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Effects of Dried Tomato, Apple and Grape Pulps on the Performance, and Egg Quality of Laying Hens

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ABSTRACT

The purpose of this study was to determine the dietary effects of fruit pulps (dried tomato, apple and grape) on the performance and egg quality characteristics of laying hens. In this trial, 196 Lohmann sandy layers 25 weeks of age were distributed into four groups with seven replicates for 9 weeks. Trial groups fed following diets, control group basal diet (no additive), 4 % dried tomato pulp, 4% apple pulp and 2.5% grape pulp. Feed conversion rate was not affected by any addition of fruit pulps throughout the trial. The dietary inclusion of dried tomato pulp increased feed consumption, egg weight and egg production and decreased egg yolk malondialdehyde (MDA) levels on day of 1 compared to the control. Egg yolk MDA level was decreased with the addition of 4% tomato and apple pulp to the diet, but increased with the addition of 2.5% grape pulp to the diet on the day of 28. Moreover, the addition of dried tomato pulp to the basal diet significantly increased egg weight and egg yolk yellow color (a). As a result, this study provides evidence that adding up to 4% tomato pulp to diets may be used without adverse effects on laying hens' productivity and may improve egg quality characteristics by decreasing MDA levels in the yolk.

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Introduction

Efforts to increase egg quality as well as economic egg production still maintain their importance in egg production industry. The rapid development in the poultry industry causes the cost of feed to increase (Yeniçeri et al., 2022). Industrial waste of certain agricultural products may be used in poultry nutrition. In addition, the use of these industrial waste agricultural by-products in the feeding of poultry can make significant contributions to reducing environmental pollution (Azizi et al., 2018). Industrially processed fruit pulps are becoming increasingly common in poultry diets in order to improve egg production performance and egg quality characteristics. Pulp emerges as by-products during the production of fruit juice, especially in fruit juice enterprises. It has been stated that fruit pulp can be used as recycled industrial feed in animal feeding by drying it through certain processes (washing, heating and drying) (Filik and Kutlu, 2018). Dried fruit pulps are exactly a potential source of many nutrients for poultry diets and specific properties such as a well source of antioxidants and vitamins. Flavonoids, phenolic acids, carotenoids and isoflavonoids commonly are phytochemicals that found in fruits and their pulps (Hasted, 2003). Fruits and vegetables, which are rich in phytochemicals, combine with free radicals in living organisms and prevent cells from being damaged by free radicals (Evans and Halliwell, 2001). Components in the structure of fruit pulps cause them to show different effects in vivo condition. Based on some observed data, various studies have been conducted to estimate the dietary level of supplementary pulps (Azizi et al., 2018; Abbasi et al., 2015). Abbasi et al. (2015) studied the effect of different levels (0,5 %, 1.0%, 1.5% and 2.0%) of dried sweet orange (Citrus sinensis) pulp in broiler chicken and found the utilization of 2% dried sweet orange pulp in diet had a significant positive effect on performance, carcass characteristics, blood metabolites, humoral immunity, and cecum microbial population of broilers. Azizi et al. (2018) stated that the citrus and grape wastes may be included in broilers diets up to 3 % without adverse effects. The same researchers reported that oxidative stress may be reduced

by adding 5% of apple by-products to broiler diets and up to 10% to layer hen diets. In another similar study, it was reported that apple pulp may be used as a feed source up to 5% in broiler diets (Ayhan et al., 2009). Similarly, Nobakht (2013) stated that dietary addition of apple pulp (5 %) caused the best performance and the highest levels of lymphocytes in laying hens. On the other hand, it has been reported that dietary inclusion of grape pulp improved the immune system of broilers and reduced serum MDA concentration (Dorri et al. 2012). In another study, the researchers reported that grape pulp can be successfully used as a source of antioxidants in poultry diets (Wang et al. 2008). Kara and Guclu (2012) reported that dietary supplementation of 2% grape pulp did not show negatively effects on eggshell thickness and weight, albumin index and egg specific gravity in laying hens. However, it seems to be very little study on the investigating the effects dietary dried tomato, apple and grape pulps on performance, egg quality and lipid peroxidation of laying hens. The purpose of this study was to determine the dietary effects of dried fruit (dried tomato, apple and grape) pulps on the performance and egg quality characteristics of laying hens.

Materials and Methods

All experimental protocols were approved by the Animal Care Committee of Dicle University. In this trial, 196 Lohmann sandy layers with 25 weeks of age were distributed into four groups with 7 replicates and 7 hens were placed in each repetition for 9 weeks. Trial groups fed following diets, control group basal diet (no additive), 2) 4% dried tomato pulp, 3) 4% apple pulp and 4) 2.5% grape pulp. During the trial, laying hens were fed *ad libitum* and they were provided with continuous access to water with nipple drinkers. During the experiment, a cycle of 16 hours of light and 8 hours of dark was used and the temperature of the facility was maintained at 22°C. The nutrient contents and chemical composition of experimental diets are shown in Table 1. Experimental diet was formulated in accordance with the nutrient requirements of laying hens (NRC, 1994). The study was carried out in the enriched cage system. The enriched cage system has 3 floors and 5 cage sections on each floor. Tomato, grape and apple pulps used in the experiment were obtained by drying the fresh fruits purchased under appropriate conditions. After the dried fruit pulp was ground in the mill, it was added to the feeds at the determined rates. They were added to the diets in the form of pre-mixtures and at the last stage of feed production. At the beginning of the experiment, chickens were weighed and placed in cages according to similar live weight and egg yields and treatment groups were formed. Feed consumption, egg production and egg weight were measured daily during the trial. Feed conversion ratio and other performance data were calculated on a weekly. Egg internal and external quality analyzes were performed using 15 eggs collected from each group at the end of each week. The egg shape index was calculated using the digital calipers (egg width / egg length) × 100 formulas. Egg shell thickness was determined by taking measurements from three different places with a digital micrometer after removing the inner shell membrane of the egg. Egg specific gravity was measured using a precision balance and a beaker. For this purpose, after weighing the weight of the eggs kept for 1 day in the air, they were placed in a beaker filled with water set at 22°C, and the specific gravity of the egg was determined after weighing their weight in the water (Hempe et al. 1988). The color of the egg yolk was determined as L*, a* and b* using a digital colorimeter (Minolta CR-300). The height of the egg white was measured with a digital foot micrometer, and calculated with the formula [albumen height (mm) / ((albumen length (mm) + albumen width (mm)) / 2)] × 100. The yolk index was measured using a digital caliper, and the diameter and length of the yolk were measured and calculated with the formula [(Height of yolk / Diameter of yolk) × 100]. Egg weight (G) and albumen height (H) were measured then Haugh unit was calculated by using the formula 100* *log* (H + 7.57-1.7G 0.37). On the one hand, the measurement of lipid peroxidation in egg yolk was calculated according to the thiobarbituric acid (TBA) method reported by Witte et al. (1970) on the other hand, the malondialdehit (MDA) was the last product of lipid peroxidation and the measurement of MDA in egg yolk was based on the spectrophotometric detection of the colored complex formed by reaction with TBA. For egg yolk MDA analysis, 2.5 grams of egg yolk from each egg was weighed and 25 ml of cooled the trichloroacetic acid (TCA) solution was added to it, and after it was brought to the desired consistency with a homogenizer, 25 ml of cold distilled water was added and the breaking process was continued for 1 hour. MDA analysis from egg yolk was made on the 1st and 28th days, and 5 ml of filtrate prepared in balloon bottles was taken from the samples prepared for analysis and 5 ml of TBA solution prepared with water was added to them. The samples were then kept in a water bath set at 80°C for 35 minutes, after which they were cooled and read in a spectrophotometer (Amsterdam, 2100 UV spectrophotometer, UK) at 532 nm against the blank (prepared with 1:1 TCA:Water). The obtained absorbance values were multiplied by the coefficient of 7.8 and the MDA level was calculated as mg. Statistical analysis of data was performed by using IBM SPSS 18 statistical package (SPSS Inc. 18.0 software). Experimental data were subjected to General Linear Model (GLM) Anova Tukey's multiple tests was used when the differences between groups was found as statistical significance. The differences were considered statistical significance were at value of $P<0.05$ or $P<0.01$.

Results and Discussion

Effects of dried tomato and apple and grape pulps supplementation in a based diet on the performance of the laying hens were given in Table 2. No mortality was recorded during the trial. Our findings regarding feed conversion rate were similar to the research results obtained by Kara et al. (2016) in which they added different levels of dried grape pulp to the diets of laying hens. Similarly, Dotas et al. (1999) obtained that the addition of dried tomato pulp did not significantly affect feed conversion rate in laying hens. In addition, it has been reported that using 4% apple pulp in diets did not have significant effects on the amount of feed consumption ($P>0.05$) (Noranian and Nobakht, 2016).

Table 1. Ingredients and chemical composition of experimental diets (as-fed basis)

Ingredients, %	Control	4% Tomato pulp	4% Apple pulp	2.5% Grape pulp
Maize	50.15	50.15	50.15	51.70
Soybean meal (46% CP)	17.50	17.50	17.50	17.50
Sunflower meal (28% CP)	12.50	12.50	12.50	12.50
Bone meal (30% Ca, 13% CP)	4.50	4.50	4.50	4.50
Calcium carbonate	5.83	5.83	5.83	5.83
Tomato pulp	N/A	4.00	N/A	N/A
Apple pulp	N/A	N/A	4.00	N/A
Grape pulp	N/A	N/A	N/A	2.50
NaCI	0.30	0.30	0.30	0.30
Vitamin+ Mineral Premix[a]	0.25	0.25	0.25	0.25
Dl-Methionine	0.12	0.12	0.12	0.12
Sunflower oil	5.15	5.15	5.15	5.10
Chemical Analysis, %				
Dry matter	90.70	90.71	90.71	90.72
Crude protein	17.00	17.00	17.00	17.00
Ether extract	6.92	6.92	6.92	6.94
Ash	12.30	12.31	12.31	12.32
Calculated energy and nutrient content				
ME (kcal/kg)	2800	2800	2800	2800
Calcium (%)	3.81	3.81	3.81	3.81
Available phosphor (%)	0.75	0.75	0.75	0.75
Na (%)	0.18	0.18	0.18	0.18
L-lysine (%)	0.76	0.76	0.76	0.76
Linoleic acid (%)	2.00	2.00	2.00	2.00

[a]Vit+Min. Mineral mixture provides the following nutrients per kg of diet: vitamin A: 12.000.000 IU, vitamin D3: 2.500.000 IU; vitamin E: 30 ppm; vitamin K3: 4.000 ppm, vitamin B1: 3.000 ppm, vitamin B2: 7.000 mg, vitamin B12: 5.000 ppm, vitamin C: 50.000 ppm, Biotin: 45 ppm, folic acid: 1.000 ppm, Fe: 60 ppm, Zn: 60 ppm, Cu: 74 ppm, Se, 150 ppm, Co: 200 ppm, I: 1.000 ppm, Mn: 80.000 ppm. NA: No added

Table 2. Effects of dietary supplementation of dried tomato, apple and grape pulps on the performance of the laying hens

Parameters	Groups				SEM	P
	Control	Tomato pulp (%4)	Apple pulp (%4)	Grape pulp (%2.5)		
Feed consumption, g/day	123.3^{bc}	129.6^{a}	124.7^{ab}	120.4^{c}	0.58	0.0001
Feed conservation ratio	2.14	2.20	2.21	2.20	0.01	0.374
Egg production, %	96.2^{ab}	97.9^{a}	94.9^{b}	95.1^{ab}	0.38	0.024
Egg yield, egg/hen/week	57.6^{ab}	59.7^{a}	57.2^{b}	56.4^{b}	0.30	0.001
Egg weight, g	59.9^{b}	61.0^{a}	60.1^{ab}	59.3^{b}	0.137	0.001

[a,b,c] Means within each period with different superscript letters are significantly different (P<0.01). SEM: Standard errors of mean

Table 3. Effects of dietary supplementation of dried tomato, apple and grape pulps to laying hen diet on internal and external egg quality

Parameters	Groups				SEM	**P**
	Control	Tomato Pulp (4%)	Apple pulp (4%)	Grape pulp (2.5%)		
Eggshell ratio, %	12.7^{b}	12.8^{ab}	13.0^{ab}	13.2^{a}	0.06	0.038
Eggshell thickness, mm	0.36	0.36	0.35	0.34	0.002	0.442
Egg specific gravity, g/cm^3	1.25	1.30	1.30	1.24	0.004	0.541
Shape index	69.7	69.9	69.6	70.3	1.30	0.997
Yolk index	47.0	46.7	46.5	47.9	0.20	0.73
Albumen index	2.4	2.5	2.3	2.5	0.03	0.355
Haugh unit	84.7	85.5	84.8	87.5	0.53	0.201
L* value	55.9	57.6	58.2	57.7	0.35	0.119
a* value	20.1^{b}	23.4^{a}	20.2^{b}	19.0^{b}	0.58	0.009
b* value	33.8^{ab}	35.2^{a}	32.8^{ab}	31.5^{b}	0.34	0.001

[a,b,c] Means within each period with different superscript letters are significantly different (P < 0.05). SEM: Standard errors of mean, L*: lightness, a*: redness, b*: yellowness

In another study, Kara and Guclu (2012) reported that adding grape pulp at 2% did not affect the feed conversion ratio of laying hens. Feed consumption and egg weight values were higher (P<0.05) for the 4% dried tomato pulp group compared to control. This effect may be attributed to lycopene which is known for its a strong antioxidant effect in tomato pulp. However, these results were not in agreement with researchers who reported that supplementing of dried tomato pulp in laying hen diets increased feed consumption and egg weight (Calislar and Uygur, 2010).

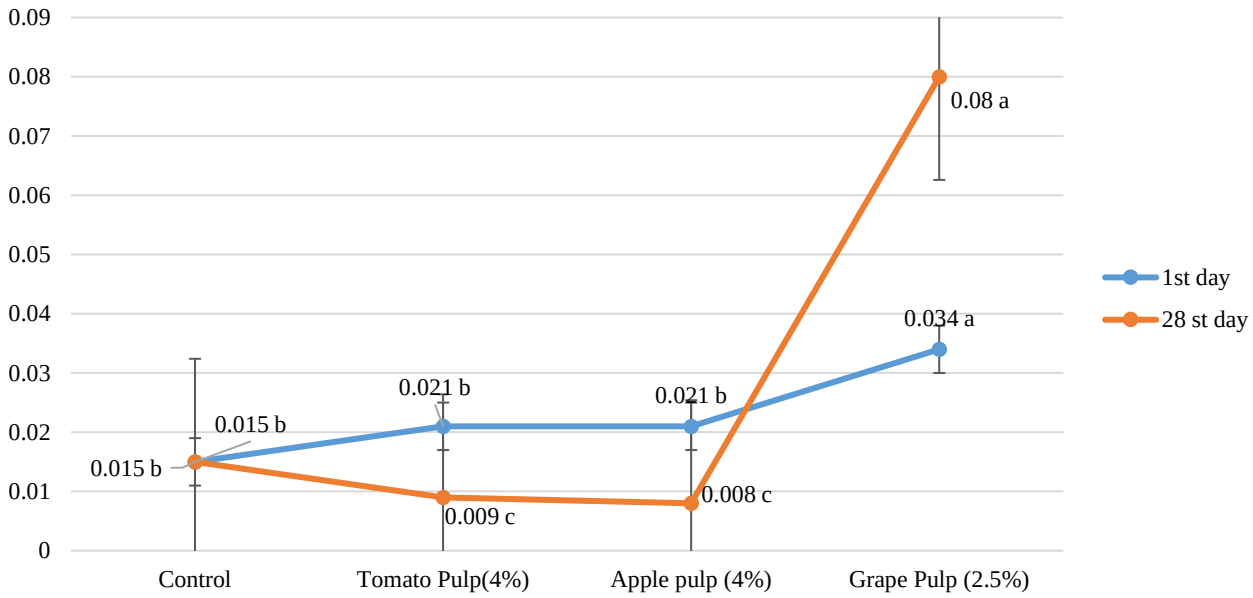

Figure 1. Effects of dietary supplementation of dried tomato, apple and grape pulps to laying hen diet on the MDA levels in egg yolk

Contrary, our results were not in agreement with Dotas et al. (1999) who reported that egg weight and feed consumption were not affected by dietary adding of dried tomato pulp in laying hens' diets. It was assumed that the differences between the results of the research may be due to the difference in the level of dried tomato pulp added to diets. While the highest egg production and egg yield were observed in the dried tomato pulp group, the lowest egg production was found in the apple pulp group and the egg yield in grape pulp group. During the trial, there was no statistical difference between the groups in terms of feed conversion rate ($P>0.05$). Effects of dietary supplementation of dried tomato and apple pulps and grape pulp to laying hen diet on internal and external egg quality were given in Table 3. There was no significant difference among the groups in terms of shape index, albumen index, yolk index, Haugh unit, eggshell thickness, egg-specific gravity, yolk color - lightness (L*) value ($P>0.05$). In our study dietary addition of tomato, apple and grape pulp on MDA levels in egg yolk is shown in figure 1. Our results in terms of the egg quality characteristics were in agreement with those of Rossi et al (2015) and Salajegheh et al. (2012) reported that dietary tomato pulp and sweet green pepper did not affect the shape index, Haugh unit, yolk index, albumen index and specific gravity. Abdel-Moneim et al (2020) is similar to the olive pulp experiment in which he added different levels to compound feeds. It is also compatible with the study of Calislar and Uygur (2010) on dried tomato pulp at different levels. Similarly, Kara et al. (2016) reported that dietary supplementation of dried grape pulp into diets did not affect the specific gravity of the egg in laying hens. Dietary inclusion of grape pulp significantly increased eggshell ratio ($P<0.01$). On the contrary, Kara et al. (2016) who found that dietary supplementation of grape pulp at 2% did not show any significant effect on the eggshell ratio of laying hens. Increases of the yolk redness color (a*) and yellowness color (b*) in our study may be due to the lycopene content of tomato. Tomato and tomato products are the major dietary source of lycopene which is known as a responsible for the red color of tomato and dietary lycopene and β-carotene can transfer to the egg yolk in laying hens fed the diet inclusion tomato by-products (Karadas et al. 2006). These results obtained from the research on egg yolk color were in accordance with the findings of some researchers (An et al. 2019). Lycopene found in tomato and tomato products are a powerful antioxidant and a carotenoid that provides red coloring (Sahin et al. 2008). In our study dietary addition of tomato, apple and grape pulp on MDA levels in egg yolk was shown in figure 1. We observed the low level of MDA in yolk on groups fed the diet included tomato and apple pulps. Our results of MDA levels in egg yolk may be due to the significant content of carotenoids and vitamins in tomatoes.

In conclusion, this study provides evidence that up to 4 % inclusion level of tomato pulp in the diets for laying hens may improve hen performance and egg quality characteristics and MDA level in egg yolk without any adverse effects. However, dietary inclusion of grape pomace at 2.5 % decreased the MDA levels in egg yolk.

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