Food Science of Animal Resources

Food Sci. Anim. Resour. 2020 May 40(3):323~337
DOI https://doi.org/10.5851/kosfa.2019.e98

pISSN : 2636-0772 eISSN : 2636-0780
http://www.kosfaj.org

ARTICLE

Effect of Partial Replacement of Soybean and Corn with Dietary Chickpea (Raw, Autoclaved, or Microwaved) on Production Performance of Laying Quails and Egg Quality

Ahmet Yusuf Şengül[1,*] and Süleyman Çalişlar[2]

[1]Department of Animal Science, Bingol University Faculty of Agriculture, 12000, Bingol, Turkey

[2]Department of Animal Science, Kahramanmaras Sutcu Imam University Faculty of Agriculture, 46000, Kahramanmaras, Turkey

OPEN ACCESS

Received October 22, 2019
Revised December 10, 2019
Accepted December 12, 2019

***Corresponding author** : Ahmet Yusuf Şengül
Department of Animal Science, Bingol University Faculty of Agriculture, 12000, Bingol, Turkey
Tel: +905067360222
Fax: +9004262160029
E-mail: yusufsengul24@hotmail.com

***ORCID**
Ahmet Yusuf Şengül
https://orcid.org/0000-0002-7155-5914
Süleyman Çalışlar
https://orcid.org/0000-0003-2880-7263

Abstract This study was conducted to investigate whether adding different levels of raw or differently processed chickpea into different diets of laying quails affected live weight, feed intake, feed efficiency, egg weight and internal and external egg quality. Chickpea was used as raw, autoclaved or microwave-processed, and it was involved in the diets on two different levels (20% and 40%). The sample was divided into 7 groups including the control, 20% and 40% raw, 20% and 40% autoclaved, and 20% and 40% microwave-processed groups. 336 ten-week-old female laying quails were used in the study, and the experiment continued for 19 weeks. In the study, the differences among the groups were insignificant in terms of live weight, feed intake, feed efficiency, egg weight and egg quality characteristics such as shell thickness, shell weight, yolk weight, yolk color and albumin index. The differences were significant in terms of the shape index, Haugh unit ($p<0.05$) and yolk index ($p<0.01$). Consequently, it was observed that different thermal processes on chickpeas did not usually have a significant effect on the yield performance of the quails, and the results that were obtained were similar to the other groups. However, it was determined that some egg quality characteristics were affected by the autoclaving and microwaving processes. Between the thermal processes, it may be stated that autoclaving provided better results.

Keywords autoclaving, chickpea, egg characteristics, microwave process, productive performance

Introduction

Grain legumes are ranked the second after cereals for human nutrition, and they have a special importance in meeting vegetal protein requirements. Their compositions include 18%–36% protein, and additionally, their protein digestibility is very high (78%). They are rich in vitamins and minerals, and their proteins have values similar to animal proteins in terms of essential amino acids (Ciftci, 2004). They are also an important food source with their low fat content and high carbohydrate content (Ciftci, 2004). Among the legumes produced in the world, chickpea is ranked the second after beans (FAO, 2016). Chickpea has been widely used in human nutrition, whereas it is also added into animal diets as a source of protein and energy (Bampidis and Christodoulou, 2011). Chickpea would be considered an alternative to soybean meal and corn in animal nutrition. In general, it is recommended to add 300 g/kg of raw chickpeas into the diets of ruminant animals (Bampidis and Christodoulou, 2011). Higher ratios may cause some disadvantages due to the antinutritional factors in chickpea. It was reported that 200 g/kg of raw chickpeas may be added into diet to support growth in poultry or not to cause loss of feed efficiency, and chickpeas should be treated by various thermal processes like boiling, autoclaving, microwave cooking and pressure cooking in order to be used at higher ratios (Bampidis and Christodoulou, 2011). Heat treatment destroys most secondary compounds, thereby improving the utilization of starch, fat and protein in chickpeas.

In addition to high nutritional values, grain legumes also contain various antinutritional factors. These lead to adverse effects on growth, feed conversion and health. These factors are lectins, various proteinase inhibitors, α-amylase inhibitors, non-protein amino acids (neurolathyritic, canavanine, mimosine), carbohydrates (galactomannan gums), polyphenolic compounds (tannins), metal binding agents (phytic acid), goitrogens, saponins, cyanogenetic glycosides, allergens, alkaloids, antivitamins and hemagglutinins (Deshpande and Damodaran, 1990; Huisman and Jansman, 1991; Gatel, 1994; Kaya and Yalcin, 1999). With these factors, legumes protect themselves against the attacks of living creatures such as mice, insects, bacteria and birds in nature. Types and effects of antinutritional factors in legumes vary depending on their types, species, variety and different parts of plants, as well as the plant development period. On the other hand, the effects of antinutritional factors are different on different animal species. Leguminous grain usage is limited without any treatment in monogastric animals (Deshpande and Damodaran, 1990; Huisman and Jansman, 1991; Kaya and Yalcin, 1999). Various treatments are performed to remove or reduce the harmful effects of antinutritional factors. These are removal of grain from its shell, deterioration in grain integrity (grinding, crushing), heat treatment (roasting in dry heat, poaching, steam treatment), water and various chemical treatments and fermentation (Abdelgadir et al., 1996; Deshpande and Damodaran, 1990; Kaya and Yalcin, 1999; Sharma and Nicholson, 1975; Van Der Poel, 1990).

Many processes such as boiling, pressure cooking, frying, roasting, germination and fermentation increase the *in-vitro* digestibility of legume starches. This increase in starch digestibility enables starch granules to swell, tear and separate into a wide variety of components during cooking. Additionally, it enables α-amylase inhibitors to activate. Ungerminated legumes may be digested less in comparison to legumes that are germinated and differently processed (Deshpande and Cheryan, 1984; Ertas et al., 2008).

In recent years, microwave irradiation began to be used to remove antinutritional factors. In the food industry, microwaves are used for many purposes such as preheating, heating, thickening, drying, freeze drying (technically known as lyophilization), roasting, baking, boiling, pasteurization, sterilization and disinfection of liquid disinfectants (Ercan et al., 1989; Mudgett, 1989; Ozdemir et al., 2003). Recent studies indicated that microwave processes applied to food increase the passage of functional nutrients into the product (Gerard and Roberts, 2004). Heating with microwave energy provides some advantages over other heat sources in some treatments. Microwave heating provides some superiorities in comparison to other heat sources. This method provides an opportunity to control the direct transformation of energy within the material into heat momentarily, and it does not create an electrical pressure that will disrupt the structure of the material. The microwave power may be changed by immediately intervening with the degree of heating, and heating can be taken under control right away (Eskibalci and Ozkan, 2008; Gungor, 1998). Using microwave energy in the food industry has several advantages. These may be listed as fast heating of food, energy saving, obtaining foods with high nutritional values, perfect operational control and achievement of selective heating if desired (Decareau and Peterson 1986; Seyhun et al., 2004). El-Adawy (2002) reported that, among processes applied on grain chickpeas as boiling, autoclaving and microwaving, the microwave application led to less vitamin and mineral loss in comparison to boiling and autoclaving.

This study investigated the effects of adding grain chickpeas processed in different forms (autoclaving, microwave application) into the rations of laying quails as a protein source to replace soybean meal and corn on feed consumption, feed utilization rate, egg yield and egg quality.

Materials and Methods

Ten-week-old Japanese quails (n=336) in total were used in this study. This study was conducted at a poultry farm of the Department of Animal Science, Faculty of Agriculture, Bingol University. The experiment was designed to have seven groups (1 control, 6 treatment) and three replications (16 quails in each replication) according to a randomized block design. The experiment was conducted in May-July, and it was completed in 19 weeks. The experimental quails were housed in 6-fold cage sections with 96×42×30 cm sizes during the experimental period. A photoperiod of 16 hours of light and 8 hours of dark was applied.

The nutrients of feed materials in the diets were analyzed, and the diets were prepared according to the results of these analyses (Table 1). In the experiment, seven different groups were created as the control group containing no chickpeas (C0) and groups fed on six different diets including 20% raw chickpeas (RC20), 40% raw chickpeas (RC40), 20% autoclaved chickpeas (OC20), 40% autoclaved chickpeas (OC40), 20% microwave-processed chickpeas (MC20) and 40% microwave-processed chickpeas (MC40).

The quails in the groups were fed *ad libitum* on isonitrogenic and isocaloric diets containing approximately 20% crude protein (CP) and 3,000 kcal/kg metabolizable energy (ME) throughout the laying period.

The crude protein, crude fat and crude cellulose contents of the diets were analyzed according to AOAC (2005), total sugar content was determined according to the method described by Dubois et al. (1956), and analysis of starch content was conducted according to the polarimetric method of Karabulut and Canbolat (2005). The Ca, P, lysine and methionine contents of the diets were calculated according to the NRC (1994). The ME values were calculated as described by Carpenter and Clegg (1956).

The industrial waste feed grain chickpea used in the experiment was supplied from a private company, and it was ground to a size that could pass through a sieve 2 mm in diameter in a feed crusher. The ground chickpea was sacked and then autoclaved at 110℃ for 15 min. The autoclaved chickpea was kept until it reached room temperature, and then, it was sacked and taken to the feed mixer.

The grain chickpea was first soaked in a basin filled with 1/4 water (one unit of chickpeas: four units of water) for 12 h. The water of the soaked chickpea was then filtered. The filtered chickpea was then placed in glass containers, and it was exposed to a microwave process at 900 watts and 8 min in a microwave oven. After the microwaving process was completed, the chickpeas were dried at 50℃ for 20 h in an oven. The dried chickpeas were taken to the feed crusher and ground to a size that could pass through a sieve 2 mm in diameter, and they were sacked to be taken to the feed mixer.

The changes in the condensed tannin content of the grain chickpea as a result of different heat treatments were determined by the analysis of tannin at the animal feeding and nutrition laboratory of KSU Agricultural Faculty (Makkar, 1995; Table 2).

Table 1. Ingredients and chemical compositions of the diets

Ingredients (g/kg)	C0	RC20	RC40	OC20	OC40	MC20	MC40
Corn	535.02	401.96	268.90	401.96	268.90	401.96	268.90
Soybean meal	319.70	257.44	195.13	257.44	195.13	257.44	195.13
Chickpea	0	200.00	400.00	200.00	400.00	200.00	400.00
Soybean oil	53.30	49.30	45.30	49.30	45.30	49.30	45.30
Marble powder	66.81	66.60	66.40	66.60	66.40	66.60	66.40
DCP	17.63	17.72	17.83	17.72	17.83	17.72	17.83
Methionine	0.98	1.33	1.67	1.33	1.67	1.33	1.67
Lysine	2.06	1.15	0.27	1.15	0.27	1.15	0.27
Salt	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vit.-Min.premix[1)]	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Nutritional analysis							
Dry matter	899.3	908.4	917.4	908.4	917.4	908.4	917.4
ME (kcal/kg)	2,999.96	3,000	3,000	3,000	3,000	3,000	3,000
Crude protein	200	200	200	200	200	200	200
Ether extract	81.3	82.3	83.3	82.3	83.3	82.3	83.3
Crude fiber	18.3	20.9	23.4	20.9	23.4	20.9	23.4
Crude ash	116.6	115.6	114.6	115.6	114.6	115.6	114.6
Calcium	2.80	2.80	2.80	2.80	2.80	2.80	2.80
Phosphorus	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Tannin	16.3	18.7	21.4	15.5	14.9	18.0	20.0

[1)] Vitamin+Mineral premix (2.5 kg)=vitamin A 12,000,000 IU; cholecalciferol (vitamin D_3) 2,000,000 IU; α-tocopherol acetate (vitamin E) 35,000 mg; menadione sodium (vitamin K_3) 5,000 IU; thiamine mononitrate (vitamin B_1) 3,000 mg; riboflavin (vitamin B_2) 6,000 mg; pyridoxine (vitamin B_6) 5,000 mg; cyanocobalamin (vitamin B_{12}) 15 mg; ascorbic acid (vitamin C) 50,000 mg; D-biotin (vitamin H) 45 mg; niacin 20,000 mg, Ca D pantothenate 6,000 mg, folic acid 750 mg, choline chloride 125,000 mg, manganese 80,000 mg, iron 60,000 mg, zinc 60,000 mg, copper 5,000 mg, iodine 1,000 mg, cobalt 200 mg, selenium 150 mg, canthaxanthin 15.000 mg, β-apo-8'-carotenoic acid ethyl ester 5.000 mg.
C0, control; RC20, raw chickpea 20%; RC40, raw chickpea 40%; OC20, autoclaved chickpea 20%; OC40, autoclaved chickpea 40%; MC20, microwaved chickpea 20%; MC40, microwaved chickpea 40%; DCP, dicalcium phosphate; ME, metabolizable energy.

In the experiment, body weight, live weight changes, feed intake, feed efficiency and egg quality characteristics (shell thickness, shell weight, shape index, yolk weight, yolk ratio, yolk diameter, albumin index, yolk index, Haugh unit and yolk color) were determined for the groups.

In order to determine the external and internal quality characteristics of the eggs obtained from the quails in the control and treatment groups, the necessary measurements of eggs collected every three weeks (5 from each replication) were made at the laboratory.

The body weights of the quails were determined using a scale at the 10^{th}, 13^{th}, 16^{th} and 19^{th} weeks. Feed consumption was determined weekly and calculated by subtracting the remaining feed from the total feed amount. Feed conversion rate was calculated by dividing the total feed consumption per week by the total egg weight per week.

After the eggs were collected, they were left at room temperature for 24 h, and measurements were made. The eggs were weighed using scales with 0.1 mm precision, and egg weights were recorded. The width and length of the eggs were then

Table 2. **Nutrient composition and condensed tannin contents of grain chickpeas processed by different heat-treatments**

Variable	Raw chickpea	Autoclaved chickpea	Microwaved chickpea
Dry matter (%)	93.48	91.36	94.33
Condensed tannin (g/kg)			
Test 1	3.07	1.54	2.91
Test 2	3.17	1.41	2.35
Test 3	3.05	1.49	2.99
Average	3.10	1.48	2.75
Crude protein (%)	20.65	19.04	20.01
Ether extract (%)	5.87	4.90	5.74
Crude fiber (%)	3.32	3.32	3.32
Starch (%)	42.40	38.65	43.72
Total sugar (%)	5.42	5.18	3.86
Metabolizable energy (kcal/kg)	3,111.4	2,823.0	3,085.0

measured with a digital caliper. To minimize the change in egg structure, the internal quality measurements were made on the eggs placed on a glass surface after 10 minutes from the breaking time of the eggs.

The eggshell was weighed with a precision scale, and its thickness was measured with a digital caliper. The yolk diameters, yolk height, albumen width, albumen length and albumen height of the broken eggs on the glass surface were measured by a digital caliper and a tripod micrometer. The yolk and albumen weights were determined by separating them from each other. Yolk color was measured using a DMS Yolk Color Fan scale.

Shell thickness: A digital micrometer was used to measure shell thickness.

The shape index was calculated using the following formula (Anderson et al., 2004):

$$\text{Shape index} = \frac{\text{Egg width (mm)}}{\text{Egg length (mm)}} \times 100$$

Albumen index: Albumen height of the broken egg was measured with a three-legged micrometer, and albumen length and width were measured with a digital caliper. The albumen index was calculated using the following formula.

$$\text{Albumen index} = \frac{\text{Albumen height (mm)}}{[\text{Albumen length (mm)} + \text{Albumen width (mm)}]\ /\ 2} \times 100$$

Yolk index: Egg yolk was measured with a three-leg micrometer, and yolk diameter was measured with a digital caliper. The yolk index was calculated using the following formula.

$$\text{Yolk index} = \frac{\text{Yolk height (mm)}}{\text{Yolk diameter (mm)}} \times 100$$

Haugh unit: It was calculated using the following formula (Haugh, 1937).

$$HU = 100 \log (H + 7.57 - 1.7 \times W0.37)$$

H = Albumen height (mm)

W = Egg weight (g)

The data obtained from the study were analyzed by using the SAS 9.1.3 statistical package program (SAS, 2006). Analysis of variance (ANOVA) was performed by using the PROC GLM command, and Duncan's test was used to determine the differences between the significant means. Probability values of $p<0.05$ and $p<0.01$ were considered to indicate significant differences.

Results and Discussion

Table 3 shows the findings on the live weights of the quails fed on diets prepared by adding different levels of raw or differently processed chickpea at different periods. It was found that the effects of controlled (C0), raw chickpea 20% (RC20), raw chickpea 40% (RC40), autoclaved chickpea 20% (OC20), autoclaved chickpea 40% (OC40), microwave-processed 20% (MC20) and microwave-processed 40% (MC40) chickpea on the live weight changes of quails were insignificant during the experiment, and the mean live weights of all weeks (10^{th}, 13^{th}, 16^{th}, and 19^{th} weeks) were close to each other. There was no noticeable change in the live weights of the different groups from the beginning to end of the experiment.

Similar to the findings obtained from this study, Farrell et al. (1999) reported that the effect of adding 36% raw chickpea into diet on the live weight gain of broiler chickens was insignificant. In their studies on diets containing raw and autoclaved chickpeas (0, 15, 30, 45% chickpea), Viveros et al. (2001) reported that diets containing raw chickpeas had no effect on the live weight gain of broiler chickens in comparison to the control group. Christodoulou et al. (2006b) determined that the effect of adding 12% chickpeas instead of soybean meal on the live weight changes of broiler chickens was insignificant; however, 24% chickpeas affected live weight gain negatively. Brenes et al. (2008) found that the effects of diets containing raw chickpeas and extruded chickpeas on the live weight changes of broiler chickens were statistically insignificant. Algam et al.

Table 3. Live weight of quails in the control and treatment groups at different periods

Groups	Live weight (g)			
	10 wk	13 wk	16 wk	19 wk
C0	247.4±0.27	257.1±3.35	257.3±4.21	253.3±3.35
RC20	247.9±0.75	250.6±0.24	244.2±4.42	251.5±2.20
RC40	247.5±0.95	255.8±1.15	258.5±0.81	252.3±1.98
OC20	247.7±1.35	256.5±2.20	254.2±2.92	240.1±5.15
OC40	248.2±0.27	254.9±2.63	247.3±8.21	244.7±6.28
MC20	248.0±0.85	254.7±5.03	248.6±3.22	248.9±5.44
MC40	248.5±1.08	258.3±3.66	253.4±6.16	251.0±4.40
p-values	0.971	0.683	0.348	0.365
	NS	NS	NS	NS

C0, control; RC20, raw chickpea 20%; RC40, raw chickpea 40%; OC20, autoclaved chickpea 20%; OC40, autoclaved chickpea 40%; MC20, microwaved chickpea 20%; MC40, microwaved chickpea 40%; NS, not significant.

(2012) stated that the effect of diets containing raw chickpeas at different rates on the live weight changes of broiler chickens was insignificant. Obregon et al. (2012) reported that the effect of diets containing 60% raw and heat-treated chickpeas on the weight changes of butchery quails was insignificant.

Table 4 shows the daily feed consumption values and feed conversion ratios of the quails, whose diets contained raw or processed chickpeas, in different periods. In feeding on diets containing differently processed chickpeas (autoclaving and microwave processes) and different ratios of chickpeas (20% and 40%), similar results were obtained at all weeks except for the 15th week. In general, there was no significant effect of the treatments on the feed consumption values, and the differences between the feed consumption mean values of the groups (except for the 15th week) were statistically insignificant. The differences in feed consumption between the control and treatment groups at the 15th week was significant ($p<0.05$), and the highest feed consumption was determined in the OC20 group. Similarly, Farrell et al. (1999) reported that the effect of feeding on diets containing different levels of raw chickpeas, feed peas, bean and sweet lupines on the feed consumption of broiler chickens was not significant. Brenes et al. (2008) found that the effects of feeding on diets containing raw chickpeas

Table 4. Daily feed consumption and feed conversion ratios of quails in the control and treatment groups

Groups	Periods (wk)				
	10–11	12–13	14–15	16–17	18–19
Daily feed intake (g)					
C0	35.73±0.60	32.54±0.94	30.92±0.79^{b}	30.41±1.08	27.73±1.33
RC20	36.03±1.04	33.13±0.33	30.92±0.41^{b}	31.41±1.05	30.37±0.80
RC40	36.14±0.71	34.77±0.38	33.01±0.56^{ab}	32.36±0.48	29.84±0.71
OC20	34.53±0.30	33.70±0.27	34.12±0.18^{a}	30.00±0.68	28.35±0.87
OC40	36.77±0.49	34.13±1.02	32.96±0.96^{ab}	31.01±1.22	30.79±0.47
MC20	34.30±0.79	32.65±0.45	30.33±1.41^{b}	30.72±0.93	28.90±0.71
MC40	34.70±1.09	33.08±0.88	31.21±0.92^{b}	30.19±1.26	29.62±0.83
p-values	0.244	0.278	0.047	0.677	0.203
	NS	NS	*	NS	NS
Feed conversion ratio (g:g)					
C0	3.40±0.06	3.14±0.17	3.19±0.20	3.07±0.14	3.19±0.08
RC20	3.42±0.13	3.14±0.05	3.98±0.05	2.99±0.14	2.81±0.10
RC40	3.82±0.07	3.47±0.10	3.31±0.18	3.37±0.17	3.27±0.10
OC20	3.56±0.18	3.12±0.15	3.37±0.01	3.20±0.01	3.18±0.04
OC40	3.55±0.09	3.27±0.19	3.40±0.28	3.43±0.23	3.23±0.22
MC20	3.74±0.05	3.32±0.12	3.55±0.25	3.39±0.18	3.48±0.13
MC40	3.51±0.11	3.10±0.13	3.18±0.14	3.31±0.43	3.08±0.34
p-values	0.144	0.475	0.389	0.793	0.303
	NS	NS	NS	NS	NS

^{a,b} Means with different superscripts in the same column are significantly different.
* $p<0.05$.
C0, control; RC20, raw chickpea 20%; RC40, raw chickpea 40%; OC20, autoclaved chickpea 20%; OC40, autoclaved chickpea 40%; MC20, microwaved chickpea 20%; MC40, microwaved chickpea 40%; NS, not significant.

and extruded chickpeas on the feed consumption of broiler chickens were statistically insignificant. The findings on feed consumption in this study showed similar results to those reported by Algam et al. (2012), Christodoulou et al. (2006a), Djeddi (1999), Fru-Nji et al. (2007), Perez-Maldonado et al. (1999) and Torki and Karimi (2007) for different poultry animals. Viveros et al. (2001) reported that autoclaving of raw chickpeas significantly affected feed consumption in broiler chickens.

Since raw chickpea contains significant amounts of tannins (5.63 mg/g), and it has trypsin inhibitor activity (107.22 TIU/g), it prevents the digestibility of feed proteins and reduces the bioavailability of important minerals (Mittal et al., 2012; Rehman and Shah, 2001). Similarly, Reed (1995) explained that, since condensed tannins in diet structures are complexed with protein and carbohydrates, they reduce feed consumption of poultry and affect performance negatively. However, the usage of raw chickpeas, which was used in this study and contained a condensed tannin content of 3.10 g/kg, in diets by up to 40%, did not cause any adverse effects on feed consumption.

In all weeks, there were no significant differences between the feed conversion ratios in the control and treatment groups. Different heat treatments did not have a significant effect on the feed conversion ratios of the quails. This result was not consistent with the results of Alajaji and El-Adawy (2006) that raw chickpea reduced the performance of poultry. However, the findings on feed conversion showed similar results to those obtained by Algam et al. (2012) for raw chickpea in broiler diets, by Brenes et al. (2008) for extruded chickpea in broiler chickens and by Torki and Karimi (2007) for diets containing raw chickpea (10%) in broilers.

During the experiment, the effect of treatments on egg production was statistically insignificant (Table 5). Addition of raw or heat-treated chickpeas into the diets did not significantly affect the egg production of the quails. However, the quails in the OC40 group generally had higher egg production than the other groups during the 19-week experiment period.

The results obtained for egg production were similar to the results of the study carried out by Djeddi (1999) that the effect of adding different levels of vetch to quail diets on egg production was insignificant and by Garsen et al. (2007) that the effect of adding 25% to 40% raw chickpeas into diets of laying hens on egg production was insignificant. On the other hand, they differed from the results obtained by Perez-Maldonado et al. (1999) that the effects of diets containing beans and sweet lupines on the egg production of chickens were significant and by Fru-Nji et al. (2007) that the effects of diets containing beans and peas on the egg production of chickens were significant.

The differences between the egg weights of the groups fed on diets containing raw, autoclaved and microwave-processed chickpeas were statistically insignificant ($p>0.05$), while the differences between the treatments were significant ($p<0.05$) only in the last week of the experiment (19^{th} week). The RC40, RC20, OC40 and OC20 groups had higher egg weights than the other groups at the 19^{th} week. In general, all treatment groups provided heavier eggs than the control group. The results obtained for egg weight were similar to the findings obtained from studies conducted by Djeddi (1999) on diets containing vetch for quails and by Fru-Nji et al. (2007) on diets containing beans and peas (50%) for egg-laying hens.

The effects of diets containing different levels of chickpeas processed with different heat treatments on the quality characteristics of some egg laying quails were investigated. External and internal quality measurements were made on egg samples collected at the 13^{th} and 19^{th} weeks, and the results that were obtained were statistically analyzed. Table 6 shows the findings on the quality characteristics of eggs.

The eggshell thicknesses of the quails in the control and treatment groups were measured at the 13^{th} and 19^{th} weeks, and the data that were obtained were statistically analyzed. The differences between the groups for shell thickness were significant for the 13^{th} week ($p<0.01$), while they were not significant for the 19^{th} week. At the 13^{th} week, eggshell thickness was

Table 5. Weekly egg production and egg weight of quails in the control and treatment groups

Groups	Periods (wk)				
	10–11	12–13	14–15	16–17	18–19
Egg production (%)					
C0	78.87±3.31	78.87±4.87	76.69±6.74	77.74±6.91	73.47±3.71
RC20	82.14±1.03	80.65±2.14	81.25±2.86	81.90±4.29	86.38±3.24
RC40	70.24±2.43	75.59±3.27	76.19±4.64	74.36±4.22	70.46±3.33
OC20	73.22±4.91	80.95±2.97	77.68±1.85	72.92±1.65	71.13±1.29
OC40	78.27±1.29	77.98±3.86	75.00±4.09	69.05±3.50	76.07±5.63
MC20	69.35±3.10	75.89±1.85	66.67±4.64	71.65±5.85	68.71±3.02
MC40	73.51±3.87	81.84±2.97	77.38±4.13	75.00±10.80	79.53±6.39
p-values	0.090	0.747	0.435	0.803	0.402
	NS	NS	NS	NS	NS
Egg weight (g)					
C0	13.35±0.25	13.24±0.25	12.79±0.06	12.86±0.26	11.83±0.24[c]
RC20	12.83±0.15	13.08±0.09	12.75±0.09	12.88±0.09	12.52±0.16[ab]
RC40	13.49±0.26	13.29±0.17	13.18±0.10	13.00±0.23	12.99±0.14[a]
OC20	13.35±0.27	13.38±0.24	13.04±0.27	12.86±0.05	12.55±0.22[ab]
OC40	13.24±0.14	13.45±0.35	13.00±0.29	13.16±0.22	12.67±0.06[ab]
MC20	13.26±0.24	12.97±0.18	12.92±0.20	12.77±0.22	12.12±0.25[bc]
MC40	13.47±0.30	13.08±0.37	12.74±0.34	12.63±0.22	12.32±0.28[abc]
p-values	0.561	0.833	0.752	0.664	0.032
	NS	NS	NS	NS	*

[a–c] Means with different superscripts in the same column are significantly different.
[*] $p<0.05$.
C0, control; RC20, raw chickpea 20%; RC40, raw chickpea 40%; OC20, autoclaved chickpea 20%; OC40, autoclaved chickpea 40%; MC20, microwaved chickpea 20%; MC40, microwaved chickpea 40%; NS, not significant.

affected positively by adding raw and heat-treated chickpeas into the diets. The highest shell thickness values in this period were respectively obtained from the OC40, OC20 and MC20 groups. The eggs of the treatment groups were generally thicker than those in the control group. At the 19th week, the differences between the groups' mean values were insignificant. The findings that were obtained were consistent with the results of shell thickness reported by Djeddi (1999) for vetch addition into the diet of quails.

While significant differences ($p<0.05$) of shell weight were observed between the control and treatment groups at the 13th week, no significant differences were observed at the 19th week. At the 13th week, the highest values for shell weight were respectively obtained from the CO, OC40, RC20, OC20 and MC20 groups, whereas the RC40 and MC40 groups showed lower values than the others. In this period, the heat treatments caused a decrease in the shell weight in two groups (RC40 and MC40). From the 19th week, it was determined that shell weight was not affected by the treatments. In some groups, although there were numerical decreases in shell weight, these decreases were not statistically significant.

It was determined that the differences between the control and treatment groups were insignificant in the statistical analyses applied to the data of the 13th week for the shape index values, but they were significant at the 19th week ($p<0.01$).

Table 6. Quality characteristics of quail eggs in the control and treatment groups

Weeks	Groups								
	C0	RC20	RC40	OC20	OC40	MC20	MC40	p-values	
Egg shell thickness (mm)									
13	0.19±0.0^{d}	0.20±0.0^{dc}	0.20±0.0^{dc}	0.21±0.0^{abc}	0.22±0.0^{a}	0.21±0.0^{ab}	0.20±0.0^{dc}	0.0001	**
19	0.21±0.0	0.21±0.0	0.21±0.0	0.21±0.0	0.21±0.0	0.22±0.0	0.22±0.0	0.451	NS
Egg shell weight (g)									
13	1.30±0.0^{a}	1.25±0.0^{ab}	1.18±0.0^{b}	1.23±0.0^{ab}	1.27±0.0^{a}	1.22±0.0^{ab}	1.18±0.0^{b}	0.036	*
19	1.10±0.0	1.13±0.0	1.17±0.0	1.11±0.0	1.12±0.0	1.10±0.0	1.10±0.0	0.622	NS
Shape index (%)									
13	77.0±0.8	77.4±1.2	77.2±0.8	75.1±0.8	75.2±1.2	76.5±1.3	77.4±0.9	0.469	NS
19	80.5±2.0^{a}	77.9±0.8^{ab}	75.6±0.6^{b}	75.3±0.9^{b}	76.5±0.6^{b}	77.3±0.6^{b}	76.9±0.5^{b}	0.007	**
Yolk weight (g)									
13	4.17±0.12	4.17±0.09	4.15±0.09	4.24±0.09	4.39±0.08	4.36±0.12	4.36±0.13	0.519	NS
19	3.91±0.12	4.24±0.09	4.49±0.11	4.12±0.14	4.13±0.08	4.24±0.14	4.31±0.12	0.058	NS
Yolk (%)									
13	31.3±0.5^{b}	32.0±0.6^{b}	32.7±0.5^{ab}	31.9±0.4^{b}	31.9±0.4^{b}	32.9±0.6^{ab}	33.8±0.7^{a}	0.026	*
19	32.1±0.5^{c}	32.9±0.5^{bc}	33.5±0.4^{abc}	32.9±0.6^{bc}	32.7±0.4^{c}	34.3±0.5a^{b}	34.5±0.5^{a}	0.005	**
Yolk diameter (mm)									
13	26.7±0.3^{c}	27.1±0.3^{bc}	27.1±0.3^{bc}	27.7±0.3^{abc}	28.1±0.3^{a}	27.9±0.3^{ab}	27.3±0.4^{abc}	0.021	*
19	26.9±0.3c	27.6±0.3^{bc}	28.6±0.3^{ab}	28.1±0.4^{ab}	28.8±0.3^{a}	28.6±0.4^{ab}	28.9±0.4^{a}	0.0002	**
Albumen index (%)									
13	10.65±0.5	11.32±0.5	11.15±0.5	10.07±0.5	10.27±0.5	9.92±0.3	10.44±0.3	0.214	NS
19	9.68±0.3^{ab}	9.52±0.4^{ab}	8.44±0.5^{bc}	9.35±0.4^{ab}	9.94±0.4^{a}	8.46±0.4^{bc}	8.04±0.4^{c}	0.006	**
Yolk index (%)									
13	43.18±0.7	43.21±0.7	43.80±0.7	42.11±0.4	42.70±1.0	41.74±0.7	44.17±0.7	0.151	NS
19	41.49±0.7^{a}	40.81±0.6^{a}	38.65±0.8^{bc}	40.28±0.6^{ab}	36.75±0.5^{dc}	36.65±0.7^{dc}	36.44±0.8^{d}	0.0001	**
Haugh unit									
13	88.08±1.0	90.59±1.2	90.12±1.0	88.55±1.0	89.04±1.3	88.26±0.7	88.86±0.6	0.466	NS
19	87.42±0.7^{a}	87.17±0.7^{ab}	84.27±1.2^{c}	87.10±0.9^{ab}	88.74±0.7^{a}	84.54±1.0^{bc}	83.58±0.9^{c}	0.0003	**
Yolk color									
13	9.38±0.4^{abc}	9.28±0.3^{bc}	10.47±0.3^{a}	9.60±0.4^{abc}	10.00±0.4^{ab}	8.87±0.4^{b}c	8.60±0.4^{c}	0.011	*
19	8.73±0.5	9.60±0.4	8.93±0.5	9.27±0.4	8.87±0.2	9.20±0.5	8.40±0.4	0.509	NS

[a–d] Means with different superscripts in the same row are significantly different.
[*] $p<0.05$, [**] $p<0.01$.
C0, control; RC20, raw chickpea 20%; RC40, raw chickpea 40%; OC20, autoclaved chickpea 20%; OC40, autoclaved chickpea 40%; MC20, microwaved chickpea 20%; MC40, microwaved chickpea 40%; NS, not significant.

Different treatments generally affected the shape indices of the eggs (except for RC20), and lower values were obtained in the treatment groups in comparison to the control group.

The findings on yolk weight indicated that adding raw or processed chickpeas into the diet did not affect egg yolk weight.

The measurements showed that the differences between the mean yolk weights of the control and treatment groups at the 13th and 19th weeks were not significant. The differences between the control and treatment groups were significant ($p<0.05$, $p<0.01$) in the measurements made for yolk rate at the 13th and 19th weeks. The highest ratios for the yolk ratio were obtained from the MC40, MC20 and RC40 groups. Considering the results obtained for yolk diameters, it was seen that the treatments that were applied were effective ($p<0.05$, $p<0.01$) in both weeks of measurement. The groups with the highest values in terms of yolk diameter at the 13th and 19th weeks were the OC40, MC20, MC40 and OC20 groups. The microwave and autoclaving processes positively affected the yolk diameter of the eggs.

The albumen index was significantly ($p<0.01$) affected by different treatments at the 19th week, while it was not affected at the 13th week. At the 19th week, the RC40, MC20 and MC40 groups had lower albumen index values than the other groups. It was observed that using microwave-processed chickpeas in the diet affected the albumen index negatively. The results obtained from this study for the albumen index were similar to the results obtained by Djeddi (1999) on diets containing vetch for quails and by Fru-Nji et al. (2007) on diets containing beans and peas (50%) for laying hens.

The differences between the yolk index values of the eggs obtained from the control and treatment groups were not significant at the 13th week, but they were significant at the 19th week ($p<0.01$). The yolk index was significantly influenced by different treatments at the 19th week. The yolk index values of the RC40, OC40, MC20 and MC40 groups were lower than those of the other groups. The microwave process was shown to cause a significant reduction in the yolk index value. This result was similar to Djeddi's (1999) results on vetch addition into diets of quails and different from Fru-Nji et al.'s (2007) results on bean and addition of peas into diets of laying hens.

In the analysis of the 13th week, it was determined that the effect of different treatments on the Haugh unit values of the quail eggs was insignificant ($p<0.01$), while it was significant at the 19th week. The Haugh unit values of the RC40, MC20 and MC40 groups were lower than the other groups. According to the results obtained, adding microwave-processed chickpeas into the diets affected the Haugh unit of the eggs negatively. This result was in line with Djeddi's report that the effect of quail fed on diets containing vetch on the Haugh unit value of the eggs was significant.

When the eggs from the control and treatment groups were examined in terms of the color of the yolk, significant differences ($p<0.05$) were observed at the 13th week. The treatments applied at the 13th week affected the yolk color. The yolk color of the RC20, MC20 and MC40 groups was lighter than the other groups. It may be stated that adding microwave-processed chickpeas into the diet affected the color of the yolk negatively. The differences between the 19th week mean values were found to be insignificant. The results on yolk color in this study were similar to the results obtained by Fru-Nji et al. (2007) on diets containing beans and peas for hens.

The most important result of this study was the revelation that industry byproduct chickpea grains, which are rich in protein and energy, may be used to a significant extent in the place of soybean meal and corn which are the two most important elements of poultry diets. In the study, in comparison to the control group, the diets of the treatment groups included chickpea grains to replace 50% of corn and 39% of soybean meal. Usage of 20% and 40% chickpea grains in the diets of laying quails did not create a significant negative effect on the production performance or egg quality of the quails. This result provided hopes that chickpea grains may be used as an alternative product in the feeds of poultry. The condensed tannin contents of the raw, autoclaved and microwaved chickpea grains in the study were found respectively as 3.10, 1.48, and 2.75 g/kg. This result showed that heat processes (especially autoclaving) created significant reductions in the tannin content of chickpeas (up to 52.26%).

The results for the 13th week of the study showed that the yolk color values of the chickpea-containing groups were significantly higher than those in the control group. The lower yolk color value in the microwave treatment group in comparison to the other treatment groups may have been caused by the microwaving process. Thus, more specific studies are needed to determine the effects of chickpea grains on the pigmentation of yolks.

Conclusion

It was observed that chickpeas added as raw, autoclaved and microwaved by the ratios of 20% and 40% into the diets of quails did not usually have a significant effect on live weight, daily feed consumption, feed conversion ratio, egg yield and egg weight. However, some significant differences were observed among the groups in terms of some internal and external egg quality characteristics. When the treatment groups were compared to the control group, it was seen that the raw, autoclaved and microwaved treatments did not cause a significant reduction in terms of yield performance. It was a promising outcome that better results were obtained in some heat treatment applications in comparison to the control group. Usage of chickpeas at high ratios (20% and 40%) did not cause a significant reduction in performance. Nevertheless, considering all these treatments together, it was determined that subjecting chickpeas to heat treatments such as autoclaving and microwaving did not show any significant difference to their usage as raw or in comparison to the control group. As a consequence, looking at the effects of the heat treatment processes, it may be stated that the autoclaving process provided partially better results especially in terms of egg quality. It may additionally be stated that, when chickpeas are used by up to 40% in the rations of laying quails, they do not cause a significant negative effect.

Conflicts of Interest

The authors declare no potential conflict of interest.

Acknowledgements

The authors would like to express their deepest gratitude to Kahramanmaras Sutcu Imam University Research Fund for supporting this research (BAP-Project number 2014/2-46D).

Author Contributions

Conceptualization: Şengül AY, Çalışlar S. Data curation: Şengül AY, Çalışlar S. Formal analysis: Şengül AY. Methodology: Çalışlar S. Software: Şengül AY, Çalışlar S. Validation: Şengül AY, Çalışlar S. Investigation: Şengül AY, Çalışlar S. Writing - original draft: Şengül AY, Çalışlar S. Writing - review & editing: Şengül AY, Çalışlar S.

Ethics Approval

All procedures performed on the quails in this study were consistent with the ethical standard indicated in directive 2010/63/EU and the experimental protocols were approved by the Animal Experimentation Ethics Committee of Kahramanmaras Sutcu Imam University, Faculty of Agriculture (Protocol no: KSUZIRHAYDEK2014/02-9).

References

Abdelgadir IEO, Morrill JL, Higgins JJ. 1996. Effect of roasted soybeans and corn on performance and ruminal and blood metabolites of dairy calves. J Dairy Sci 79:465-474.

Alajaji SA, El-Adawy TA. 2006. Nutritional composition of chickpea (*Cicer arietinum* L.) as affected by microwave cooking and other traditional cooking methods. J Food Compos Anal 19:806-812.

Algam TA, Atti KAA, Dousa BM, Elawad SM, Elseed AMF. 2012. Effect of dietary raw chick pea (*Cicer arietinum* L.) seeds on broiler performance and blood constituents. Int J Poult Sci 11:294-297.

Anderson KE, Tharrington JB, Curtis PA, Jones FT. 2004. Shell characteristics of eggs from historic strains of Single Comb White Leghorn chickens and the relationship of egg shape to shell strength. Int J Poult Sci 3:17-19.

AOAC. 2005. Methods of analysis. 18th ed. Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Bampidis VA, Christodoulou V. 2011. Chickpeas (*Cicer arietinum* L.) in animal nutrition: A review. Anim Feed Sci Technol 168:1-20.

Brenes A, Viveros A, Centeno C, Arija I, Marzo F. 2008. Nutritional value of raw and extruded chickpeas (*Cicer arietinum* L.) for growing chickens. Span J Agric Res 6:537-545.

Carpenter KJ, Clegg KM. 1956. The metabolizable energy of poultry feeding stuffs in relation to their chemical composition. J Sci Food Agric 7:45-51.

Christodoulou V, Bampidis VA, Hucko B, Mudrik Z. 2006a. The use of extruded chickpeas in diets of broiler turkeys. Czech J Anim Sci 51:416-423.

Christodoulou V, Bampidis VA, Hucko B, Iliadis C, Mudrik Z. 2006b. Nutritional value of chickpeas in rations of broiler chickens. Eur Poult Sci 70:112-118.

Ciftci C.Y. 2004. Dunyada ve Turkiye'de yemeklik tane baklagiller tarimi. TMMOB Ziraat Muhendisleri Odasi Teknik Yayinlar Dizisi 5:88 (in Turkish).

Decareau RV, Peterson R. 1986. Microwave processing and engineering. VCH, Weinheim, Germany. pp 18-21.

Deshpande SS, Cheryan M. 1984. Preparation and antinutritional characteristics of dry bean (*Phaseolus vulgaris* L.) protein concentrates. Plant Food Hum Nutr 34:185-196.

Deshpande SS, Damodaran S. 1990. Food legumes: Chemistry and technology. In Advances in cereal science and technology. Pomeranz Y (ed). American Association of Cereal Chemists, St. Paul, MN, USA. pp 47-241.

Djeddi AN. 1999. The effects of vetch seed used in quail rations on egg production, egg quality and some blood parameters. Ankara Univ Vet Fak Derg 46:9-19.

Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. 1956. Colorimetric method for determination of sugars and related substances. Anal Chem 28:350-356.

El-Adawy TA. 2002. Nutritional composition and antinutritional factors of chickpeas (*Cicer arietinum* L.) undergoing different cooking methods and germination. Plant Food Hum Nutr 57:83-97.

Ercan B, Acar J, Askin O. 1989. Microwaves, their use in food industry and effects on microorganisms. Gida Dergisi Cilt 14:141-148.

Ertas N, Turker S, Bilgicli N. 2008. Cesitli proseslerin baklagilin besinsel ve antibesinsel ogelerine etkisi. Proceedings of the Turkey 10th Food Congress, Erzurum, Turkey. pp 21-23.

Eskibalci MF, Ozkan SG. 2008. Application of microwave energy in mineral processing and investigation of its effects on grind ability of boron minerals. Ist Earth Sci 11-23.

FAO [Food and Agriculture Organization of the United Nations]. 2016. Statistical database. Available from: http://www.fao.org. Accessed at Jul 30, 2019.

Farrell DJ, Perez-Maldonado RA, Mannion PF. 1999. Optimum inclusion of field peas, faba beans, chick peas and sweet lupins in poultry diets. II. Broiler experiments. Br Poult Sci 40:674-680.

Fru-Nji F, Niess E, Pfeffer E. 2007. Effect of graded replacement of soybean meal by faba beans (*Vicia faba* L.) or field peas (*Pisum sativum* L.) in rations for laying hens on egg production and quality. J Poult Sci 44:34-41.

Garsen A, Dotas D, Florou-Paneri P, Nikolakakis I. 2007. Performance and egg quality traits of layers fed diets containing increasing levels of chickpea. Anim Sci Rev 36:3-14.

Gatel F. 1994. Protein quality of legume seeds for non-ruminant animals: A literature review. Anim Feed Sci Technol 45:317-348.

Gerard KA, Roberts JS. 2004. Microwave heating of apple mash to improve juice yield and quality. LWT-Food Sci Technol 37:551-557.

Gungor A. 1998. Grindability of microwave-heated ores. MS thesis, Middle East Technical Univ., Ankara, Turkey.

Haugh RR. 1937. The Haugh unit for measuring egg quality. US Egg Poult Mag 43:572-573.

Huisman J, Jansman AJM. 1991. Dietary effects and some analytical aspects of antinutritional factors in peas (*Pisum sativum*), common beans (*Phaseolus vulgaris*) and soybeans (*Glycine max* L.) in monogastric farm animals. Nutr Abst Rev B 61:901-921.

Karabulut A, Canbolat O. 2005. Yem degerlendirme ve analiz yontemleri. 1st ed. Uludag Universitesi Yayinlari. Bursa, Turkey. p 520.

Kaya I, Yalcin S. 1999. Grain legumes and usage in ruminant rations. Lalahan Hayvancılık Arast Enst Derg 39:101-114.

Makkar HPS, Becker K, Abel H, Szegletti C. 1995. Degradation of condensed tannins by rumen microbes exposed to quebracho tannins (QT) in rumen simulation technique (rusitec) and effects of QT on fermentative processes in the rusitec. J Sci Food Agric 69:495-500.

Mittal R, Nagi HPS, Sharma P, Sharma S. 2012. Effect of processing on chemical composition and antinutritional factors in chickpea flour. J Food Sci Eng 2:180-186.

Mudgett RE. 1989. Microwave food processing. Food Technol 43:117-126.

NRC. 1994. Nutrient requirements of poultry. 9th ed. National Academy Press, Washington, DC, USA.

Obregon JF, Bell C, Iliana Elenes A, Estrada A, Portillo JJ, Rios FG. 2012. Effect of discarded chickpea (*Cicer arietinum* L.) cooking on the productive response and carcass yield of Japanese quail (*Coturnix coturnix japonica*) at the fattening stage. Cuban J Agric Sci 46:169-173.

Ozdemir F, Golukcu M, Topuz A. 2003. Some chemical, physical properties of raw peanut (*Arachis hypogaea*) and microwave roasting effect on fatty acid composition of peanut's. Gida Dergisi Cilt 28:39-45.

Perez-Maldonado RA, Mannion PF, Farrell DJ. 1999. Optimum inclusion of field peas, faba beans, chick peas and sweet lupins in poultry diets. I. Chemical composition and layer experiments. Br Poult Sci 40:667-673.

Reed JD. 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. J Anim Sci 73:1516-1528.

Rehman ZU, Shah WH. 2001. Tannin contents and protein digestibility of black grams (*Vigna mungo*) after soaking and cooking. Plant Food Hum Nutr 56:265-273.

SAS. 2006. SAS 9.1.3 user manual. SAS Institute, Cary, NC, USA.

Seyhun N, Sumnu G, Sahin S. 2004. Effects of different starch and emulsifier types and fat contents on staling of microwave-baked cakes. Gida Dergisi Cilt 29:337-343.

Sharma HR, Nicholson WG. 1975. Effects of treating faba beans with formaldehyde or volatile fatty acids on the performance of dairy calves and fistulated sheep. Can J Anim Sci 55:705-713.

Torki M, Karimi A. 2007. Evaluation of dietary replacement of soybean meal by chickpea supplemented by enzymes on performance of broiler chicks. Proceedings of the 16th European Symposium on Poultry Nutrition, Strasbourg, France. pp 651-654.

Van Der Poel AFB. 1990. Effect of processing on antinutritional factors and protein nutritional value of dry beans (*Phaseolus vulgaris* L.). A review. Anim Feed Sci Technol 29:179-208.

Viveros A, Brenes A, Elices R, Arija I, Canales R. 2001. Nutritional value of raw and autoclaved Kabuli and Desi chickpeas (*Cicer arietinum* L.) for growing chickens. Br Poult Sci 42:242-251.