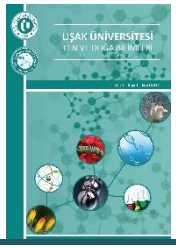
Uşak Üniversitesi Fen ve Doğa Bilimleri Dergisi
Usak University Journal of Science and Natural Sciences

http://dergipark.gov.tr/usufedbid
https://doi.org/10.47137/usufedbid.1393216



Research Article (Araştırma Makalesi)

Effects of Inulin Use in Broiler Chick Rations on Performance and Digestive System Development

*Berrin Çetinkaya[1], Cevdet Gökhan Tüzün[1]**

[1]Department of Animal Science, Faculty of Agriculture, Isparta University of Applied Sciences, Isparta, Türkiye

Geliş: 20 Kasım 2023 *Revizyon: 22 Aralık 2023* *Kabul: 27 Aralık 2023*
Received: 20 November 2023 *Revised: 22 December 2023* *Accepted: 27 December 2023*

Abstract

The aim of the study was to evaluate the effects of the addition of inulin to broiler diets on performance and physical development of the digestive tract. Performance and digestive system development were analyzed in two separate trials. The starter feed containing 0.25, 0.50 and 1.00% inulin was given in powder form to mixed sex and one day-old animals. Inulin, the source of which was chicory, was obtained from a commercial company and 400 Ross 308 broiler chicks for performance monitoring and 160 chicks for digestive system investigations were randomly distributed to 4 experimental groups with 4 replicates. Performance data were investigated at 0-21 and 21-42 days of age from the beginning of the study and the digestive system sections of the chicks were evaluated on the 10th day. It was observed that the addition of inulin to broiler chick diets had a negative effect on performance but did not have a detrimental effect on digestive system development. The addition of inulin to the feed caused a significant decrease in body weight gain and feed efficiency. As a result, it was determined that inulin and doses used in this study had negative effects on the performance of broiler chickens but had some effects on the digestive organs examined and it was concluded that there was no need to add inulin to broiler rations.

Keywords: *Chicks, inulin, digestive system development, prebiotic.*

Etlik Piliç Rasyonlarında İnülin Kullanımının Performans ve Sindirim Sistemi Gelişimi Üzerine Etkileri

Özet

Çalışma, broyler civciv yemlerine inülin eklenmesinin performans ve sindirim sistemi fiziksel gelişimi üzerindeki etkilerini değerlendirmeyi amaçlamaktadır. İki ayrı deneme ile performans ve sindirim sistemi gelişimi incelenmiştir. Karışık cinsiyette ve bir günlük yaştaki hayvanlara %0.25, 0.50 ve 1.00 oranlarında inülin içeren başlangıç yemi toz formda sunulmuştur. Çalışmada özel bir ticari firma tarafından üretilen ve hindibadan elde edilmiş inülin kullanılmış ve performans takibinde, 400 adet etlik Ross 308 civciv, sindirim sistemi incelemeleri için ise 160 adet civciv 4 tekerrürlü 4 deneme grubuna rastgele olarak dağıtılmıştır. Performans verileri, araştırmanın başlangıcından itibaren 0- 21 ve 21-42 günlük yaşta incelenmiş; ayrıca 10. gün civcivlerin sindirim sistemi bölümleri değerlendirilmiştir. İnülin ilavesinin etlik civciv yemlerinde performansı olumsuz etkilediği ancak sindirim sistemi gelişimi üzerinde zararlı bir etki yaratmadığı gözlemlenmiştir. Yemlere inülin takviyesi, canlı ağırlık artışı ve yem değerlendirme sayısının önemli ölçüde düşmesine sebep olmuştur. Sonuç olarak, bu çalışmada kullanılan inülin ve dozlarının etlik piliçlerin performansı üzerinde olumsuz etkileri olduğu ancak incelenen sindirim organları üzerinde bazı etkileri olduğu tespit edilmiş ve etlik piliç rasyonlarına inülin eklenmesine gerek olmadığı sonucuna varılmıştır.

Anahtar Kelimeler: *Civciv, inülin, sindirim sistemi gelişimi, prebiyotik.*

E-mail: berrin198430@gmail.com (ORCID ID: 0000-0003-1768-080X)
*Corresponding author-E-mail: gokhantuzun@isparta.edu.tr (ORCID ID: 0000-0002-4778-6202)

1. Introduction

Scientific research on farm animals has focused on natural feed additives that have positive effects on production performance and animal gut health since the European Union completely banned the use of antibiotics as growth factors in animal feed in 2006 [1]. The most important reasons why these natural feed additives are preferred instead of antibiotics are that when they are added to the feed, the nutrients in the feed are more easily digested by the animals, absorbed from the intestines and transported faster to the body cells, increase the amount and quality of the product obtained, and improve the utilization of feed.

Prebiotics are indigestible by endogenous enzymes feed additives that affect animals in a beneficial way, trying to improve animal health by selectively stimulating the growth and activity of many bacterial species in the large intestine. Prebiotics are feed additives used because they contribute to the healthy digestion of nutrients taken with feed in the intestine, increase the level of mineral absorption, help the development of intestinal microflora in the direction of beneficial bacteria, and most importantly, they contribute significantly to the health of poultry by strengthening the immune system [2-5].

Inulin is a carbohydrate that occurs naturally in many plants and has prebiotic properties due to inulin cannot be broken down by host digestive enzymes and thus reaches the intestine without any change. In plants, it is usually found in root vegetables, onions, garlic, chicory roots and artichoke roots. Here it undergoes fermentation and becomes a food source for some healthy bacteria species [6-8]. When the scientific publications on this subject are examined; it is seen that the addition of inulin to compound feeds improves the performance values of animals, increases carcass yield and egg production and quality, and also shows positive effects on the digestive tract of animals [9-16].

However, the results presented in literature reports show considerable variability [17-21]. It is thought that this is due to the fact that the mode of action of inulin appears to be complex and multifaceted and more research is needed. It has been reported that the different effects of inulin may vary depending on the different inulin contents of the source from which it is obtained, and the results obtained may be different [22]. This study aims to evaluate the effect of different doses of inulin derived from chicory on performance and digestive system development in broiler diets, based on a literature review.

2. Materials and Methods

2.1. Animal and Feed Material

In the study, 560 Ross-308 broiler chicks of mixed sex (male-female ratio 50:50) at the age of one day after hatching were used as animal material. Feed raw materials used in the study were obtained from Isparta University of Applied Sciences, Faculty of Agriculture, Education, Research and Application Farm and the basic feed mixtures (chick starter and finisher) were prepared in the feed unit of the same farm. All experimental feeds were given to the animals in powder form.

2.2. Method

2.2.1. Preparation and Chemical Composition of Research Feeds

The compound feeds used in the study were arranged according to [23] and the catalogue descriptions of the broiler hybrid. In the study, broiler chick starter feed was given to all groups on days 0-21 and a single type of finishing feed was given to all groups between days 22-42. The structures and chemical compositions of the compound feeds are presented in Table 1. Inulin was added to the broiler chick starter feed (0-21 days) at the levels of 0.25, 0.50 and 1.00 %, respectively. Feed additives of the research feeds were firstly premixed with a mixer blender and then added to the compound feed mixer during the production of the feeds.

2.2.2. Formation of Research Groups and Conduct of the Research

Ross-308 broiler chicks of mixed sex, which constitute the animal material in the study, were brought to the broiler chick research cluster, which was started to be heated two days in advance after the hatching was completed at around 10:30 on 6 June 2018. In order not to adversely affect the performance criteria in the study, two separate trials were conducted under the same conditions and time for the chicks to be evaluated in the performance test and digestive system examinations.

Table 1. Structures and calculated chemical compositions of compound feeds used in the study

Feed ingredients, g/kg	**Starter feed (0-21 days)**	**Finisher feed (21-42 days)**
Corn grain	533.62	601.47
Soybean meal	313.29	254.21
Full-fat soya	80.01	79.99
Sunflower oil	26.31	16.91
Dicalcium phosphate	19.54	20.04
Limestone	13.46	13.65
DL-Methionine	3.30	2.32
L-Lysine HCl	2.69	2.04
$NaHCO_3$	2.37	4.47
Salt	2.22	1.90
Vitamin premix[1]	1.00	1.00
Mineral premix[2]	1.00	1.00
L-Threonine	0.90	0.50
Choline-chloride % 60	0.30	0.50
Total (g)	1000.00	1000.00
Calculated chemical compositions, %		
ME, kcal/kg	3014	3196
Crude protein	22.93	19.31
Ether extracts	6.32	5.68
Calcium	1.04	0.91
Available phosphorus	0.51	0.44
Potassium	0.94	0.70
Chlorine	0.23	0.21
Na+K-Cl, mEq	250.00	250.00
Sodium	0.17	0.20
Lysine	1.44	1.11
Methionine + Cystine	1.03	0.85
Threonine	0.94	0.76
Tryptophan	0.25	0.20
Arginine	1.55	1.25
Isolysine	0.96	0.74
Valine	1.03	0.84
Analyzed values		
Crude protein	22.70	19.13
Ether extracts	5.19	4.38
Crude fiber	2.59	2.28

[1] 1 kg of vitamin premix contains 12.500.000 I.U. Vitamin A, 5.000.000 I.U. Vitamin D3, 200.000 mg Vitamin E, 4.000 mg Vitamin K3, 3.000 mg Vitamin B1, 8.000 mg Vitamin B2, 5.000 mg Vitamin B6, 40 mg Vitamin B12, 60.000 mg Niacin, 12.000 mg Calcium-D-pantothenate, 2.000 mg Folic acid, 50 mg Biotin, 150.000 mg Vitamin C (Ascorbic acid).

[2] 1 kg of mineral premix contains 100.000 mg Manganese, 150.000 mg Zinc, 100.000 mg Iron, 20.000 mg Copper, 1.500 mg Iodine, 500 mg Cobalt, 200 mg Selenium, 1.000 mg Molybdenum, 50.000 mg Magnesium

Inulin, the source of which was chicory, was obtained from a commercial company and the research was carried out in 4 groups in a factorial arrangement with 3 inulin levels in a randomised block design. In the performance test, a total of 400 newly hatched broiler chicks, 25 chicks in each replicate, were distributed in 4 groups in a factorial arrangement of randomised plots.

The initial body weight averages of the research groups were controlled by analysis of variance to ensure that there was no significant difference between them and then the experiment was started by feeding the relevant research feeds. Feeders and automatic nipple drinkers with varying sizes according to the age periods and body sizes of the chicks were used during the study.

For investigations of the digestive system, 160 chicks with the same characteristics as those in the performance test were distributed into groups within the same poultry house and given inulin feeds at the same doses and under the same conditions as in the performance test. After hatching, feed and water were given to the broiler chicks ad-libitum and 24 hours lighting was applied in the poultry house throughout the study. The temperature in the poultry house was 32ºC in the first week, 30ºC in the second week and 24ºC was reached by decreasing the temperature by 3ºC each week and kept constant at this temperature until the end of the research. Relative humidity level in the poultry house was kept at 60-65% throughout the study.

2.2.3. Determination of Performance Values

Body weight (BW) and feed intake (FI) of the chicks in the research groups were determined on the 10th, 21st and 42nd days and at the same time on a scale with a sensitivity of ±0.01 g. Feed intake was determined by subtracting the amount of leftover feed from the total amount of feed given. The body weights of the mortalities occurring during the research period were recorded daily and this was taken into consideration while calculating the feed intake. Feed conversion ratio (FCR, feed:gain) was determined by dividing the amount of feed consumed according to the periods analyzed by the body weight gain.

2.2.4. Investigation of the Physical Development of the Digestive System

At the end of the 10th day, cervical dislocation was performed on 4 chicks taken from each group for digestive system examinations and necessary measurements were made on the digestive system organs. The weights and lengths of the proventriculus, gizzard, pancreas, liver, *Bursa fabricius* and small intestine and their ratios to body weight were determined. The weights of the digestive system sections were measured after the contents of the digestive system were emptied.

2.2.5. Chemical Analyses of Feeds

Chemical analyses of feeds were carried out in two parallels in all samples, and when the difference between the parallels was more than 5%, the analyses were repeated. Crude protein, ether extract and crude fiber contents in compound feed samples used in the study were analyzed according to Weende analysis method [24]. The metabolic energy values of the compound feeds were calculated according to [25].

2.2.6. Statistical Analyses

The results of the data obtained as a result of the research were evaluated by using Minitab 18.0 package program for analysis of variance [26] in random plots experimental design and Duncan's test [27] was used in Mstat-C program to determine the difference between the groups when the difference was significant. Khi-Square method was used for statistical control of mortality rates [26].

3. Results

3.1. Performance Parameters

The results of the average BW are presented in Table 2, 3 and 4. At the beginning of the study, there were no statistically significant differences between the mean BW of the chicks ($P>0.05$) and the study was started under equal conditions in terms of BW. At 0-10 days and 11-21 days of the initiation period, the difference between the group averages in terms of BW values was found to be statistically significant ($P<0.01$). While the highest BW value was observed in the control group, lower average BW values were determined in the inulin added groups compared to the control group in the 0-10 day period.

During the 11-21 day period from the starter period, the group that received 1% inulin had the lowest BW value, which was significantly lower than the control and other inulin groups ($P=0.01$). In the 22-42 days of the finishing period, the difference between the group averages in terms of BW values was found to be statistically significant ($P=0.01$). During the finishing period, the control group exhibited the highest BW value compared to the inulin groups. No statistically significant difference was found in terms of BW values among the different inulin-added groups ($P>0.05$).

In the 0-10-, 22-42- and 0-42-day periods of the study, animals in the control group had better BWG than the inulin supplemented groups. In the 11-21 day period of the study, the lowest BWG was obtained in the group supplemented with 1% inulin and this difference was significantly lower than the other groups ($P<0.01$). It was observed that inulin supplementation at different doses did not significantly affect the BWG compared to each other (Table 3).

The effects of different inulin levels on FI were found to be significant ($P<0.05$) in the 11-21 days starter period, but insignificant ($P>0.05$) in all other periods analyzed. As a matter of fact, the groups consuming the feed with 1.00% inulin level and the control feed showed lower FI than the groups consuming 0.25 and 0.50% inulin during the initialization period between 11-21 days. When the effects of inulin levels on FCR in the initial, final and all periods of the study were analyzed, it was found that the differences between the groups were significant ($P<0.01$). In the 0-10 days of the study, 0.25 and 1.00 % inulin groups showed worse FCR than the control and 0.50 % inulin groups. In the 0-10-, 11-21-, 22-42- and 0–42-day periods of the study, the animals in the control group provided better FCR than the inulin supplemented groups ($P<0.01$). In all periods analyzed (Table 4), the effects between the groups consuming different inulin levels in terms of FCR were found to be insignificant ($P>0.05$)

Table 2. The effects of inulin level on the performance of broiler chicks during the starter period (0-21. day)

Starter period, 0-10 day	**BW,g**	**BWG,g**	**FI,g**	**FCR,g**
Control	238.2±2.01 a	201.3±2.15 a	237.2±2.75	1.175±0.0037 c
0.25% Inulin	227.7±2.15 b	191.1±2.17 b	238.5±2.12	1.248±0.0077 a
0.50% Inulin	227.1±3.20 b	190.1±2.29 b	232.2±3.13	1.221±0.0082 b
1.00% Inulin	226.7±2.02 b	190.2±2.01 b	237.8±2.77	1.251±0.0016 a
P values	0.01	0.01	0.487	0.01
Starter period, 11-21 day	**BW,g**	**BWG,g**	**FI,g**	**FCR,g**
Control	1089.7±7.35 a	851.4±7.66 a	1171.7±8.83 b	1.376±0.012 b
0.25% Inulin	1038.6±5.60 b	810.8±6.51 b	1201.5±9.56 a	1.482±0.014 a
0.50% Inulin	1041.9±5.83 b	814.7±5.50 b	1187.8±8.63 a	1.458±0.023 a
1.00% Inulin	1014.4±5.61 c	787.6±5.31 c	1170.2±7.25 b	1.486±0.014 a
P values	0.01	0.01	0.041	0.01

[abc] The differences between the values shown with different letters for the means of each effect in the same column are statistically significant. (P<0.05).

Table 3. The effects of inulin level on the performance of broiler chicks during the finisher period (22-42. day)

Finisher period, 22-42 day	**BW,g**	**BWG,g**	**FI,g**	**FCR,g**
Control	2941.8±33.50 a	1852.0±28.61 a	3108.2±47.81	1.677±0.015 b
0.25% Inulin	2752.1±33.17 b	1713.4±26.85 b	3100.4±50.59	1.808±0.015 a
0.50% Inulin	2790.9±29.70 b	1749.1±30.13 b	3192.7±48.64	1.824±0.003 a
1.00% Inulin	2707.1±23.80 b	1692.6±20.13 b	3036.8±41.37	1.793±0.015 a
P values	0.01	0.01	0.166	0.01

[ab] The differences between the values shown with different letters for the means of each effect in the same column are statistically significant. (P<0.05).

Table 4. Effects of inulin level on performance of broiler chickens during the whole study period (0-42. day)

Whole research period, 0-42 day	**BWG,g**	**FI,g**	**FCR,g**	**Mortality, %**
Control	2904.8±38.13 a	4517.4±56.24	1.555±0.008 b	1.0
0.25% Inulin	2715.2±39.41 b	4540.6±62.11	1.672±0.013 a	2.0
0.50% Inulin	2753.8±44.53 b	4613.1±54.14	1.675±0.005 a	2.0
1.00% Inulin	2670.2±42.46 b	4445.2±54.62	1.665±0.014 a	1.0
P values	0.01	0.194	0.01	0.876

[ab] The differences between the values shown with different letters for the means of each effect in the same column are statistically significant. (P<0.05).

3.2. Digestive System Sections and Organ Weights and Lengths

The absolute (g) and relative weights (g/100g BW) of the digestive system parts and organ weight and length averages of the research groups on the 10th day are given in Table 5 and Table 6. The effects of inulin level on the mean length and weight of duodenum, length and weight of jejunum, length and weight of ileum, length and weight

of ileum and absolute (g) and relative weights (g/100g BW) of pancreas, liver, proventriculus and gizzard (g/100g BW) were not statistically significant (P>0.05). When Table 5 was analysed, inulin levels had a statistically significant effect (P<0.05) on the absolute (g) and relative weights (g/100g BW) of *Bursa fabricius* on the 10th day. Accordingly, those who consumed 1.00 % inulin level had lower absolute weight of *Bursa fabricius* than the control group. 0.25 and 0.50 % inulin levels had no statistically significant effect on absolute weight of *Bursa fabricius* compared to the control group (P>0.05). In the same way, it was observed that the absolute weight of *Bursa fabricius* did not change statistically between the chicks fed with different inulin levels (P>0.05). On the relative weights of *Bursa fabricius* (g/100g BW), the groups consuming 0.50 and 1.00 % inulin levels provided higher relative weights of *Bursa fabricius* than the control group. 0.50 and 1.00 % inulin levels and 0.25 % inulin levels were not statistically different between the groups consuming 0.50 and 1.00 % inulin levels.

Table 5. Effects of inulin level on organ weights in broiler chicks (10th days)

Groups	Pancreas		Liver		Bursa fabricius	
	g	g/100 g BW	g	g/100 g BW	g	g/100 g BW
Control	1.665±0.061	0.698±0.031	11.12±0.731	4.66±0.337	0.682±0.035 a	0.286±0.017 a
0.25% Inulin	1.646±0.051	0.722±0.033	9.63±0.431	4.23±0.238	0.605±0.022 ab	0.266±0.014 a
0.50% Inulin	1.555±0.035	0.684±0.041	9.79±0.326	4.31±0.242	0.566±0.016 ab	0.249±0.011 ab
1% Inulin	1.523±0.080	0.671±0.024	9.61±0.417	4.24±0.134	0.481±0.045 b	0.212±0.018 b
P values	0.511	0.288	0.244	0.779	0.023	0.007

ab The differences between the values shown with different letters for the means of each effect in the same column are statistically significant. (P<0.05)

Table 6. The effects of inulin level on digestive system parts, weight and length of broiler chicks. (10th days)

Groups	Proventriculus		Gizzard		Duodenum length		Duodenum weight	
	g	g/100 g BW	g	g/100 g BW	g	g/100 g BW	g	g/100 g BW
Control	2.08±0.11	0.873±0.045	7.63±0.40	3.21±0.15	18.8±0.24	8.02±0.27	2.88±0.04	1.21±0.03
0.25% Inulin	2.01±0.12	0.882±0.037	7.41±0.51	3.26±0.21	17.9±0.81	7.86±0.15	2.52±0.23	1.11±0.07
0.50% Inulin	1.83±0.11	0.806±0.031	7.16±0.11	3.15±0.14	18.2±0.67	8.01±0.43	2.58±0.17	1.14±0.04
1% Inulin	1.90±0.07	0.838±0.017	7.14±0.15	3.00±0.11	17.4±0.65	7.67±0.11	2.66±0.13	1.17±0.04
P	0.311	0.178	0.710	0.531	0.566	0.948	0.084	0.264
Groups	Jejunum length		Jejunum weight		Ileum length		Ileum weight	
	g	g/100 g BW	g	g/100 g BW	g	g/100 g BW	g	g/100 g BW
Control	44.1±1.31	18.5±0.31	4.14±0.11	1.74±0.05	44.3±1.65	18.6±0.55	2.91±0.15	1.22±0.05
0.25% Inulin	43.6±1.63	19.1±0.34	3.71±0.23	1.63±0.03	44.2±1.24	19.4±0.81	2.68±0.23	1.18±0.03
0.50% Inulin	42.9±1.55	18.8±0.35	3.68±0.17	1.62±0.15	43.3±1.13	19.1±0.73	2.97±0.18	1.31±0.23
1% Inulin	42.6±1.71	18.8±0.83	4.12±0.27	1.82±0.05	44.8±1.67	19.8±0.85	3.03±0.17	1.34±0.16
P	0.876	0.523	0.156	0.188	0.913	0.268	0.481	0.495

(P>0.05)

4. Discussion and Conclusion

4.1. Performance Values

The study found that adding inulin to the ration did not significantly increase BW and BWG. Throughout the study, inulin levels had a decreasing effect on BWG. Analysis of FI for the entire study period showed that inulin did not affect FI. During the 0-42 day period, the inclusion of inulin in the diets had a significant negative impact on the FCR. However, after the first 10 days, the effects of different levels of inulin added to the ration on FCR were no longer distinguishable from each other. The control group had better FCR throughout all experimental periods. The results of this study are consistent with previous studies [9, 11, 14, 15, 17,18, 20, 21] which found that inulin supplementation did not have a significant effect on performance values in broiler chicks. However, these results are inconsistent with the findings of studies [18,19] which investigated the effects of different inulin levels in broiler chick diets and reported improved performance, particularly in terms of BWG and FCR.

4.2. Physical Development of the Digestive System

According to the physical development results of the digestive system on the 10th day of the study, the weights and lengths of the small intestine sections, pancreas, liver, proventriculus and gizzard weights were not significantly affected by inulin levels. It was observed that there was a numerical decrease in the organ weights examined with the addition of inulin. Increasing inulin levels significantly decreased the absolute and relative weights of the Bursa fabricius, which is an important parameter in terms of immunity in broiler chicks. The lowest Bursa fabricius weight was obtained at 1.00% inulin level. [17] reported that small intestine, pancreas and gizzard weights in the treatment groups did not show a statistically significant difference compared to the control group as a result of prebiotic addition to broiler chick diets. Our research findings are in agreement with the report of [17]. On the other hand, the digestive system results of this study are inconsistent with the reports [11,14] which investigated the effects of inulin levels in broiler chick diets and reported that the addition of 1% inulin caused an increase in the length of the small intestine. The findings obtained from the literature reports are variable, and [22] suggested that the different effects of inulin used in diets may be due to the inulin source types in the light of the data obtained from his studies. The fact that the inulin contents used are different suggests that the results obtained may be different.

As a result, it was determined that inulin and doses used in this study had negative effects on the performance of broiler chickens but had some effects on the digestive organs examined and it was concluded that there was no need to add inulin to broiler diets.

Acknowledgement

This study used research data before 2020 and was produced from Berrin Çetinkaya's master's thesis.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Author Contribution

Authors contributed equally to this work.

Ethics Consent

This research is based on Berrin Çetinkaya's master's thesis, which was accepted in 2019. As it was conducted prior to 2020, ethics committee approval is not required for this article.

References

1. Buclaw M. Inulin in poultry production. World's Poultry Science Journal, 2017;73(2):301-308. doi:10.1017/S0043933917000010
2. Aşan M and Özcan N. Kanatlı beslemede inulinin prebiyotik olarak önemi. Hayvansal Üretim, 2006;47(2): 48-53.
3. Gülmez M and Güven A. Probiyotik, Prebiyotik ve Simbiyotikler. Kafkas Univ. Vet. Fak. Derg., 2002;8 (1):83-89.

4. Flickinger EA, Van Loo J, Fahey GC. Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals: A review. Crit Rev Food Sci Nutr, 2003;43(1):19-60.
5. Gibson GR and Roberfroid MB. Dietary modulation of the human colonic microflora: introducing the concept of prebiotics. J. Nutr., 1995;125:1401-1412.
6. Young J. European market developments in prebiotic and probiotic containing foodstuffs. British Journal of Nutrition, 1998;80:231-233.
7. Niness KR. Inulin and oligofructose: What are they. J. Nutr., 1999;129:1402-1406.
8. Sezen A. Prebiyotik, probiyotik ve sinbiyotiklerin insan ve hayvan sağlığı üzerine etkileri, Atatürk Üniversitesi Veteriner Bilimleri Dergisi, 2013;8:248-258.
9. Yusrizal Y and Chen TC. Effect of adding chicory fructans in feed on broiler growth performance, serum cholesterol and intestinal lenght. Int. J. Poult. Sci., 2003;2(3):214-219.
10. Ammerman E, Quarles C and Twining, PV. Evaluation of fructooligosaccharides on performance and carcass yield of male broilers. Poult. Sci., 1989;68 (Suppl. 1):167 (Abstr).
11. Chen YC Nakthong C and Chen TC. Improvement of laying hen performance by dietary prebiotic chicory oligofructose and inulin. Int. J. Poultry Sci.,2005; 2:103-108.
12. Yıldız G, Saçaklı P and Güngör T. The effect of dietary Jerusalem artichoke (Helianthus tuberosus L.) on performance, egg quality characteristics and egg cholesterol content in laying hens. Czech. J. Anim. Sci., 2006;8:349-354.
13. Van Leeuwen P, Verdonk JMAJ, Van Der Klis JD and Van Loo J. Inulins (chicory fructans) improve performance of young broilers. In, XII European Poultry Conference (EPC), September 10-14, 2006, Verona, Italy.
14. Elrayeh AS. Broyler rasyonlarında kullanılan inulin ve β-glukanın besi performansı, serum kolesterol düzeyi, bağırsak uzunluğu ve immun sistem üzerine etkileri. Doktora tezi, Ankara Üniversitesi, Sağlık Bilimleri Enstitüsü, 2006.
15. Ortiz LT, Rodriguez ML, Alzueta C, Rebole A and Trevino J. Effect of inulin on growth performance, intestinal tract sizes, mineral retention and tibial bone mineralisation in broiler chickens. Br Poult Sci, 2009;50 (3):325-332.
16. Ao Z and Choct M. Oligosaccharides Affect Performance and Gut Development of Broiler Chickens. Asian-Aust. J. Anim. Sci. 2013;26(1):116-121.
17. Iji PA, Saki A and Tivey DR. Intestinal structure and function of broiler chickens on diet supplemented with a mannan oligosaccharide. J. Sci. Food Agric., 2001;81:1186-1192.
18. Rebolé A, Ortiz L, Rodríguez ML, Alzueta C, Trevıño J and Velasco S. Effects of inulin and enzyme complex, individually or in combination, on growth performance, intestinal microflora, cecal fermentation characteristics, and jejunal histomorphology in broiler chickens fed a wheat-and barley-based diet, Poultry Science, 2010;89:276-286.
19. Shang HM, Zhou HZ, Yang JY, Li R, Song H and Wu HX. In vitro and in vivo antioxidant activities of inulin. PLoS ONE, 2018;13(2), e0192273.
20. Şen G and Başalan M. Etlik Civciv ve Piliç Rasyonlarında Üzüm Posası İle İnülin Kullanımının Performans, Karkas Randımanı, Barsak Viskozitesi Üzerine Etkileri.1.st International Animal Nutrition Congress, September 28-October 1, 2016, Antalya, Turkey.
21. Şen G. Broyler Rasyonlarında Üzüm Posası İle İnülin Kullanımının Performans, Karkas Randımanı, Barsak Viskozitesi, Bağışıklık Ve Antioksidan Durum Üzerine Etkileri. Doktora Tezi, T.C. Kırıkkale Üniversitesi Sağlık Bilimleri Enstitüsü, 2018.
22. Fanworth ER, Modler HW, Jones JD and Cave N, Yamazaki H and Rao AV. Feeding Jerusalem artichoc flour rich in fructooligosaccharides to weanling pigs. Canadian J. Anim. Sci., 1992;72:977-980.
23. NRC: Nutrient Requirements of Poultry. Ninth Revised Edition, National Academy Press, Washington, USA, 1994
24. Akyıldız AR. Yemler bilgisi laboratuvar kılavuzu. A.Ü.Z.F. Yay.:895. Uygulama kılavuzu: 213, 236 s., A. Ü. Basımevi, Ankara; 1984.
25. Anonymous. European tables of energy values for poultry feedstuffs, third ed. WPSA subcommittee, Netherlands; 1989.
26. Düzgüneş O, Kesici T and Gürbüz F. İstatistik metodları. I.Ankara Üniv. Ziraat Fak. Yayınları 861, Ders Kitabı 229; 1983.
27. Duncan DB. Multiple Range and Multiple F Tests. Biometrics 1955;11:1-42.