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Investigation of opportunities the addition of canned watermelon pomace and watermelon juice produced from unmarketable watermelon in broiler quail ration

İbrahim Halil Çerçi[1] **Aydın Erocağı**[2] **Fatma Karagözoğlu**[3,*]

[1]Hatay Mustafa Kemal University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Hatay, Turkey
[2]Fırat University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Elazığ, Turkey
[3]Bingöl University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Bingöl, Turkey

[*]Corresponding Author: fterlemez@bingol.edu.tr

Abstract

This study was conducted to evaluate the use of watermelon pomace and watermelon juice obtained from unmarketable watermelon in the diets of fattening quails. A total of 90 Japanese quails (*Coturnix coturnix japonica*) were assigned to three groups (30 quails in each group), each comprising of 5 replicates each having 6 quails. One group was designated as control groups whereas other groups fed 5% watermelon pomace or watermelon juice on dry matter basis. All the diets were isonitrogenous and isocaloric formulated in order to meet the nutrient requirements of quails outlined in NRC standards. Live weight was greater in quails fed watermelon pomace compared with control group in first week only (P<0.05). Average daily gain of the quails was not different among the groups (P>0.05). In first week and overall period (1 to 4 wk), average daily feed intake (ADFI) was higher in control group than quails fed watermelon juice which, in turn, was higher in comparison with those fed watermelon pomace (P<0.001). In second week, ADFI was greater in control group than other dietary treatments (P<0.01). The ADFI was higher in quails fed diet with watermelon juice than those fed diets containing watermelon pomace (P<0.05). Feed conversion ratio (FCR) in the first week was lower quails fed watermelon pomace than control group (P<0.01). The FCR in overall period improved in quails receiving diets with watermelon pomace compared with other dietary treatments (P<0.001). Nutrients digestibility and mortality rates almost were similar across the groups (P>0.05). In conclusion, it was observed that watermelon pomace can be used in quail diets having additional growth enhancer properties.

Keywords: Juice, Pomace, Quail, Watermelon

Introduction

Turkey annually produces 4 million tons of watermelon (Turkish Statistical Institute, 2019) and ranks second worldwide (Özbay and Çelik, 2016). Depending on the temperature and humidity of the warehouse, the storage time of the watermelon is short (Turkey Standards İnstitute, 2019). It has been reported that approximately 20% of watermelon produced remains unmarketable attributed to storage conitions (temperature and humidity) and shorter storage time (Fish et al., 2009). The watermelon flesh (Anguelova and Warthsen, 2000; Edwards et al., 2003; Scott, 2012; Johnson et al., 2013; Sa'id, 2014; USDA, 2019), rind (Rimandoa and Perkins-Veazie, 2005; Rasheed, 2008; Erukainure et al., 2010; Choudhary, 2014), and seed (Sabahelkhier et al., 2011; Acar et al., 2012) contain water, carbohydrates, fat, protein, vitamins, minerals, citrulline, pectin, and lycopene. Recent studies have reported the use of lemon wastes (Chaudry et al., 2004), orange and banana shells (Siyal et al., 2016), cashew meal (Fernandes et al., 2016), and apple by-products (Zafar and Idrees, 2005) in poultry diets. Other study reported that corn can be replaced by 20% fruit juice mixture consisting of carrot, apple, mango, avocado, orange, melon, and tree tomato (Rizal et al., 2010).

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ORCID: İbrahim Halil Çerçi: 0000-0001-5678-1203 Aydın Erocağı: 0000-0002-3354-3517 Fatma Karagözoğlu: 0000-0001-7970-0306
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It is well known that the addition of vitamin C (ascorbic acid) into poultry diet enhances growth performance of poultry at high ambient temperature (Konca and Yazgan, 2002). In addition, β-carotene protects from oxidative stress and stimulates the immune system of birds (Ayaşan and Karakozak, 2010). Moreover, supplemental electrolytes in poultry diets increase egg yield, body weight and breeding performance, and decrease mortality rate (Register, 2019).

Recently, Shazali et al. (2013) reported an increase in live weight, protein consumption, protein efficiency rate, and feed utilization rate in response to addition of 20% full-fat watermelon seeds in broiler diets (Shazali et al., 2013).

The instability of unmarketable watermelon at room temperature and humidity poses considerable challenge as it yields waste at large. Terlemez (2017) concluded that unmarketable watermelon can be converted to durable canned watermelon pomace and watermelon juice by processing at an elevated temperature with the addition of acid. These by-products can be used as new feedstuffs in poultry production. No previous study has reported the use of watermelon pomace and watermelon juice in poultry diet. Therefore, unmarketable watermelons were converted into stable watermelon pomace and juice that were added to quail diets in order to evaluate their effect on growth performance and nutrient digestibility.

Material and Methods

Animals

A total of 90 male Japanese quails (*Coturnix coturnix japonica*) were used in the study. The animals were divided randomly into three experimental groups. These groups were further divided into 5 replicates each consisting of six animals. Experimental procedures were approved by Animal Experiments Local Ethics Committee of Fırat University (Decision / Protocol no: 157 / 10.05.2016 / 103).

Isocaloric and isonitrogenous diets were prepared for each group according to the nutrient requirements of quails recommended by NRC (1994). The trial groups were assigned as follows: 1) control group (Group C) without canned watermelon pomace and watermelon juice, 2) diet with 5% watermelon pomace (Group P), and 3) diet with 5% watermelon juice.

The composition and nutrient content of experimental diets are given in Table 1.

Table 1. The composition and nutrient content of diets

	Group C	Group J	Group P
Feed materials (%)			
Corn	47.62	42.50	39.75
Wheat bran	7.88	10	10
Soybean meal (48% CP)	39.40	38	39
Vegetable oil	2.60	2	3.75
Watermelon juice (on DM basis)	-	5	-
Watermelon pomace (on DM basis)	-	-	5
Dicalcium phosphate	0.99	1	1
Limestone	1.15	1.15	1.14
Sodium bicarbonate	0.10	0.10	0.10
Salt	0.26	0.26	0.26
Nutrient content (%)			
Dry matter	93	93	94
Crude protein	24	23.9	23.9
Crude fiber	8	8	10
Crude fat	3	2	4
Crude ash	0.30	0.30	0.30
Metabolizable energy (kcal/kg)*	2900	2898	2899

*: has been determined through the calculation. ME (kcal / kg) = 53 + 38 B formula was used where
B = (crude protein%) + (2.25 x crude fat%) + (1.1 x starch%) + (sugar %)

The experiment was carried out in fattening quail cages at poultry research unit, Faculty of Veterinary Medicine, Fırat University. The experiment lasted for 37 days (7 days preparation and 30 days trial). Then, digestion experiment was carried out in individual cages for 7 days. Animals were given feed and water ad libitum.

The production of watermelon pomace and watermelon juice

Unmarketable watermelons were washed, and watermelon pomace was obtained by blending the chopped rind, seed, and edible parts. Citric acid was added to the watermelon pomace and juice to adjust the pH between 3.5-4. Then the watermelon pomace and juice were transferred to cauldron and boiled.

Meanwhile the lid of the cauldron was closed and left at the boiling point for 10 minutes on low heating rate. The product in the boiler was then allowed to cool to 60 °C and the canned product was filled into 5-liter plastic bottles and the bottles were capped.

Live weight and average daily gain determination

The quails were weighed before the experiments. The weighing process was repeated weekly. Average daily gain (ADG) was calculated by subtracting the live weight between the consecutive weeks and dividing by the number of days.

Determination of average daily feed intake

Feeds were weighed daily and then was given to the quails. After one week, all the residual feed was weighed again. Average daily feed intake (ADFI) was calculated by subtracting residual feed amount from feed given for one week. The ADFI per animal was calculated by dividing the amount of feed consumed by the group by the number of days and the number of animals belonging to that group.

Determination of feed efficiency

The amount of feed consumed by the quails in the two weighing periods was divided by the total live weight gain between those two weighing periods and the feed efficiency rates were calculated.

Mortality and vitality

The number of animals that died during the trial was recorded and then the mortality calculated using the following formula at the end of the trial.

$$Mortality\ (\%) = \frac{No.of\ birds\ befor\ experiment - No.of\ birds\ at\ the\ end\ of\ experiment}{Initial\ No.of\ animals} \times 100$$

Determination of nutrient digestibility

The degree of nutrient digestibility was determined by using the indicator method. Natural lignin was used as an indicator. For this purpose, at the end of the experiment, 10 animals were taken from each group and fed in individual cages. The fecal samples of the animals were collected once a day during the 7 days, dried at 60°C for 36-48 hours. Nutrient digestibility was calculated according to the following formula.

$$DDNF\ (\%) = 100 - \left[100 \times \frac{Indicator\ in\ feed\ (\%)}{Nutrient\ in\ feed\ (\%)} \times \frac{Nutrient\ in\ feces\ (\%)}{Indicator\ in\ feces\ (\%)}\right]$$

Laboratory analysis

Dry matter, crude protein, and crude fat content of feed and feces were determined according to the methods specified in AOAC. (1980). Crude fiber and lignin levels were determined in Fiber Analyzer Ankom 220 according to the method reported by Van Soest et al. (1991). Crude protein content of poultry excreta samples was corrected for uric acid (Rotter et al., 1989).

Statistical analysis

Analysis of variance was applied for comparison among the groups using Duncan's test as post-hoc test. Chi square analysis was used for mortality and vitality data. These analyses were performed in a computer software package SPSS.

Results and Discussion

No systematic studies are available for the evaluation of unmarketable watermelons in the feed industry and animal feeding areas. To fill this gap, unmarketable watermelons were converted into durable watermelon pomace and watermelon juice that were added to male quail rations as concentrate feed (Table 1).

Table 2. Effect of canned watermelon juice and pomace on live weight in quails (g)

Parameter	Groups			P
	Group C	Group J	Group P	
Beginning	84.1±4.12	84.39±2.66	84.86±1.38	NS
1. Week	122.84±4.09^{b}	129.35±1.67^{ab}	137.31±3.99^{a}	*
2. Week	156.84±4.01	156.24±1.99	162.16±3.66	NS
3. Week	174.61±3.31	174.00±4.78	180.42±5.71	NS
4. Week	182.31±2.51	182.68±4.81	189.01±5.72	NS

±: Standard error value of means

*:P<0.05, NS: not significant p>0.05

$^{a, b, c:}$ The difference between values expressed in different letters on the same line is important.

Table 3. Effect of canned watermelon juice and pomace on average daily gain in quails (g/quail/day)

Parameter	Groups			P
	Group C	Group J	Group P	
1. Week	5.30±0.58	6.08±0.52	7.35±0.67	NS
2. Week	4.64±0.47	3.75±0.32	3.45±0.34	NS
3. Week	2.61±0.28	2.53±0.48	2.66±0.42	NS
4. Week	1.17±0.12	1.40±0.14	1.25±0.11	NS
1-4. Week	3.43±0.25	3.44±0.22	3.68±0.23	NS

±: Standard error value of means

NS: not significant p>0.05

Table 4. Effect of canned watermelon juice and pomace on average daily feed intake in quails (g/quail/day)

Parameter	Groups			P
	Group C	Group J	Group P	
1. Week	10.35±0.13[a]	8.23±0.17[b]	7.04±0.45[c]	***
2. Week	13.23±0.56[a]	11.41±0.30[b]	9.90±0.44[b]	**
3. Week	11.56±1.03	8.89±0.70	9.01±0.65	NS
4. Week	6.54±0.30[ab]	7.34±0.63[a]	5.19±0.24[b]	*
1-4. Week	10.42±0.37[a]	8.97±0.17[b]	7.79±0.23[c]	***

±: Standard error value of means
*: P<0.05, **:P<0.01, ***:P<0.001, NS: not significant p>0.05
[a, b, c:] The difference between values expressed in different letters on the same line is important.

Table 5. Effect of canned watermelon juice and pomace on feed conversion ratio in quails (g/quail/day)

Parameter	Groups			P
	Group C	Group J	Group P	
1. Week	2.06±0.26[a]	1.39±0.11[ab]	1.00±0.12[b]	**
2. Week	2.94±0.24	3.10±0.18	2.97±0.32	NS
3. Week	4.60±0.60	4.03±0.87	3.62±0.44	NS
4. Week	5.80±0.59	5.42±0.67	4.29±0.43	NS
1-4. Week	3.85±0.18[a]	3.48±0.13[a]	2.97±0.08[b]	***

±: Standard error value of means
**:P<0.01, ***:P<0.001, NS: not significant p>0.05
[a, b, c:] The difference between values expressed in different letters on the same line is important.

Although isocaloric and isonitrogenous rations were used in this study, live weight development value was found higher in watermelon group P (Table 2). The results of ADG in the first week and in the average of four weeks were found to be higher in Group P than in other groups, and lower in the other three weeks than in other groups. However, these differences between the groups were not found to be statistically significant (Table 3). The ADFI was higher in the control group than in group P and group J. The lowest value was also determined in Group P (Table 4). The FCR was statistically significantly higher in Group P than in other groups in the average value of four weeks of the research process (Table 5).

As mentioned in the materials and methods section, watermelon pomace contains the rind, edible parts and seeds whereas watermelon juice contains water and water-soluble substances and does not contain pulp. The pulp found in watermelon pomace, but not in watermelon juice, consists of the fleshy, core and rind part of the watermelon. The pulp contains carbohydrate, crude protein, crude fat, crude fiber as well as lycopene, beta carotene and ascorbic acid (Terlemez, 2017). Studies have reported that lycopene is higher in the fleshy part of watermelon whereas beta carotene and citrulline in the rind of watermelon. It was reported that watermelon seed contains 16.06-18.13% crude protein, 23.31-26.83% crude fat, 44.70-45.72% crude fiber, 2.31-2.59% crude ash, and 0.28-0.30 mgGAE / g total phenol (Acar et al., 2012). It has also been reported that its protein contains a lot of glutamic acid, aspartic acid, arginine and leucine (Khalil, 1998; Mello et al., 2001; El-Adawy and Taha, 2001). Also, its fat contains 63.19-72.03% linoleic acid, 17.55% (feed watermelon) – 24.65% oleic acid and 6.41-9.73% stearic acid (Acar et al., 2012). According to the information given here, watermelon pomace is more advantageous in terms of amino acids, fatty acids, vitamins and antioxidants than both watermelon juice and control group. However, it is disadvantageous in terms of crude fiber structure due to the watermelon seed peel found in watermelon pomace. Watermelon pomace has been more effective than the control group and watermelon juice on the live weight development, daily weight gain and feed efficiency in quails due to this advantageous structure. The reason that feed consumption in watermelon pomace group was lower than in other groups may be the crude fiber content and structure incoming from watermelon seeds, rind, and pulp. Although there are not many studies on the effect of the addition of canned watermelon pomace and juice to poultry rations on fattening performance, we believe that the examination of the studies with other fruit and vegetable waste products will contribute to the understanding of the research results. In this context, a previous study revealed that addition of 20 g and 30 g watermelon seed meal significantly improved the growth performance and carcass yield of broiler chicken compared to the control group (Ukpanukpong et al., 2018). On the other hand, the watermelon peel powder crush diet supplementation increases plasma L-citrulline concentration in chicks. The increase in plasma L-citrulline concentrations suggest that watermelon rind could be used as a natural source of L-citrulline in poultry to ameliorate the adverse effects of heat stress (Nguyen et al., 2019). Studies conducted with other fruit by-products reported that feed consumption was lower and live weight and feed efficiency were higher in the banana peel group than orange peel group although the crude fiber content of banana peel is higher than orange peel (Siyal et al., 2016). Again, in another study,

it has been reported that the addition of apple juice instead of corn to the broiler ration increases the live weight gain (Zafar and Idrees, 2005). All these arguments and literature data support the results obtained in this study.

Digestibility of dry matter, crude protein and crude fat were determined in control group, canned watermelon pomace and juice groups as 62.50, 62.64 and 62.56; 67.42, 67.50 and 67.56; 69.12, 69.14 and 69.18, respectively. The digestibility of dry matter, crude protein and crude fat were not statistically significant among the groups (Table 6). These results show that watermelon juice and pomace can be used in poultry rations instead of corn and soybean meal in terms of digestibility.

Although there was a slightly higher mortality rate in the Group-J, the difference between the groups was not statistically significant (Table 7).

Table 6. Effect of canned watermelon juice and pomace on nutrient digestibility in quails (%)

Parameter	Groups			SEM	P
	Group C	Group J	Group P		
Dry matter	62.50	62.64	62.56	0.28	NS
Crude protein	67.42	67.50	67.56	0.13	NS
Crude fat	69.12	69.14	69.18	0.27	NS

SEM: Standard error value of means

Table 7. Mortality and vitality values in research groups

Days	Group C	Group J	Group P	---P--- X^2
1-8	-	-	-	
8-15	-	-	1	
15-22	-	1	-	
22-29	2	1	1	0.856
29-36	-	1	-	X^2=0.310
Total number of dead	2	3	2	
Death rate, %	6.7 (2/30)	10 (3/30)	6.7 (2/30)	
Vitality rate, %	94.59	91.89	94.59	

Conclusion

In conclusion, the study suggest that canned watermelon pomace and canned watermelon juice can be added to quail diets without any negative effect on the growth performance of quails. In addition, quails fed diet with canned watermelon pomace had better growth performance than those fed control or canned watermelon juice added diets. Accordingly, it can be said that watermelons that cannot be marketed can be added to the poultry rations as canned watermelon pomace and watermelon juice. It is a preliminary study that requires further studies in this area to support this idea.

Compliance with Ethical Standards

Conflict of interest

The authors declare that for this article they have no actual, potential or perceived the conflict of interests.

Author contribution

The contribution of the authors is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Experimental procedures were approved by Animal Experiments Local Ethics Committee of Fırat University (Decision / Protocol no: 157 / 10.05.2016 / 103).

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Data availability

Not applicable.

Consent for publication

Not applicable.

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