. J. Surg. Res. 94: 99–106

28-Salary J., M. Kalantar, M. Sahebi, K. Ranjbar, and H.R.H. Matin. 2014. Drinking water supplementation of licorice and aloe vera extracts in broiler chickens. J. Anim. Sci. 3: 41–48.

29-SAS. 2003. SAS User Guide for Personal Computers, Statistical Programme release 9.01 Windows Version 4.10.22222

30-Sato J., K. Goto, F. Nanjo, S. Kawai, and K. Murata. 2000. Antifungal activity of plant extracts against arthrinium sacchari and chaetomium funicola. J. Biosci. Bioeng. 90: 442–446

31-Sedghi M., A. Golian, H. Kermanshahi, and H. Ahmadi. 2010. Effect of dietary supplementation of licorice extract and a prebiotic on performance and blood metabolites of broilers. South Afri. J. Anim. Sci. 40: 371–380

32-Shibata, S. 2000. Drug over millennia: Pharmacognosy, chemistry and pharmacology of licorice. Yakugaku Zasshi. 120: 849–862

33-Snow, J. 1996. Glycyrrhiza glabra. Monograph. Prot. J. Bot. Med. 1: 9–14

34-Utsunomiya T., M. Kobayashi, R.B. Pollard, and F. Suzuki. 1997. Glycyrrhizin, an active component of licorice roots, reduces morbidity and mortality of mice infected with lethal doses of influenza virus. Antimicro. Age. Chemother. 41: 551–556

35-Vaya J., P.A. Belinky, and M. Aviram. 1997. Antioxidant constituents from licorice roots: Isolation, structure elucidation and antioxidative capacity toward LDL oxidation. Free Rad. Biol. Med. 23: 302–313

36-Windisch W., K. Schedle, C. Plitzner, and A. Kroismayr. 2008. Use of phytogenic products as feed additives for swine and poultry. J. Anim. Sci. 86: 140–148

37-Zhou S., H.L. Koh, Y. Gao, Z.Y. Gong, E.J.D. Lee, 2004. Herbal bioactivation: The good, the bad and the ugly. Life Sci. 74: 935–968.