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Effect of Feed Uniformity (Particle Distribution) and Particle Size of Starter and Finisher Diets on the Performance and Carcass Weight in Japanese Quails

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Abstract
Two experiments were conducted to determine the ability to discriminate of feeds varying only in particle size and the effect of uniformity and particle size starter and finisher diets on the performance of young Japanese quail. Corn was ground through hammer 3, 5 or 8 mm mill screen openings (HMSO) and used prepare diets. The first experiments were carried out in completely randomized design with six replicates of thirty quails each. Each three diets containing corn with different degrees of grinding were taken as a group. The quails were fed in a choice situation with these diets during 10 days, starting at 8 th days. In this experiment, the quails consumed diets in accordance to their coarseness and feed intake of quails with fine diet (3 mm screen) was significantly higher ($p<0,01$) than of the other two diets, but as quails become older, preferring amount of larger particles was also increased. The 2 nd experiment was the four replicated treatments involving ten quails per treatment were as follows: 1st, 2 nd and 3 rd groups were fed the diets made from corn ground with HMSO of 3, 5, 8 mm during six weeks, 4 th and 5 th groups were fed a diet prepared with mixing in ratio of 30/70 of corn ground through the 3 and 8 mm screen and 5 and 8 mm screen during six weeks; 6 th, 7 th and 8 th groups were fed the diets made from corn ground with 3, 3 and 5 screen at the first 3 weeks and 5, 8 and 8 mm screen respectively at the last 3 weeks of the experiment. Quail performance differences due to degree of grind were minor. The diets containing HMSO corn ground through on HMSO of 5 and 8 mm produced same performance compared with that diet with corn ground through 3 mm. However, there was a trend toward lower performance for quails in the groups 5 th, 6th and 7 th.

Keywords: Japanese quail, Particle size, Corn, Hammer mill, Performance

1. Introduction

The diets for the poultry should provide the required nutrients in proper amounts and in a balanced way, and as well as having a high level of digestibility, they should be easily consumed. The feeds that are digested in a difficult way due to their physical structures (particle size) will adversely affect the performance (Recee et al., 1986a; Nir, 1987; Amerah et al., 2007). In recent years, the interest in the particle size of the feed and in the uniformity of the diet has increased since this is closely related to the issue involved. The screens conducted have shown that poultry have the capacity to distinguish different diets that have the same chemical structures but differing particle size or texture (Moran.1982; Nir,1987; Savory,1980) and that, with age, bigger particles are favored as the beak has grown and that the performance is favorably affected (Schiffman, 1969; Portella et al., 1988a,b; Nir, 1994 a, b).
With the grinding of the feeds, their particle size was reduced and therefore the surface areas of the grains are increased, this process enables the material to be better hydrolyzed by the digestive enzymes of the

animals, a homogenous mixture is obtained, and it becomes easier to process the feeds in further handling such as making pellets. Also, this is necessary to prevent the birds from selectively consuming an ingredient with large partical size (Reece et all., 1986). The size of the screens used to grind feeds in hammer mills are between 0.3 and 10 mm or bigger (Melcoin ve Monredan, 1987).
Literature is too limited regarding the effects of degree of grinding and the particle size distribution in quails. The purpose of this trial is to determine the effect of grinding degree on the particle sizes, the distribution (uniformity) and the preference of the feed by young quails, their ability to distinguish between the feeds with differing particle sizes, the performance and the weight of the carcass.

2. Material and Method

Two distinct trials are conducted for this research; in the first trial, 180 and in the second trial 320 one-day-old quails are used. The chicks that have just hatched were weighed one by one, only those that weighed 6, 7, 8 and 9 g. were divided into four groups and put into four different boxes and only the chicks with a body weight (BW) of 7 and 8 g were used in the studies. The quails were raised in rearing cages with five-tier stacked battery system that were locally manufactured, electrically heated, equipped with thermostats and wire grate on the floor and tiers with two divisions (90 cm x 150 cm first trial) or four divisions (45cm x 150cm; second trial) on each tiers. The feed and water was provided to the quails for ad libitum and the birds were constantly exposed to lighting for 24 hours.
In both trials, standard quail diet that contained 10 % more nutrient (for safety) than recommended by NRC, (1994; Table 1). In order to prepare diets ground to differing extents, corn, soybean meal, and sunflower meal were broken down at a hammer mill that had screens of 3, 5 and 8 mm, and were put into separate sacks. The hammer mill used in the trial (Haseki Commerce and Industry Joint-Stock Co., Haseki YK.87.1, type, Ankara) had a full-circle screen and the breaking capacity of it changed, depending on the grain type to be broken down and on the grinding degree, and it was 150-200 kg/hour and the top bunker was 40 liters. The working voltage of the electric engine was 220 volts, the working frequency was 50 Hz, its rotation was 2900 turnover/minute, and its power was 1 horsepower. The hammer mill was driven by a 5.5-kW electric motoroperated at approximately 7,125 rpm, i.e., peripheral speed of approximately 60 m/sec.

Table 1. Composition of the experimental diet

Ingredients	%
Yellow corn	50.4
Soybean meal (44% CP)	33.3
Sunflower meal (36 % CP)	8.0
Fish meal (67% CP)	3.1
Vegetable oil	2.3
Limestone (36 % Ca)	0.85
Dicalcium phosphate (24 % Ca, 18 % P)	1.20
Salt	0.30
Vitamin premix*	0.20
Trace minerals mix**	0.20
DL-Methionine	0.15
TOTAL	100.00
Calculated analysis	
Metabolizable energy, kcal/kg	2905
Crude protein, %	23.99
Calcium,%	0.85
Available phosphorus,%	0.46
Lysine, %	1.31
Methionine	0.55
Methionine plus cystine	0.92

**Vitamin premix provided per kg of diet: 12.000 IU vitamin A, 3500 IU vitamin D3,50 mg vitamin E, 3 mg vitamin K3, 3mg vitamin B1, 6 mg vitamin B2, 45 mg niacin, 15 mg Ca-D-pantothenate, 5 mg vitamin B6, 0.015 mg vitamin B12, 0,150 mg D-biotin, 150 mg BHT, 400 mg choline chloride*

***Trace mineral mix provided per kg of diet: 120 mg manganese, 80 mg iron, 100 mg zinc, 10 mg copper, 1 mg iodine, 0,4 mg cobalt, 0,3 mg selenium*

In the first trial, the diets that were prepared from the feeds ground through HMSO of 3, 5 and 8 mm were put into separate plastic feeder in quantities of 200 grams. They were placed in each cage together and the quails were allowed to feed freely choice. All the three feeds that were ground with using different screen size were taken as a group or treatment, and they were replicated three times, and 30 chicks were put into each group. The quails were fed for 7 days with the diets prepared from the feeds ground through a screen of 3 mm. The plastic feeders were 23 cm in diameter and 4 cm in height. A plastic cover that had a diameter of 22.5 cm and holes of 1.2 cm. shaped as circles was laid on the feed to prevent the quails from reaching the interior of the feeders and scratching, thus causing feed loss.

In this trial, 200 grams of feed was put into feeders everyday morning at 9 o'clock, and the feeders were separately weighed the next day at the same hour. Thus, the amount consumed from the diets prepared through the broken-down feeds using screens of 3, 5 and 8 mm was found, and later the total daily feed consumption (FC) was found, adding the amount of these three feeds.

Daily feed consumption per quail was calculated, dividing the total daily feed consumption to the number of the quails in the section. The percentage share of each diet in total feed consumption was calculated as: (the amount of daily consumption for each diet / the total daily feed consumption) x 100.

In the second trial, the diets prepared from feed materials ground to varying extents were given either individually or after being blended with each other at certain ratios for 6 weeks or at the starter (0-3 weeks) and finisher (4-6 weeks) periods. Although the same diets were fed during both the periods of growth in the second trial, the grinding levels and particle distribution (uniformity) of the experimental diets were different. The particle sizes of the experimental diets are given below.

The first, second and third groups were respectively fed with the diets prepared from the feeds ground through screens of 3, 5 and 8 mm for 6 weeks; the fourth group was fed with a blend of 30/70 % of the diet prepared from the feeds ground through screens of 3 and 8 mm for 6 weeks; the fifth group was fed with a blend of 30/70 % of the diet prepared from the feeds ground through screens of 5 and 8 mm for 6 weeks; the sixth group was fed with the diets prepared from the feeds ground through the screens of 3 and 5 mm at the starter and finisher periods respectively; the seventh group was fed with the diets prepared from the feeds ground through the screens of 3 and 8 mm at the same period; the eight group was fed with the diets prepared from the feeds ground through the screens of 5 and 8 mm.

In the second trial, eight diets (treatments) were tested with four replicates, and in each replicates, 10 quails (320 quails in total) were used. BW and feed consumption (FC) of the quails were detected by weighing them weekly as a group and the increase body weight gain (BWG) and the feed conversion ratio (FCR) were calculated from these values. At the end of the experiment, all the quails were slaughtered, and hot carcass weight was found by weighing them in groups except for the heart and the lung.

In order to establish the sizes of corn grain and particles in the diets, five different laboratory screens with a diameter of 26 cm were used. The hole diameters of the screens were 1.7; 1.18; 0.85; 0.425 and 0.212 mm. Samples of 100 grams were taken from the ground corn and the diets three times, after the samples were sifted for ten minutes in a shaker machine using a sieve system of five, the particles remaining on each sieve were weighed, and the particles >1.7; >1.18; >0.85; >0.425; >0.212 and <0.212 mm were identified; each fraction was expressed as gram in 100 gram feed. Measurements were carried out with a digital scale sensitive to 0.01 gram.

Because both studies were designed and conducted in completely randomized design, the data collected were analyzed in accordance with this design; the mathematical model of the experiment is Y_{ij}: $\mu+\alpha_i+e_{ij}$ (μ: general mean, α_i: the effect of the grinding degree, e_{ij}: error). Whether the effects of treatments particle size distribution were significant was carried out a variance analysis through MINITAB package program, differences between treatments means were analyzed by Duncan's multiple range test (Düzgüneş, 1963).

3. RESULTS and DISCUSSION

3.1. The Effect of Grinding Degree on The Particle Size Distribution of The Corn Grain and Trial Diets

The degree of grinding had an effect on the particle size distribution of corn grains and trial diets (Figure 1 and 2), and in connection with the increase in the diameter of the screen at the mill, the rate of the big particles (>0,85 mm) increased. Whereas the rate of big particles in the corn ground finely, moderately finely and coarsely (through screens of 3, 5 and 8mm) was 55.47; 65.67 and 74.24% respectively, the rate of smaller particles (<0,85 mm) was % 44.53; 34.33 and 25.76 respectively. Another point that draws attention here is the rate of particles bigger than 1.70 mm, which is 49.36 % in coarsely ground corn. In other words, almost half of the corn particles that were ground through a screen of 8 mm remained on a screen of 1.70 mm. In contrast, the rate of the particles smaller than 0.85 mm but bigger than 0.425 mm in corn ground through a screen of 3 mm was 36.05 %, and this is higher than the rate with the other

screen, particularly the 8mm screen. When compared with corn grain, the amount and percentage of fine particles increased as a result of using finely ground feed materials in diets.
However, the rate of big particles in the diets prepared from the mixtures of the feeds that were ground moderately finely (a screen of 5 mm) and coarsely (a screen of 8 mm) was higher than in diets ground finely (Figure 2). The percentage of the big particles (>0.85 mm) in trial diets was 35.67, 47.29 55.90, 57.68, 52.71, 44.1, 42.32 and 38.87 respectively in the diets 1, 2, 3, 4 and 5. The fact that the percentage of big particles in the diets 1 and 3 and in the diets prepared by blending the diets 4 and 5 in a rate of 30/70, % was higher than those in the diet 3 prepared from the corn ground through a screen of 8 mm shows that the particle uniformity of the diet decreased. In the finely ground feed (the diet 1) the rate of the particles smaller than 0.85 mm but bigger than 0.425 mm was 51 %, and this fraction was 20 to 30 % higher than the other diets.

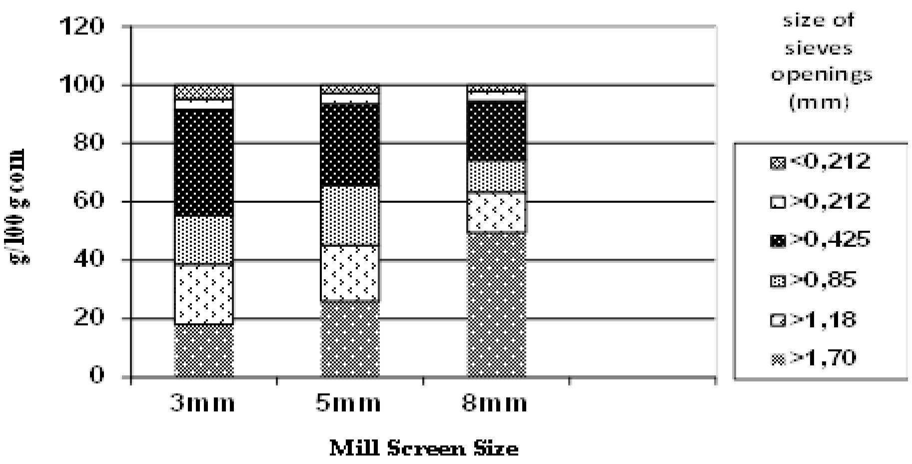

Figure 1. Effect of grinding grade on particle size distribution of corn grain, %

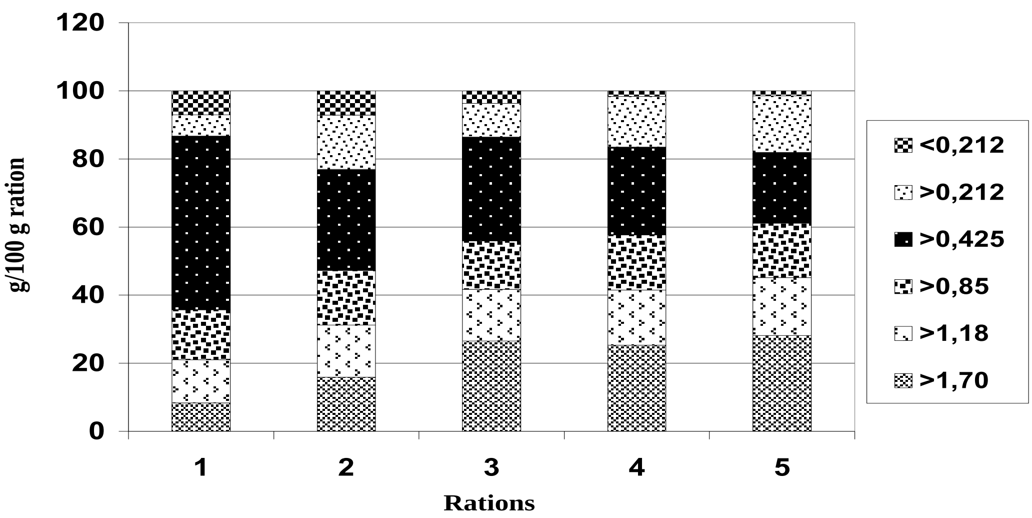

Figure 2. Effect of grinding degree on particle size distribution of trial diets, %

3.2. The Effect of Free-Choice Feeding on The Feed Consumption of The Quails

When young quails were choicely fed with the diets which were different in degree of grinding, they preferred the feeds according to the particle size (Table 2). Throughout the trial, finely ground feed was always consumed or preferred significantly more than the coarsely and moderately finely ground feed (except on the day 12) ($p<0.01$). Besides, the finely ground diet was preferred significantly more, except on the first day of the trial, than the coarsely ground diet ($p<0.01$). However, as the age increased, also the amount of consumption for moderately and coarsely ground feeds were gradually increased.

Table 2. Effect of free-choice feeding with diets ground at different degree on average feed consumption (g/quail) and standard error (first experiment)

Age (day)	Hammer mill screen size (mm)			Daily Feed Consumption (g)	Cumulative Feed Consumption (g)
	3	5	8		
8	4.37±0.30 ^{A}	2.07±0.16 ^{B}	1.25±0.22 ^{B}	7.69	7.69
9	4.07±0.27 ^{A}	2.65±0.17 ^{B}	1.88±0.21 ^{B}	8.60	16.29
10	5.15±0.18 ^{A}	3.28±0.32 ^{B}	1.87±0.12 ^{B}	10.30	26.59
11	5.42±0.20 ^{A}	3.78±0.36 ^{B}	1.68±0.18 ^{B}	10.88	34.47
12	5.18±0.28 ^{A}	3.98±0.44 ^{B}	2.17±0.08 ^{B}	11.30	48.77
13	6.12±0.30 ^{A}	3.73±0.31 ^{B}	2.50±0.18 ^{B}	12.35	61.12
14	6.40±0.42 ^{A}	4.32±0.20 ^{B}	2.47±0.18 ^{B}	13.19	74.31
15	6.98±0.28 ^{A}	4.35±0.36 ^{B}	2.70±0.17 ^{B}	14.03	88.34
16	7.13±0.24 ^{A}	4.43±0.26 ^{B}	2.07±0.14 ^{B}	13.63	101.97
17	8.13±0.67 ^{A}	4.40±0.21 ^{B}	2.45±0.09 ^{B}	14.98	116.95

^{A,B,C}: Values within a row with no common superscripts are significantly different ($p<0.01$)

3.3. The Effect of The Feeds with Ground at Different Degrees on The Performance and Carcass Weight of The Quails

The effect of the feeds ground at different degrees and of the diets prepared by blending these feeds with differing uniformities on the performance of the quails was given on Table 3 and 4. The effects of the diets on the BW of the quails in weeks 3 and 6 were generally small but significant. Whereas BW of the group 5 in the week 3 were detected to be lower ($p<0,05$) than all the other groups except for the BW of the group 8, final BW of the group 6 were found to be lower than the groups fed with the diets 1, 2, 3 and 8, and the final BW of the group 7 were lower than the BW of the groups 1 and 8($p<0,01$) (Table 3). While the BWG of the group 5 in weeks 0 to 3 were lower than that of all the groups except for the group 8, and the BWG of the group 8 was significantly lower than that of the group 1 ($p<0,05$), this effect was not observed in the periods 4 to 6 weeks and 0 to 6 weeks. BWG of the groups 5 and 8 were found to be significantly higher than that of the groups 4, 6 and 7 in the periods of 4 to 6 weeks, but BWG of only the group 8 was significantly higher than that of the groups 4, 6 and 7 in the periods of 0 to 6 weeks ($p<0,01$) (Table 3).

The effect of the diets on FC was low as on the values of BW and BWG. The daily FC of the quails in the group 3 was significantly higher than that of the other groups except for the groups 2 and 4 ($p<0.05$) (Table 4). The effect of the trial diets on FCR was found to be significant only in the period of 4 to 6 weeks; the FCR of the group 8 (4.69) was found to be lower than that of the group 7 (5.92) in this period ($p<0.01$). The group with the lowest FCR in the period of 0 to 6 weeks was the group 8 (Table 4). The trial diets did not have a significant effect on the carcass weight of the quails. The carcass weights and standard errors of their for the groups 1, 2, 3, 4, 5, 6, 7 and 8 were respectively found to be 132.25±1.99, 130.85±1.97, 126.32±0.85, 126.12±3.28, 128.62±2.28, 125.87±0.99, 121.58±4.12 and 125.35±2.95 g.

Table 3. Effect of the particle size distribution of diet (uniformity) on average body weight and daily body weight gain of quails at different age periods (second experiment)

Treatments (diets)	Body Weight, g/quail			Body Weight Gain (g/quail - day)		
	Starter	3 rd week	6 th week	0-3 weeks of age	4-6 weeks of age	0-6 weeks of age
1	7.5	103.5±1.25^{a}	192.1±2.6^{A}	4.75±0.15^{a}	4.23±0.11^{AB}	4,40±0.07^{AB}
2	7.5	104.9±1.24^{a}	190.8±1.58^{AB}	4.68±0.06^{ab}	4.03±0.21^{AB}	4.30±0.17^{AB}
3	7.5	104.8±1.37^{a}	189.4±2.92^{AB}	4.63±0.06^{ab}	4.05±0.12^{AB}	4.35±0.18^{AB}
4	7.5	102.5±1.62^{a}	181.7±2.06^{ABC}	4.53±0.07^{ab}	3.75±0.15^{B}	4.18±0.13^{B}
5	7.5	94.6±3.15^{b}	188.1±2.04^{AB}	4.15±0.15^{c}	4.48±0.08^{A}	4.30±0.13^{AB}
6	7.5	103.0±1.6^{a}	178.5±1.99^{C}	4.55±0.06^{ab}	3.60±0.09^{B}	4.08±0.20^{B}
7	7.5	104.3±1.35^{a}	180.2±2.44^{BC}	4.58±0.06^{ab}	3.63±0.10^{B}	4.13±0.21^{B}
8	7.5	98.6±2.91^{ab}	192.5±3.66^{A}	4.35±0.15^{bc}	4.65±0.29^{A}	4.6±0.65^{A}

^{A,B,C}: Means with different superscripts in the same column are significantly different ($p<0.01$)

$^{a,\,b,\,c}$: Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 4. Effect of the particle size distribution of diet (uniformity) on daily average feed consumption and feed conversion ratio of quails at different age periods (second experiment)

Treatments (diets)	Feed Consumption g /quail - day			Feed Conversion Ratio (g feed/ g BWG)		
	0-3 weeks	4-6 weeks	0-6 weeks	0-3 weeks	4-6 weeks	0-6 weeks
1	10.33±2.29^{b}	21.78±0.56	16.08±0.42	2.18±0.08	5.16±0.14^{AB}	3.65±0.06
2	10.58±0.16^{ab}	22.55±0.30	16.55± 0.12	2.26±0.03	5.65±0.26^{AB}	3.86±0.08
3	11.10±0.23^{a}	22.23±0.27	16.68±0.22	2.40±0.06	5.50±0.10^{AB}	3.83±0.04
4	10.63±0.07^{ab}	21.05±0.55	15.58±0.37	2.45±0.06	4.69±0.22^{B}	3.62±0.06
5	10.15±0.12^{b}	20.95±0.62	15.88±0.30	2.35±0.02	5.66±0.35^{AB}	3.81±0.10
6	10.28±0.24^{b}	20.55±0.48	15.90±0.27	2.34±0.07	4.69±0.26^{B}	3.47±0.09
7	10.20±0.23^{b}	21,38±0.69	15.43±0.25	2.26±0.06	5.72±0.20^{AB}	3.79±0.10
8	10.15±0.09^{b}	21.60±0.53	15.78±0.44	2.23±0.07	5.92±0.33^{A}	3.83±0.16

^{A,B,C}:Means with different superscripts in the same column are significantly different ($p<0.01$)

$^{a,\,b,\,c}$: Means with different superscripts in the same column are significantly different ($p<0.05$)

In the analysis of the feeds, probably the easiest and most popular method is to sift the feeds through a set of screens with holes of differing diameters. As the particle size of the feed decreases, the number of particles in a unit volume of the feed and the surface area that digestive enzymes can affect and thus the activity of digestion are enhanced (Goodband et al., 2002). Also the feed materials used in the diet can be blended more easily and homogenously (Martin and Behnk, 1984). However, there are limits in practice to reducing the particle size of the feed and to the degree of grinding, because the poultry may have difficulty in consuming too huge-coarse and too fine particles. (Lott et al., 1992, Amerah et al., 2007).

In the present experiment, the degree of grinding changed the particle size distribution of the corn grain and of the trial diets and the FC of birds. In connection with the increase in the screen diameter of the mill, the proportion of the big particles did increase. Similar results were reported by other researchers (Reece et al.,1986a, b; Lott et al.,1992; Nir et al.,1990,1994a). The screen diameter of the mill, the speed of the hammers that came into contact with the material and the humidity level of the material are the most important factors in determining the fineness of the feed and mill efficiency and the rotation speeds of the hammers used in the feed industry are between 27 and 146 m/second (Melcoin and Monredan, 1987). The hammer mill used in this trial was one with a small capacity, and the rotation speeds of the hammers were 17.5 m/seconds. When the facts that the speeds of the hammer or roller mills used in the screens by the researchers mentioned above were much higher than that of the mill used in this trial and that as the speed of the hammer increased, the size of the particles decreased were taken into conceded, it can be said that the rate of big particles in the trial diets and in corn grain is relatively higher. In the

first trial, half or a little more of the daily FC was composed of finely ground feeds at almost every age. The cumulative FC of the quails for ten days was 116.95 grams (Table 2), the rate of the diets in total feed consumption that were prepared by grinding the feeds finely, moderately finely and coarsely (through screens of 3, 5 8 mm) were 50.4, 31.6 and 18 % respectively. The results of the this trial have clearly shown that young quails have the ability to distinguish the differences between particle sizes of the feeds, that they consume the feeds according to the particle sizes, that, although finely ground feeds are consumed more, the consumed amount of the big-size particles increases slightly with age and that the consumption of the very big particles is difficult in choice feeding. In this regard, Schiffman (1969) and Moran (1982) reported that the choice of particles is related to the sizes of beak. It is known that the senses of taste and smell are weak in the poultry and it is believed that the effect of the taste of the feed does not have an important effect on FC (Scott et al., 1982). Nir et al. (1990) reported that this deficiency is compensated by the mechanical receptors on the beak. In this way, the poultry can regulate their FC thanks to these receptors according to particle size, the hardness and softness of the feeds.
In the second trial in which the effect of the uniformity (particle distribution) and particle size of the starter and finisher diets was examined, the effects of the diets (group 1, 2 and 3) prepared from the feeds ground through screens of 3, 5 and 8 mm on the performance were the same. Also, performance values as high as or higher than the 3 groups were obtained through the diets prepared by using screens of 5 and 8 respectively at the starter and finisher periods. When this outcome is taken into account in terms of feed production, it shows that coarsely ground feeds with uniform particle sizes can also provide enough performance (Amerah et al., 2007) and it can be important in practice due to an increase in grinding speed with moderately finely or coarsely ground diets and to a decrease in energy expenditures. When the particle distribution of the feed was changed and the rate of the big particles in the diet was increased (groups 4 and 5) in the second trial, the performance values of 0-3 weeks decreased. This can be an indication that feed uniformity can significantly affect the performance in the early growth period. However, the performance improved as a result of an increase with age in the sizes of the beak and in consumption of big corn grains and therefore of energy. Another point that draws attention in this trial is that when the quails that had been fed, in the first three weeks of their growth, with a diet prepared through a screen of 3 mm were fed with the diet prepared through screens of 5 or 8 mm in the subsequent period, 6 th ve 7 th treatments that is when more coarsely ground feeds replaced finely ground feeds, is that there emerged a tendency of decrease in performance. This might be the result of the fact that it takes quails long to adapt to sudden particle changes in the feed. It was reported that, while the sudden shift from granule feed to pellet feed did not unfavorably affect FC and performance in broilers, a sudden shift in laying chickens from finely ground feed to coarse granule feed led to a decrease in FC. (Portella et al., 1988 a, b).

4. Conclusion

In conclusion, when given a choice, quails prefer finely ground diets more, and although the amount of the moderately finely or coarsely ground feed through screens 5 and 8 mm increases in consumption with an increase in age, they can sufficiently consume moderately finely or coarsely ground feeds and exhibit a satisfactory performance when selection of feed is not allowed.

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