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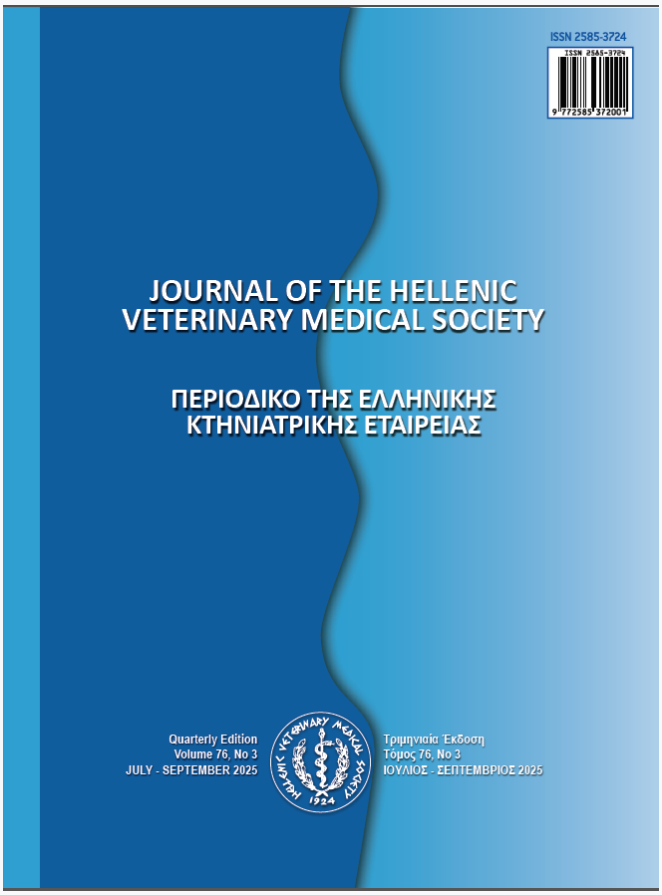

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Research article
Ερευνητικό άρθρο

The investigation of jujube fruit added into diets on performance and meat quality of broiler chickens*

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ABSTRACT: This study was conducted to determine the effects of jujube (*Ziziphus jujuba Mill.*) fruit added at different rates into the mixed feed on performance, carcass characteristics and meat quality of broiler chickens. A total of 160 male broiler chickens (Ross-308) including 40 in each group, were used in the study. The groups were divided into 4 subgroups, including 10 broiler chickens in each. The study groups were set as follows; the group without jujube fruit was the control group, the group with 0.5% jujube fruit was the H-0.5% group, the group with 1% jujube fruit was the H-1 group and the group with 2% jujube fruit was the H-2 group. At the end of the experiment (42nd day), the highest body weight, daily body weight gain, daily feed intake and feed conversion ratio were determined in the H-1 group. The highest thigh and heart weights were determined in the H-1 group, while the lowest hot carcass, breast, back-neck weights and carcass yield were determined in the H-2 group. The lowest poly unsaturated fatty acid, omega-6 and omega-3 levels and the highest omega-6/omega-3 ratio were determined in the control group. In the study, mortality rate was similar in all groups.

As a result, it was concluded that jujube fruit, which is used especially for its antioxidant properties, can be used in poultry compound feeds, especially at 0.5 or 1% level due to its positive effects on performance, carcass and meat quality and its low cost.

Keyword: Broiler chicken, carcass, jujube fruit, meat quality, performance.

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INTRODUCTION

Adequate and balanced nutrition is important for people to lead a healthy and quality life. If half of the daily protein requirement is met from foods of animal origin, they can achieve a high quality balanced diet (Yavaş, 2013). In the world, the need for quality protein is increasing in direct proportion to population growth. Being the most economical source of animal protein under current conditions, poultry meat is a very popular food product worldwide and its production is estimated to be about one hundred million tons (Choi et al., 2023). The reasons for this rapid rise in its production vary. Among these include the (low) cost, easy access for consumers, diverse and practical cooking methods, universally popular taste, and universal acceptance across all religions.

Poultry meat is also preferred by consumers due to its low cost, low-fat content and high nutritional content (Uçar & Türkoğlu, 2018). Jujube is a plant with stone fruits that belongs to the Rhamnaceae family and has more than 135 species (Pandey et al., 2010). Jujube originally hails from China, but spread to other parts of the world (namely India, Iran, Afghanistan and Central Asia) via the Silk Road (Tatari et al., 2016). Jujube is a fragrant deciduous tree or shrub that grows a height of 8-10 meters and blooms with yellow flowers in spring. Its fruits are, sweet and juicy, egg-shaped, olive green at first, then dark red-black in colour, and single-seeded (Yaşa, 2016). The most commonly cultivated species for their fruits are *Ziziphus jujuba* and *Ziziphus mauritiana*, and their fruits are consumed fresh or dried (Gao et al., 2003; Wang et al., 2016). Jujube is also used in traditional medicine and as a food additive due to its rich nutritional content and bio-functional properties of its components (Xue et al., 2009; Choi et al., 2011).

The aim of this study is to determine the effects of jujube fruit powder, which has strong antioxidant properties, added into broiler compound feeds at different levels on performance parameters, carcass characteristics, and thigh muscle fatty acid levels.

MATERIALS AND METHODS

Research and Publication Ethics

The study was approved by Fırat University Animal Experiments Local Ethics Committee (FUHADYEK) (Date: 22.06.2021 - Protocol No: 2021/2633).

Location of the Study

The experiment was conducted in an environmentally controlled broiler house numbered TR230000360680 operating in Elazığ province. During the experiment, the animals were fed in the poultry houses with the same ventilation, light intensity (20 lux) and other maintenance conditions. Broiler chickens were reared in ventilated poultry houses containing 16 compartments (10 broilers/m2) and wood shavings were used as litter material. These houses were heated using electric radiators. In the first week, their temperature was kept between 32-35°C and gradually decreased to 22°C until the end of the experiment. The houses were illuminated for 24 hours with natural daylight during the day and fluorescent lamps at night house.

Animal Material

In this study, 160 day-old male broiler chicks (ROSS 308) purchased from a private poultry farm were used as animal material.

Feed Material

The feeds used in the experiment were prepared by a feed factory. For this purpose, taking into account the requirements specified in NRC (1994) standards, compound feeds based on corn and soybean meal were prepared as isonitrogenic and isocaloric in 3 periods as starting (between days 0-21), growing (between days 22-35) and finishing (between days 36-42). Tables 1, 2, and 3 show the structure and nutrient composition of the compound feeds. Table 4 shows the fatty acid profiles of the compound feeds used in broiler feeding and jujube fruit added to the compound feed.

Jujube Added into Mixed Feed

Jujube fruit added into the mixed feed was obtained from a grower in Hatay province. Fully ripe fruits were collected in August, dried and then ground together with the seeds. Jujube fruit, which was collected, dried and ground in season, was added into compound feeds as powder. Tables 5 and 6 show raw nutrient and chemical compositions of jujube fruit.

Experimental Design

The study was carried out on a total of 160 male chicks at 7 days of age. The chicks were randomly distributed to 4 experimental groups in accordance with the random plots experimental design and each group had 4 replicates. In this context, after the initial body weights of the chicks were measured, average body weights of the groups were arranged

Table 1. Ingredients and nutrient composition of experimental diets (0-21 days) (%)

	Jujube, %			
Feed Ingredients	**Control**	**0.5**	**1**	**2**
Maize	46.10	46.15	45.65	45.65
Soybean meal (%48 HP)	38.00	38.00	38.00	38.00
Wheat bran	6.55	6.00	6.00	5.00
Vegetable Oil	5.00	5.00	5.00	5.00
Dicalcium phosphate (DCP)	1.70	1.70	1.70	1.70
Ground limestone	1.15	1.15	1.15	1.15
Salt	0.35	0.35	0.35	0.35
DL- Methionine	0.35	0.35	0.35	0.35
L-Lysine hydrochloride	0.20	0.20	0.20	0.20
L-Threonine	0.10	0.10	0.10	0.10
Vitamin-Mineral mix*	0.50	0.50	0.50	0.50
Jujube fruit	0	0.50	1.00	2
Nutritional composition, (%)				
Dry matter	90.38	90.20	90.45	90.60
Crude protein	23.50	23.40	23.30	23.20
Crude fibre	3.65	3.75	3.78	3.56
Ether extract	4.92	5.15	5.08	4.98
Crude ash	5.44	5.66	5.55	5.38
Calcium**	0.97	0.97	0.97	0.97
Available Phosphorus**	0.49	0.49	0.49	0.49
Sodium**	0.17	0.17	0.17	0.17
Chlorine**	0.25	0.25	0.25	0.25
Methionine+Cystine**	1.10	1.10	1.10	1.10
Lysine**	1.44	1.44	1.44	1.44
Threonine**	0.97	0.97	0.97	0.97
Tryptophan**	0.33	0.33	0.33	0.33
ME, kcal/kg**	3044	3039	3022	3009

*: Per kg: Vitamin A, 12000 IU; Vitamin D3, 3000 IU; Vitamin E, 30 mg; Manganese, 80 mg; Iron, 60 mg; Zinc, 60 mg; Copper, 5 mg; Iodine, 1.5 mg; Cobalt, 0.3 mg; Selenium 0.15 mg **: Obtained by calculation.

in such a way that they were equal and a distribution was made with 10 chicks in each replicate and a total of 40 animals in each experimental group. Accordingly, the experimental groups were set as follows; the group without jujube was the control group, the group with 0.5% jujube was the H-0.5% group, the group with 1% jujube was the H-1 group and the group with 2% jujube was the H-2 group. The chicks were fed water and feed ad libitum during the experiment.

Measurements and Analyses

The average body weights of the animals were individually determined weekly using a scale with a precise accuracy of 1 g. The differences between the body weight measurements of two consecutive weeks were recorded as body weight gain data. The amount of feed consumed was found by subtracting the remaining feed in the feeders on the days when the animals were weighed from the total amount of feed weighed every day during that period. The average daily feed consumption per animal was calculated by dividing the amount of feed consumed between two weighings by the number of days and the number of animals belonging to that group. Dead animals were taken into consideration in determining the average feed consumption. Weekly feed conversion ratios were calculated by dividing the total amount

Table 2. Ingredients and nutrient composition of experimental diets (22-35 days) (%)

	Jujube, %			
Feed Ingredients	**Control**	**0.5**	**1**	**2**
Maize	49.35	49.15	49.15	49.15
Soybean meal (%48 HP)	33.00	33.50	33.50	34.00
Wheat bran	7.90	7.05	6.55	4.85
Vegetable Oil	5.70	5.80	5.80	6.00
Dicalcium phosphate (DCP)	1.55	1.55	1.55	1.55
Ground limestone	1.00	1.00	1.00	1.00
Salt	0.35	0.35	0.35	0.35
DL- Methionine	0.35	0.30	0.30	0.30
L-Lysine hydrochloride	0.20	0.20	0.20	0.20
L-Threonine	0.10	0.10	0.10	0.10
Vitamin-Mineral mix*	0.50	0.50	0.50	0.50
Jujube fruit	0	0.50	1.00	2
Nutritional composition, (%)				
Dry matter	90.30	89.90	89.54	89.68
Crude protein	21.62	21.65	21.60	21.50
Crude fibre	3.85	3.15	3.78	3.75
Ether extract	5.42	5.15	5.18	5.28
Crude ash	4.44	4.66	4.95	4.74
Calcium**	0.87	0.87	0.87	0.87
Available Phosphorus**	0.45	0.45	0.45	0.45
Sodium**	0.17	0.17	0.17	0.17
Chlorine**	0.25	0.25	0.25	0.25
Methionine+Cystine**	0.99	0.99	0.99	0.99
Lysine**	1.32	1.32	1.32	1.32
Threonine**	0.89	0.89	0.89	0.89
Tryptophan**	0.30	0.30	0.30	0.30
ME, kcal/kg**	3116	3115	3109	3118

*: Per kg: Vitamin A, 12000 IU; Vitamin D3, 3000 IU; Vitamin E, 30 mg; Manganese, 80 mg; Iron, 60 mg; Zinc, 60 mg; Copper, 5 mg; Iodine, 1.5 mg; Cobalt, 0.3 mg; Selenium 0.15 mg, **: Obtained by calculation.

of feed consumed by the animals in two weighing intervals by the total body weight gain determined in these two weighing intervals. A total of 32 broiler chickens, two from each sub-group and eight from each group, were selected, then they were fasted for 10 hours and weighed and their pre-slaughter live weights were recorded and slaughtered using the neck-cutting technique. After slaughtering, the feathers were plucked, the head and feet were cut and the internal organs (except for kidneys and lungs) were removed. After the hot carcass weights of broiler chickens were determined, thighs, breast, wings and neck+back parts were separated from the carcass in accordance with T.S.E. shredding technique and the weights of the carcass parts were determined with skin (Atasoy & Aksoy, 2005). After determining the carcass characteristics of the slaughtered animals, 5 grams were taken from the thigh muscle and the laboratory of Mustafa Kemal University Technology and R&D Application and Research Centre was used within the scope of service procurement. Crude nutrient levels of compound feed were determined in the laboratories of Fırat University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases. Dry matter, crude ash, crude protein, crude fat, and non-nitrogenous

Table 3. Ingredients and nutrient composition of experimental diets (36-42 days) (%)

		Jujube %		
Feed Ingredients	**Control**	**0.5**	**1**	**2**
Maize	53.50	53.50	53.50	52.00
Soybean meal (%48 HP)	29.50	29.50	30.00	30.40
Wheat bran	6.75	6.25	5.25	5.00
Vegetable Oil	6.45	6.45	6.45	6.80
Dicalcium phosphate (DCP)	1.35	1.35	1.35	1.35
Ground limestone	1.00	1.00	1.00	1.00
Salt	0.35	0.35	0.35	0.35
DL- Methionine	0.30	0.30	0.30	0.30
L-Lysine hydrochloride	0.20	0.20	0.20	0.20
L-Threonine	0.10	0.10	0.10	0.10
Vitamin-Mineral mix*	0.50	0.50	0.50	0.50
Jujube fruit	0	0.50	1.00	2
Nutritional composition (%)				
Dry matter	89.33	89.95	89.74	89.62
Crude protein	20.10	20.00	20.10	20.10
Crude fibre	3.65	3.75	3.88	3.95
Ether extract	5.70	5.55	5.48	5.68
Crude ash	3.99	4.16	3.95	3.74
Calcium**	0.81	0.81	0.81	0.81
Available Phosphorus**	0.41	0.41	0.41	0.41
Sodium**	0.17	0.17	0.17	0.17
Chlorine**	0.25	0.25	0.25	0.25
Methionine+Cystine**	0.95	0.95	0.95	0.95
Lysine**	1.21	1.21	1.21	1.21
Threonine**	0.83	0.83	0.83	0.83
Tryptophan**	0.27	0.27	0.27	0.27
ME, kcal/kg**	3220	3213	3213	3201

*: Per kg: Vitamin A, 12000 IU; Vitamin D3, 3000 IU; Vitamin E, 30 mg; Manganese, 80 mg; Iron, 60 mg; Zinc, 60 mg; Copper, 5 mg; Iodine, 1.5 mg; Cobalt, 0.3 mg; Selenium 0.15 mg, **: Obtained by calculation.

Table 4. Fatty acid profile of experimental diets and jujube fruit added to experimental diet, %

Özellik	**J**	**E1**	**E2**	**E3**
SFA	20.60	22.24	23.53	21.85
MUFA	59.01	33.03	35.65	37.20
PUFA	20.39	44.73	40.82	40.95
Ω-6	13.77	41.76	38.28	38.34
Ω-3	4.77	2.98	2.54	2.60
Ω-6/Ω-3	2.89	14.01	15.07	14.75

J: Jujube fruit, **E1:** Broiler starter feed, **E2:** Broiler growth feed, **E3:** Broiler finisher feed

SFA: Saturated Fatty Acid, **MUFA:** Mono Unsaturated Fatty Acid, **PUFA:** Poly Unsaturated Fatty Acid, **Ω-6:** Omega-6, **Ω-3:** Omega 3

Table 5. Nutritional composition of jujube fruit added to compound feed

Nutritional composition	%
Dry matter	94.54
Moisture	5.46
Crude protein	3.20
Crude fibre	32.80
Ether extract	2.30
Crude ash	1.84
Nitrogen free substances	54.40
ME, kcal/100g	304.70

solids of compound feeds were analysed according to the analysis methods reported in AOAC (1980) and crude cellulose content was determined according to Crampton and Maynard (1983). The ration program (Poultry_V5.05) prepared by Coşkun et al., (2019) was used to calculate the energy, mineral and amino acid levels of the mixed feed. Crude nutrient analysis of the powdered additive obtained from jujube fruit was carried out by Makimtek Special Food Control Laboratory of the Ministry of Agriculture and Forestry of the Republic of Turkey. The chemical composition and fatty acid level of jujube fruit added into the compound feed and the fatty acid level of the feed were determined by using high performance liquid chromatography (HPLC), gas chromatography (GC) and liquid chromatography-mass spectrometry (LC-MS) devices as service procurement from Mustafa Kemal University Technology and R&D Application and Research Centre Laboratory.

Statistical Analysis

After the normality analysis (Shapiro-Wilk) was performed on the data of the study, analysis of variance was used to compare the groups for performance, carcass and fatty acid analysis of rump muscle. Duncan's test was used for further analysis. Chi-square analysis was used to evaluate the data related to survival. SPSS packaged software was used for the analysis (Kalaycı, 2006). Data were presented as Mean ± Standard error and differences were considered significant at the level of $p \leq 0.05$.

RESULTS

Table 7 shows the live weight, daily live weight gain, daily feed intake and feed conversion ratio data of broiler chickens. Accordingly, statistically significant differences were found between the groups in terms of live weight on the other days except for the 7th and 14th days. On the 42nd day, the highest live weight (3437.29 g) was observed in the H-1 group ($P<0.01$). When the daily body weight gains were evaluated, the lowest daily body weight gain levels were found in the H-2 group on days 14-21 ($P<0.05$) and 21-28 ($P<0.01$). On days 35-42 ($P<0.01$) and 7-42 ($P<0.05$), the highest daily body weight gain levels were determined in H-1 group. When examining the daily feed intake values of broiler chickens, it was found that there was no statistically significant difference between the groups on days 7-14, 14-21 and 28-35 ($P>0.05$), while statistically significant differences were determined on days 21-28 ($P<0.05$), 35-42 and 7-42 ($P<0.01$). When the total average daily feed consumption from the beginning to the end of the experiment was analysed, it was observed that H-1 group had the highest daily feed consumption (132.35 g/day/animal). When the feed conversion ratio was analysed, statistically significant differences were observed between the groups from the beginning to the end of the experiment. When the data between days 7-42 were analysed, the highest feed conversion ratio (1.43) was detected in the H-1 group ($P<0.05$). In the cost analysis performed in the study (Table 7), it was determined that the group with 2% jujube was more costly than the other groups in the 7-42 day period ($P<0.001$), while the costs of the other groups were similar. Table 8 shows carcass parameters of broiler chickens. Accordingly, the highest values in terms of slaughter and hot carcass weight were observed in the H-1 group ($P<0.05$). When the carcass yield value was analysed, it was determined that the H-2 group had the lowest carcass yield level ($P<0.05$). The highest heart and thigh weight was determined in the H-1 group ($P<0.05$). The lowest breast and back+neck weight was observed in the H-2 group ($P<0.05$). There was no statistical difference between the groups in terms of wing, liver and spleen weight ($P>0.05$). Table 9 shows fatty acid profile of thigh muscle of the broiler chickens. Accordingly, the lowest polyunsaturated fatty acid (PUFA), omega-6 (Ω-6) and omega-3 (Ω-3) levels and the highest Ω-6/Ω-3 level were found in the control group ($P<0.05$). Saturated (SFA) and monounsaturated fatty acid (MUFA) levels were similar in all experimental groups ($P>0.05$). Table 10 shows the effect of jujube fruit addition on mortality and survival rate at the end of the study. When Table 10 was analysed, no statistical difference was found between the groups ($P>0.05$).

Table 6. Chemical composition of jujube fruit added to compound feed

RT	Compound Name	%
13.40	Methyl formate	1.92
16.53	Propanoic acid	0.7
17.08	Propanoic acid, 2-methyl	0.45
17.80	2-Propenoic acid, methyl ester	0.87
19.51	Butanoic acid	2.53
20.53	Butanoic acid, 2-methyl	2.17
20.79	Iso-Valeric acid	1.15
24.23	2-Furanmethanol	1.55
25.61	Decanoic acid, ethyl ester	0.43
26.86	Hexanoic acid	0.26
29.24	Mebutamate	0.67
30.29	9,12-Octadecadienoyl chloride	0.26
30.42	Hexadecadienoic acid, methyl ester	0.48
31.88	Benzene, 1-methoxy-4-(1-propenyl)	11.22
34.95	Phenol	0.58
35.43	2,5-Dimethyl-4-hydroxy-3(2H)-furanone	0.64
36.06	2H-Pyran-2,6(3H)-dione	0.27
37.31	Aspartame	0.56
37.90	2,4-Pyrimidinedione, 5-methyl	1.18
38.45	2-Hexenoic acid, 4-amino-5-methyl-, methyl ester	0.29
39.22	Decanoic acid	0.3
40.49	2-Amino-3-methyl-1-butanol	5.32
40.73	Benzaldehyde, 4-methoxy	0.34
41.88	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl	4.99
42.40	Hexadecanoic acid, ethyl ester	4.12
43.68	Desulphosinigrin	0.26
44.34	2,5-Octadecadiynoic acid, methyl ester	1.21
45.54	4-Oxopental	0.8
46.36	1-Bromo-3-butene-2-ol	1.01
47.19	Butanal, 2-methyl	4.69
47.73	9-Octadecenoic acid-ethyl ester	1.23
48.93	8-Azabicyclo[3.2.1]octane-3-carbonitrile, 8-methyl	12.67
49.33	10-Heptadecen-8-ynoic acid, methyl ester	0.71
49.69	Methyl arachidonate	2.19
50.74	1,2-Cyclohexanedicarboxaldehyde	0.61
51.08	2-Butyl-1-iodo-bicyclo[2.2.1]heptane	1.27
52.04	1'-Hydroxy-4,3'-dimethyl-bicyclohexyl-3,3'-dien-2-one	1.71
52.69	Propane, 1-methoxy-2,2-dimethyl	2.5
53.28	5-Hydroxymethylfurfural	21.14
54.03	Thiophene, 2,5-dihydro-	0.57
54.16	Phenol, (1,1-dimethylethyl)-4-methoxy	0.78
55.01	Dihydro-5-(1-hydroxyethyl)-2(3H)-furanone	0.46
56.04	Procainamide	0.78
56.44	Androstan-17-one, 3-ethyl-3-hydroxy	1.21

RT: Retention Time

Table 7. The effect of jujube fruit added to mixed feed on performance and economic implication of broiler chickens, ($\bar{x}$ ±S $\bar{x}$) (n=40)

	Jujube, %				
Days/Group	**Control**	**0.5**	**1**	**2**	**P**
Live weight, g					
7. day	209.25±2.17	209.18±2.13	209.18±1.74	209.20±2.58	NS
14. day	530.95±6.47	549.50±5.90	543.23±5.74	534.91±7.30	NS
21. day	1060.77±16.62^{bc}	1111.09±13.05^{a}	1086.55±11.05^{ab}	1031.61±16.02^{c}	**
28. day	1796.68±26.17^{b}	1867.86±24.08^{a}	1876.16±17.20^{a}	1686.95±30.99^{c}	***
35. day	2573.41±33.73^{bc}	2640.57±28.56^{ab}	2660.16±27.76^{a}	2517.75±30.44^{c}	*
42. day	3260.88±52.27^{b}	3287.44±41.77^{b}	3437.29±38.43^{a}	3211.17±44.05^{b}	**
Daily live weight gain, g/day/bird					
7-14 days	45.96±0.88	48.19±0.89	47.72±0.88	46.53±1.08	NS
14-21 days	75.69±2.12^{ab}	80.23±2.06^{a}	77.62±1.56^{a}	70.96±2.45^{b}	*
21-28 days	105.13±4.58^{a}	108.11±4.18^{a}	112.80±3.21^{a}	93.62±4.79^{b}	**
28-35 days	110.96±6.38	110.39±4.09	112.00±4.76	118.69±6.27	NS
35-42 days	98.21±7.26^{b}	92.41±6.48^{c}	111.02±7.79^{a}	99.06±6.39^{b}	**
7-42 days	87.19±1.81^{b}	87.95±1.83^{b}	92.23±2.02^{a}	85.77±2.65^{b}	*
Daily feed intake, g/day/bird					
7-14 days	59.31±0.27	57.79±0.56	58.98±0.40	58.45±0.64	NS
14-21 days	101.44±1.80	106.89±1.79	104.95±2.20	100.01±3.80	NS
21-28 days	138.69±1.43^{bc}	144.19±2.01^{ab}	146.46±1.60^{a}	136.43±3.41^{c}	*
28-35 days	175.63±1.35	175.37±0.58	176.46±0.45	175.00±1.07	NS
35-42 days	164.67±1.16^{b}	162.13±1.27^{b}	174.92±6.77^{a}	164.32±0.82^{b}	**
7-42 days	127.95±0.66^{b}	129.27±0.60^{ab}	132.35±1.67^{a}	126.95±1.56^{b}	**
Feed conversation ratio, g feed/g gain					
7-14 days	1.29±0.02^{a}	1.20±0.02^{b}	1.24±0.04^{ab}	1.26±0.01^{ab}	*
14-21 days	1.34±0.02^{b}	1.33±0.05^{b}	1.35±0.02^{b}	1.41±0.06^{a}	*
21-28 days	1.32±0.01^{b}	1.33±0.01^{b}	1.30±0.03^{b}	1.46±0.04^{a}	**
28-35 days	1.58±0.03^{a}	1.59±0.02^{a}	1.58±0.03^{a}	1.47±0.03^{b}	*
35-42 days	1.68±0.04^{b}	1.75±0.02^{a}	1.58±0.02^{b}	1.66±0.03^{b}	**
7-42 days	1.47±0.01^{a}	1.47±0.01^{a}	1.43±0.01^{b}	1.48±0.01^{a}	*
Economic Implication, Euro (€)					
7-42 days	0.6260±0.002^{b}	0.6280±0.004^{b}	0.6340±0.004^{b}	0.6840±0.005^{a}	***

NS: P>0.05, * : P<0.05, ** : P<0.01, ***: P<0.001, a-c :The difference between the values expressed with different letters in the same row is significant.

DISCUSSION

In the poultry sector, the use of feed additives is an important strategy to increase animal productivity, to prevent diseases and to enable animals to utilise feed better (Pirgozliev et al., 2019).

When the live weight averages and daily live weight gains of the groups were compared, it was observed that the highest averages were detected in the H-1 group. The data of this study are compatible with the findings of Cellat et al., (2022) on quails and Yang et al., (2023) on broiler chickens, which reported that jujube supplementation positively affected both body weight and daily body weight gain. As a matter of fact, plant products promote digestion by positively affecting the endogenous secretions of

Table 8. The effect of jujube fruit added to mixed feed on carcass characteristics in broiler chickens, ($\bar{x} \pm S\bar{x}$) (n=8)

	Jujube, %				
Parameter/Group	**Control**	**0.5**	**1**	**2**	**P**
Slaughter weight, g	3199.25±46.20^{b}	3251.00±56.05^{ab}	3374.25±51.48^{a}	3172.00±68.87^{b}	*
Hot carcass weight, g	2471.25±32.15^{ab}	2524.75±42.67^{ab}	2621.00±41.51^{a}	2377.25±53.41^{b}	*
Hot carcass yield, %	77.31±1.09^{a}	77.71±0.42^{a}	77.68±0.42^{a}	74.95±0.67^{b}	*
Thigh weight, g	965.75±20.60^{b}	980.00±30.61^{b}	1032.75±22.06^{a}	947.75±22.39^{b}	*
Breast weight, g	972.25±16.11^{ab}	1008.50±22.23^{a}	1024.50±22.58^{a}	928.50±24.14^{b}	*
Wing weight, g	228.25±2.21	235.50±3.59	242.75±3.93	219.75±4.83	NS
Back+Neck weight, g	305.00±8.41^{ab}	300.75±9.79^{ab}	321.00±7.26^{a}	281.25±10.10^{b}	*
Heart weight, g	12.36±0.42^{b}	12.28±0.69^{b}	14.38±1.17^{a}	13.47±0.88^{ab}	*
Liver weight, g	61.79±3.93	69.00±4.94	63.50±3.74	68.75±4.98	NS
Spleen weight, g	3.70±0.35	3.53±0.55	2.92±0.13	2.77±0.26	NS

NS: P>0.05, *: P<0.05, a-b: The difference between the values expressed with different letters in the same row is significant.

Table 9. The effect of jujube fruit added to mixed feed on fatty acid profile of thigh muscle in broiler chickens, ($\bar{x} \pm S\bar{x}$) (n=8)

	Hünnap, %				
Özellik	**Kontrol**	**0.5**	**1**	**2**	**P**
SFA	30.52±0.34	29.44±0.46	29.47±0.30	29.73±0.29	NS
MUFA	43.62±0.38	42.76±0.46	42.68±0.37	42.65±0.40	NS
PUFA	25.86±0.57^{b}	27.80±0.89^{a}	27.85±0.39^{a}	27.62±0.52^{a}	*
Ω-6	23.81±0.58^{b}	25.41±0.84^{a}	25.55±0.36^{a}	25.27±0.48^{a}	*
Ω-3	2.05±0.09^{b}	2.39±0.05^{a}	2.30±0.03^{a}	2.35±0.04^{a}	*
Ω-6/Ω-3	11.61±0.81^{a}	10.63±0.84^{b}	11.11±0.80^{ab}	10.75±0.70^{b}	*

NS: P>0.05, * : P<0.05, ^{a,b}: The difference between the values expressed with different letters in the same row is significant.

SFA: Saturated Fatty Acid, **MUFA:** Mono Unsaturated Fatty Acid, **PUFA:** Poly Unsaturated Fatty Acid, **Ω-6:** Omega-6, **Ω-3:** Omega-3

the digestive tract and have protective effects on the villi that play an active role in the digestion of nutrients, thus increasing the degree of digestion of nutrients in the feed structure (Zhang et al., 2005). The differences between body weights and daily body weight gains in this study can be explained in a few points. First, the palatability of the feed is a reason to increase feed intake. The addition of jujube fruit to the mixed feed is expected to increase the palatability of the feed and thus feed intake. In fact, when Table 7 was examined, it was observed that feed intake in the H-1 group on days 7-42 was higher than the other groups. Secondly, the flavonoids in jujube may have a positive effect on the intestinal function of the birds, which may contribute to improved performance. In this study, the increased feed consumption can be attributed to addition of the jujube fruit used to increase the palatability of the feed. Feed palatability is one of the main factors affecting feed consumption (Abou-Elkhair et al., 2014).

Table 10. The effect of jujube fruit added to mixed feed on mortality and survival rate in broiler chickens (n=40)

		Jujube, %		
Weeks	**Control**	**0.5**	**1**	**2**
7-14 days	1	1	1	1
14-21 days	0	0	0	0
21-28 days	0	1	1	1
28-35 days	1	0	1	1
35-42 days	1	1	1	1
7-42 days	3	3	4	4
Mortality rate, %	7.5	7.5	10.0	10.0
Survival rate, %	92.5	92.5	90.0	90.0

X2: 0.313, P>0.05

When the feed utilisation levels (days 7-42) were analysed, it was observed that the H-1 group had the highest feed utilisation rate. Similarly, Abdulameer et al., (2017) conducted a study by adding 0, 3, 7 and 10 ml of jujube leaf extract to 1 litre of water in 160 male chicks at daily age and found that 3 ml/litre of extract significantly improved feed conversion compared to the control group. Herbal products increase intestinal and pancreatic lipase activities (Jamroz et al., 2005) and have a stimulating effect on digestion (Çabuk et al., 2003).

When carcass parameters of the broiler chickens were examined, it was observed that the H-1 group had the highest values in terms of slaughter and hot carcass weight. When the carcass yield value was analysed, the lowest carcass yield level was determined in the H-2 group. The highest heart and thigh weights were determined in the H-1 group. The lowest breast and back+neck weights were observed in the H-2 group. The findings of the present study are compatible with Muhl and Liebert (2007) who reported that phytogenic extracts did not affect carcass yield in broiler chickens, Halle et al., (2004) who reported that oregano or oregano oil addition to broiler diets did not affect their carcass yield and characteristics, Hernandez et al., (2004) reported that oregano, cinnamon and pepper mixture did not affect carcass yield and characteristics, and Şimsek et al., (2005) reported that thyme, clove and anise mixture did not affect carcass yield and characteristics in broiler chickens. The reason for this similarity can be attributed to the similarity in rearing conditions. Contrary to the findings obtained from these studies, there is a study reporting that jujube fruit added to mixed feed had a positive effect on carcass yield (Cellat et al., 2022).

Fatty acids are essential, some are synthesised in the body, but some others cannot be produced in the human body and must be ingested through food for a healthy life (Guil-Guerrero et al., 2004). Fatty acids are generally classified as saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids (Beyhan et al., 2017). Saturated fatty acids (SFA) have been associated with the development of coronary heart disease due to their hypercholesterolemic properties. Lowering SFA levels in the diet and elevating PUFA levels in meat may reduce the threat of cardiovascular disease and improve human health (Du et al., 2018). In previous studies, jujube fruits were found to be a good source of fatty acids and rich in unsaturated fatty acids (Guil-Guerrero et al., 2004; Gao et al., 2013; San & Yıldırım, 2010). In animals fed diets rich in unsaturated fatty acids (linoleic and linolenic acid) (e.g. oilseeds), these fatty acids are reported to be transferred to the animal's products. The present study revealed that jujube addition to mixed feed elevated PUFA levels compared to the control group. This may be due to the fact that jujube added to compound feed increases the activity of delta 9-desaturase, the enzyme that plays a key role in the conversion of SFA to MUFA. This enzyme converts SFA to MUFA by forming a double bond at the ninth carbon position of the saturated fatty acid chain, and when the double bond is added, the fatty acid can be converted to PUFA by other enzymes (Gnoni & Paglialonga 2009). Indeed, in a study investigating how the addition of dried jujube fruit powder (DJFP) to the mixed diet affected the growth performance, antioxidant stability, meat composition and quality of Cobb broilers, the total

saturated fatty acids (SFA) were lower, monounsaturated fatty acids (MUFA) and polyunsaturated fatty acid/saturated fatty acid (PUFA/SFA) ratios were higher in the groups in which DJFP was added to the mixed diet (Yang et al., 2023). The findings obtained in this study support the findings of the present study except for the MUFA part.

In this study, it was determined that the difference between the groups in terms of mortality rate and survival rate was not statistically significant. This may be attributed to the presence of in-cage hygiene conditions and effective ventilation in the cages. The studies using aromatic plant extracts reported that the additives used did not have any effect on the mortality rate as in the present study (Ertaş et al., 2005; Çiftçi et al., 2005; Güler et al., 2006).

CONCLUSION

As a result, it was revealed that jujube fruit added to the ration at a rate of 0.5 and 1% significantly increased the levels of polyunsaturated fatty acids (PUFA) in the thigh muscle in addition to its positive effects on the growth performance of broiler chickens and there was no significant difference with the control group in terms of cost. Within the framework of these findings, it is seen that jujube fruit has the potential to be used as a natural additive in poultry nutrition for both performance increase and improvement of meat quality. Therefore, jujube is recommended as an ingredient that can be safely evaluated in poultry feeding programmes in line with the increasing need for sustainable and functional feed additives.

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