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The Effects of Feed Restrictions in Rearing Period on Growing and Laying Performances of White and Brown Layer Hybrids in Different Adult Body Weights

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Abstract: This study was conducted to determine the effects of feed restriction in the rearing period on growth and laying performances of layers. Three egg type local commercial lines differing in body size (heavy brown, heavy medium brown and light white layer) were used in the experiment. Chicks were reared on litter pens for 17 weeks and than transferred to laying battery cages. All birds were fed a standard starter diet 1 to 8 weeks of age and 9 to 12 weeks of age were fed a growing diet and 13 to 17 weeks of age were fed a developer diet. Chicks were fed *ad libitum* in the first 8 weeks, than *ad libitum*, one day and two days feed restriction in a week applied to three each replicates of genotype. Birds were fed *ad libitum* a standard laying diets in the laying period. Two days feed restriction groups consumed less feed ($p<0.05$) in the rearing period, but there was no significant differences among the body weights and chick uniformity. Also, two days feed restricted groups had lower viability in all genotypes ($p<0.01$). The effect of feed restriction in the rearing period on egg production was found significant, but sexual maturity ages were delayed by the feed restriction ($p<001$). Feed consumption of laying period were found significantly different ($p<0.01$) and restricted groups consumed more feed than the control groups. Shell thickness is the only egg quality trait which was affected from feed restriction ($p<0.01$). Also, feather score was affected by feed restriction ($p<0.01$).

Key words: Feed restriction, uniformity, body weight, egg yield, egg quality, feather score

INTRODUCTION

Serious yield increase has been supplied in laying hens by the effects of genetic improvement, feed quality and management techniques. Management practices applied in the rearing period have important effects on body weight, uniformity, egg yield, egg quality, feather pecking, cannibalism and hatching properties. Light and feed restrictions are the most important factors to control the body weight before laying period, preventing fatness and regulating the sexual maturity age (Gous *et al.*, 2000; Rossi and Loerch, 2003; Leeson *et al.*, 2005). Also, breeding practices based on lighting and feed restriction may have different effects on broiler breeders, layer breeders in different body weights and other poultry species (Leeson *et al.*, 1997; Ali and Brenøe, 2002; Hangalapura *et al.*, 2005). Management programs of rearing period are applied in the direction of suggestions of each hybrid or line, the effects

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of the programs applied to the genotypes in different body weights can be change (Ali and Brenøe, 2002; Hangalapura *et al*., 2005). Reaching chickens to sexual maturity in a uniform body weight, decreasing fatness before laying, having heavier eggs by delaying sexual maturity age, decreasing feed consumption in rearing period, increasing hatching eggs and improving animal health is the main purposes of light and feed restriction (Fassbinder-Orth and Karasov, 2006). Many different feed restriction programs have been applied such as; limiting the quantity of feed (Tolkamp *et al*., 2005), high-fiber or low-energy in diets (Hester and Stevens, 1990); low dietary protein levels (Leeson *et al*., 1997; Ali and Brenøe, 2002), changing energy-protein ratios and diets deficient in selected essential amino acids (Scott *et al*., 1999), skip-a-day feeding (Vakili and Akbaroglu, 2006).

Feed restriction in the rearing period has important effects on the laying traits. Adult body weight decreases (Bruggeman *et al*., 2005), sexual maturity age delays and mortality decreases (Bruggeman *et al*., 2005) by the effect of feed restriction. Also, the number of the heavy follicles decreases at the onset of the laying (Hocking and Robertson, 2005). Besides, it is indicated that, in light layer genotypes, 15% feed restriction in the rearing period has positive effects on egg production traits (Ahsan-ul-haq *et al*., 1997). But, Kim *et al*. (2004) showed that feed restriction between 6-18 weeks positively affects egg production in brown layers, although it causes a little increase in feed consumption in the laying period and does not affect egg quality traits.

Feed restriction in the rearing period of genotypes with similar body weights is rather common both in broiler breeders and laying hens. In laying hens, there are limited studies which discuss the reactions of different layer genotypes with different body weights to the same feed restriction program in the rearing period. This study aims to evaluate the effects of same restriction program in genotypes with different body weights. The objectives of this experiment was to assess the effects of *ad libitum* (control) and 1 to 2 days feed restriction in a week in the rearing period, on growth performance, feed consumption, egg production, egg quality and plumage condition in three local egg type commercial hybrids which are in different body weights.

MATERIALS AND METHODS

The present study was carried out at the experimental farm of Agricultural Faculty, Ondokuz Mayis University, over the period from March 2006 to September 2007. The experiment was started with 1800 one-day-old female chicks produced by Ankara Poultry Research Institute (heavy-medium brown layer ATAK, 540 chicks; heavy brown layer ATAK-S, 540 chicks and white layer ATABEY, 540 chicks). Chicks were reared in a house with windows and ventilating aspirators additional to natural ventilating. Rearing house was divided to 27 pens covered with wood shaving litter in dimensions of 3.5×3.5 (m) floor area and each pen has 3 round feeders and 2 round drinkers. Sixty chicks of each genotype were randomly allocated to the pens in 9 replicate. Decreasing lighting program was used in the rearing period. Lighting was reduced to 20 h in the first week after 24 h lighting in first day. Natural lighting was applied at the end of second week and continued during the rearing period (about 11 h day^{-1}). Birds were vaccinated against Marek, New Castle, Gumboro and Infectious Bronchitis diseases. Beak trimming was enforced to birds at 2 weeks of age.

All birds were fed a standard starter corn and soya bean based diet 1 to 8 weeks of age (2900 Kcal kg^{-1}, 20% CP) and 9 to 12 weeks of age were fed a growing diet (2800 Kcal kg^{-1}, 16% CP) and 13 to 17 weeks of age were fed a developer diet (2700 Kcal kg^{-1}, 14% CP). Chicks were fed *ad libitum* in the first 8 weeks of age period. After 8 weeks of age, 3

replicates of each genotype fed *ad libitum* (Control, C), 3 replicates restricted 1 day a week (T1) and the other 3 replicates restricted 2 days (T2) in a week (Monday and Thursday). Water was allowed *ad libitum* for all treatment.

Pullets were carried out to laying house at the end of the 17th weeks of age. Traditional 3-tier battery cages were used in laying period and two birds were located to each cage (0.40×0.40 m floor area). Pullets from each genotype were allocated randomly to each cage block and cage floor. Feed consumptions of the laying period were determined in 24 subgroups which have 6 cages in a group for every genotype. In the laying period, birds were fed a standard laying diets (2800 Kcal kg^{-1} ME, 18 CP, 3.11 crude cellulose and 3.6% Ca in 18 to 40 weeks of age; 2650 Kcal kg^{-1} ME and 17 CP, 3.71 crude cellulose and 3.8% Ca in 41 to 72 weeks of age). Lighting was increased weekly from 18 weeks in addition to natural lighting and reached to 15 h in 26 weeks and this duration was pegged during laying period. Fluorescent light was used in lighting.

Body weights were recorded at 8 and 17 weeks of age. Effects of restricted feeding and genotypes were exposed in the traits of chick uniformity, feed consumption and mortality. Feed consumption, 50% production age, body weight at 50% production age and mortality were determined in the laying period. Egg production data were recorded daily for each cage and eggs were weighted once in every week. Also, egg quality traits such as; egg weight, specific gravity, shell breaking strength, yolk index, yolk colour and Haugh unit were determined in randomly chosen 30 eggs from each genotype between 28-38 weeks. Yolk colour was measured by the Roche colour scale and egg specific gravity was determined by plunging eggs into salt solutions of different concentrations. The other quality traits were evaluated by methods and equipments described by Stadelman (1995) and Sekeroğlu *et al.* (2008).

Feather scores were graded in all animals according to feather loss on the neck, chest, dorsal side, tail and wings at 72 weeks of age. Feathers were scored with assigned numbers as follows: (1) a few feathers and nakedness, (2) spilling more than half, (3) a few spilling and (4) protected plumage and the total of these grades as total feather score. Numerical expression of the protected feather can be change according to the researcher; some researchers define small numbers as protected feather (Ambrosen and Petersen, 1997; Sarica *et al.*, 2008). Body weights of the birds were assessed at 72 weeks of age which means the end of laying period.

Data were subjected to analyses of variance for a fully randomised design with factorial arrangement of treatments. Duncan Multiple Range test was utilized to separate these differences (SPSS 10.0 Version, 1999). Also, viability data were trans formed on Arcsine vx before analysis of variance was applied to the data.

RESULTS AND DISCUSSION

Rearing Period

The differences of feed consumptions among the genotypes were found significant in 8 weeks and 8-17 weeks of age restriction period for heavy, medium heavy and light genotypes ($p<0.05$) (Table 1). T2 caused less feed consumption than C and T1 groups in all genotypes ($p<0.05$). Two and one days feed restriction caused 500 and 310 g less feed consumption per chicks than the control group in the restriction period, respectively. These decreases occurred as 861 and 610 g in heavy genotype, 230 and 170 g in medium-heavy genotype and 390 and 160 g in light genotype. It is conceivable that main reason of the feed consumption differences between the genotypes in the feed restriction period can be based

Table 1: Changes in feed consumptions of genotype and treatment groups in rearing period

Genotype	Restriction (day/week)	Feed consumption (g day^{-1}) 0-8 weeks	9-17 weeks	0-17 weeks
ATAK	C	40.71	72.22	57.39
	T1	41.25	69.04	55.97
	T2	41.20	68.09	55.46
ATAK-S	C	50.71	84.92	68.91
	T1	47.26	77.94	63.78
	T2	46.43	75.23	61.68
ATABEY	C	35.36	60.48	48.66
	T1	34.64	58.57	47.31
	T2	34.82	54.76	45.38
Genotype				
ATAK		41.07b	69.84b	56.30b
ATAK-S		48.39a	79.37a	64.79a
ATABEY		35.00c	57.94c	47.06c
Feed restriction				
C		42.32	72.54a	58.32a
T1		41.25	68.57ab	55.71ab
T2		40.89	66.03b	54.12b
SE		00.13	00.15	00.18
Effects				
Genotype		**	**	**
Feed Restriction		NS	*	*
Genotype x Restriction		NS	NS	NS

*p<0.05; **p<0.01; NS: Insignificant differences. Value with different letter(s) are shown significant difference

on body weights of the hybrids. Thus, Ergül *et al*. (1992) defined differences in feed consumptions of brown and white egg type hybrids in the rearing period of 7-20 weeks. Same researchers defined that, more feed saving provided in white egg type light genotypes in feed restriction practices similar to our study.

In restricted feeding programs, there are differences in feed consumptions according to the feeding techniques in rearing period. Leeson *et al*. (1997) found no differences between *ad libitum* and protein level decreasing feeding in the rearing period in light layer genotypes. Although, Kim *et al*. (2004), showed that there were differences in feed consumptions between the feed restriction periods of 6-18 weeks and 12-18 weeks of brown layers. Performing practice in short times before laying period, no differences were consisted in feed consumptions of *ad libitum* and restricted feeding and did not provide the inevitable advantages in following production period (Sandoval and Gernat, 1996).

But particularly in breeders, programs applied both in early and late periods had more effects (Tolkamp *et al*., 2005).

There was no difference between the body weights of the C, T1 or T2 groups at 8 weeks when restriction started. But the differences between genotypes were significant ($p<0.01$). Coefficient of variation was found the lowest in heavy groups, medium in light groups and the highest in medium-heavy groups, but all values were in acceptable for the pullet uniformity (Table 2). Lower coefficient of variation values were assessed in T2 groups in 18 weeks. In other words, T2 had positive effects on pullet uniformity. In feed restriction period of 8-17 weeks, the differences among the body weights of genotypes were found significant ($p<0.01$), while the differences of feed restriction groups were insignificant. But, T1 and T2 groups had lower body weights than the C groups (Table 2). As in insignificant differences in feed consumptions, no differences were found in point of body weights in feed restriction period among the groups, but the differences among the genotypes were significant ($p<0.05$, Table 1). Coefficient of variation was found lower in pullet uniformity for heavy and medium heavy genotypes in C groups. In 17 weeks body weights, there were differences among the

Table 2: Changes in body weights of genotype and treatment groups in rearing period

		Body weights (8 weeks of age, g)			Body weights (17 weeks of age, g)		
Genotype	Restriction		CV (%)	Confidence intervals		CV (%)	Confidence intervals
ATAK	C	670.19	13.51	657-682	1428.75	7.10	1412-1444
	T1	670.96	13.78	658-683	1410.34	8.39	1394-1426
	T2	639.58	15.17	626-652	1404.81	7.66	1388-1421
ATAK-S	C	749.82	9.92	737-762	1603.53	6.65	1587-1619
	T1	747.59	10.40	735-759	1595.76	7.05	1580-1611
	T2	749.45	11.21	737-761	1594.99	7.30	1579-1610
ATABEY	C	535.10	13.45	521-549	1169.84	6.08	1152-1187
	T1	532.93	13.82	519-546	1154.17	7.27	1136-1171
	T2	534.21	12.83	519-549	1147.24	9.30	1128-1166
Genotype							
ATAK		660.75b	14.26	652-887	1414.87b	7.75	1405-1423
ATAK-S		748.95a	10.50	741-756	1598.10a	6.99	1589-1607
ATABEY		534.08c	13.36	525-542	1157.57c	7.58	1146-1167
Feed restriction							
C		660.99	12.71	644-659	1419.21	7.53	1391-1410
T1		659.82	12.73	643-657	1405.46	7.60	1377-1396
T2		654.65	13.02	633-648	1411.20	7.69	1372-1392
SE		2.23			2.83		
Effects							
Genotype		**			**		
Restriction		NS			NS		
Genotype x Restriction		NS			NS		

**p<0.01, NS: Insignificant differences. Value with different letter(s) are shown significant difference, CV: Coefficient of variance

genotypes but not in feed restriction groups, this situation was based on the body weight differences of the genotypes. Fassbinder-Orth and Karasov (2006), showed that, feed restriction practices cause a decrease in body weight in Leghorn layers; Bruggeman *et al.* (1999), defined that the effect of the difference in body weights can change according to chicken age.

Viability values of genotypes in heavy, medium-heavy and light genotypes were 99.81, 98.86 and 96.51% at first 8 weeks, respectively ($p<0.05$). In the feed restriction period, viabilities were obtained in same order ($p<0.05$) and heavy hybrids had the highest viability values.

Also, in this period, there were not significant differences among the restriction groups. T2 groups had lower viability in all genotypes (Table 3).

Laying Period

Sexual maturity age is the most distinct trait which is affected by feed restriction and genotype. In this study, age at 50% egg production was determined as the indicator of sexual maturity age and body weights at this age were considered as the sexual maturity weights. The heavy genotype (ATAK-S) which had the heaviest body weight at 17th week in the growing period reached the sexual maturity first, medium heavy (ATAK) and light (ATABEY) genotypes followed this genotype ($p<0.01$). Also, differences among the live weights of all genotypes were significant in this period ($p<0.01$; Table 4). In addition, feed restriction programmes have affect on sexual maturity age and most studies, feed restriction in the rearing period does not affect viability negative (Tolkamp *et al.*, 2005). Otherwise, feed restriction practices have different effects on the traits about weight, T2 groups reached sexual maturity later than the other groups. Body weights of this group were also highest (Table 4). Gous *et al.* (2000), determined that sexual maturity weight was affected by both

Table 3: Changes in viabilities of genotypes and treatment groups in rearing period

		Viability (%)		
Genotype	Restriction	0-8 weeks of age	9-17 weeks of age	0-17 weeks of age
ATAK	C	99.41	98.83	98.24
	T1	99.41	98.85	98.24
	T2	97.77	97.00	94.77
ATAK-S	C	100.00	100.00	100.00
	T1	99.71	99.71	99.42
	T2	99.71	99.71	99.42
ATABEY	C	95.91	93.33	93.43
	T1	95.91	95.33	93.43
	T2	97.10	95.33	92.91
Genotype				
ATAK		98.86a	98.22a	97.08b
ATAK-S		99.81a	99.81a	99.61a
ATABEY		96.31b	94.66b	92.59c
Feed restriction				
C		98.44	97.38	97.22a
T1		98.34	97.96	97.03a
T2		98.19	97.35	95.70b
SE		0.40	0.49	0.88
Effects				
Genotype		**	**	**
Restriction		NS	NS	*
Genotype x Restriction		NS	NS	NS

**p<0.01; *p<0.05; NS: Insignificant differences. Value with different letter(s) are shown significant difference

Table 4: Changes in sexual maturity age (50% production age) and weight of genotype and treatment groups

		50% Production age (day)			Live weight of 50% production age (g)		
Genotype	Restriction		CV (%)	Confidence intervals		CV (%)	Confidence intervals
ATAK	C	143.58	1.41	141-145	1779.74	7.66	1757-1801
	T1	145.50	2.02	143-147	1719.05	8.83	1697-1741
	T2	147.58	3.42	145-149	1758.63	9.10	1735-1781
ATAK-S	C	139.75	0.81	137-141	1938.05	8.37	1916-1959
	T1	141.00	1.13	139-142	1916.46	7.88	1894-1938
	T2	142.83	2.49	140-144	1941.74	8.18	1920-1963
ATABEY	C	145.33	2.79	143-147	1532.66	6.56	1508-1557
	T1	147.67	2.52	145-149	1501.07	8.34	1476-1525
	T2	149.25	2.82	147-151	1509.26	8.90	1482-1535
Genotype							
ATAK		145.56b	2.64	144-146	1752.27b	8.42	1739-1765
ATAK-S		141.19c	1.85	140-142	1932.05a	9.34	1919-1944
ATABEY		147.42a	2.82	146-148	1514.58c	10.84	1499-1528
Feed Restriction							
C		142.89c	2.46	141-143	1767.51a	12.05	1737-1763
T1		144.72b	2.74	143-145	1729.39b	12.72	1699-1725
T2		146.56a	3.39	145-147	1764.43a	13.01	1722-1750
Sx		0.32			3.92		
Effects							
Genotype		**			**		
Restriction		**			**		
Genotype x Restriction		NS			NS		

**p<0.01; NS: Insignificant differences. Value with different letter(s) are shown significant difference, C.V: Coefficient of variance

light and feed restriction when two of them applied together and also showed that restriction programs increase the body weight in this period. Vakili and Akbarogli (2006) found the lowest body weight by skip a day restriction in four different restriction practices. Chicken uniformity decreased in parallel with the frequency of restriction in a week (8.61 and 12.09%).

In present study, coefficient of variation values of body weights were found rather lower in all genotypes; but values partially increased by the comparison of feed restriction groups (Table 2). Body weight differences which cause difference in genotypes have effect on this. Sandoval and Gernat (1996) defined that, feed restriction before laying period did not affect uniformity in pullets' body weights, as in this study. Leeson *et al*. (1997) showed that feed restriction significantly affect 22 weeks body weight, in the experiment done with commercial layers in different body weights and also did not assess significant differences between genotypes. Despite of finding significant differences between genotypes in our experiment, insignificant differences of feed restriction programs are conflicted with some of the results above.

Egg production among the genotypes was found significantly and the heavy genotype had the highest production ($p<0.05$). Heavy group had also the highest egg weight ($p<0.05$). Egg production and egg weight were not significantly affected by the feed restriction in the rearing period. However, control group had higher egg weights in all genotypes, same as the sexual maturity weights (Table 5).

The differences of viability values among the restriction groups were not found significant, but in all genotypes, C and T2 groups had higher viability. The viabilities of the genotypes in the laying period were 95.24, 89.37 and 94.13% in order in heavy, medium-heavy and light genotypes ($p<0.05$).

Highest viability and lowest pecking tendency occurred in heaviest genotype. In contrast with heavy medium genotype, higher mortality and pecking tendency was observed in light genotype. In immunity according to the genetic structures of animals (Hangalapura *et al*., 2005), hence, differences in viability is indispensable. But there are studies which found no effects of feed restriction on the parameters about immunity in light genotypes (Fassbinder-Orth and Karasov, 2006).

Hens which were fed *ad libitum* reach sexual maturity earlier than feed restricted hens depending on the time of lighting regimen before laying period (Renema *et al*., 1999). In this

Table 5: Changes in egg production, egg weight and mortality of genotype and treatment groups

Genotype	Feed restriction	Hen/day egg production	Hen/house egg production	Egg weight (g)	Mortality (17-72 weeks, %)
ATAK	C	276.84	275.34	62.51	11.66
	T1	273.98	272.55	61.83	10.22
	T2	273.68	272.45	61.95	10.00
ATAK-S	C	282.43	282.09	63.35	5.25
	T1	284.12	283.88	63.07	4.57
	T2	283.48	281.67	62.56	4.46
ATABEY	C	283.68	281.87	57.82	6.02
	T1	279.65	277.67	57.23	5.85
	T2	277.34	277.19	57.31	5.74
Genotype					
ATAK		274.74b	273.36b	62.10b	10.63a
ATAK-S		283.39 a	282.59a	62.99a	4.76c
ATABEY		279.99 ab	278.70ab	57.46c	5.87b
Feed Restriction					
C		280.61	279.55	61.23	7.64
T1		279.38	278.33	60.71	6.88
T2		278.51	277.30	60.61	6.73
Sx		1.44	1.43	0.15	0.37
Effects					
Genotype		*	**	**	**
Restriction		NS	NS	NS	NS
Genotype x Restriction		NS	NS	NS	NS

*p<0.05, **p<0.01; NS: Insignificant differences. Value with different letter(s) are shown significant difference

study, feed restrictions significantly affected sexual maturity age, C groups reached sexual maturity earlier than the other groups ($p<0.01$). Also, heavy genotype reached sexual maturity earliest and light genotype reached last ($p<0.01$, Table 4). The age at the onset of the light stimulation, level of feed restriction and genotype can be effective on delaying sexual maturity (Robinson *et al*., 1996). Partially heavy genotypes start laying earlier despite feed restriction and have partially more body fat (Summers and Leeson, 1983), sexual maturity age can be controlled by body weight and hormonal balance (Leeson *et al*., 1988). But, sexual maturity age and body weight can be changed in light layers by changing feeding, depending on feeding time of lighting duration in the rearing period (Leeson *et al*., 2005). Gous *et al.* (2000) inform that, sexual maturity age can be delayed by feed restriction in medium-heavy layers and body weight increases in parallel with this. Robinson and Sheridan (1982) showed that feed restriction programs delay sexual maturity age 8-12 days according to *ad libitum* feeding in White Leghorns and its crossbreeds selected with Australorp. Similarly, Ahsan-ul-haq *et al.* (1997) informed that feed restriction delays sexual maturity age; Sandoval and Gernat (1996) found 3-5 days delaying in sexual maturity age and partially an increase in body weight.

The chicks which were fed *ad libitum* or a little restricted can reach sexual maturity earlier but these chicks do not always have higher egg productions (Yu *et al*., 1992). Similar egg production values in hen-day and hen-housed assessments and egg weight for control and restricted groups in this study confirm these results. Enough studies about laying hens inform that feed restriction in the rearing period increases egg production and egg mass (Ahsan-ul- haq *et al*., 1997; Kim *et al*., 2004), also some studies inform no effect (Sandoval and Gernat, 1996; Leeson *et al*., 2005) or decreasing effect (Koelkebeck *et al*., 1993). The positive effects of feed restriction on egg production and egg mass occur distinctive in heavy layers and broiler breeders (Robinson and Sheridan, 1982; Renema *et al*., 2004; Tolkamp *et al*., 2005).

The effects of the restricted feeding on feed consumptions of 18-40, 41-72 and 18-72 weeks of age were found significant. Also, the differences among the genotypes were found significant in all periods. The heavy genotype consumed most feed, medium-heavy and light genotypes followed this genotype, respectively ($p<0.01$). The difference of feed consumptions is the expected result of these groups which have different body weight from the rearing period on. However, two days feed restricted groups had the highest feed consumption in consideration of 18-72 weeks feed consumptions (Table 6). The differences of feed conversion ratios among the genotypes and feeding treatments were found significant ($p<0.05$). C groups had better FCR in all genotypes, but there were no difference among the restriction groups.

Increase in the body weights of the hens can be seen in the laying period after changing feeding form and *ad libitum* feeding in the laying period. In present study, T2 groups consumed more feed. Also, significant differences occurred in the feed consumptions of the genotypes, as an expected result (Renema *et al*., 2004). Some studies confirm that; feed restriction at the onset of the laying has no effect on feed consumption (Sandoval and Gernat, 1996); also, feed consumption of the hens does not change in the laying period of which were reared with light restriction (Leeson *et al*., 1988), but feed consumption can increase at the onset of the laying period according to the level of feed restriction (Kim *et al*., 2004).

The chickens which fed restricted in the rearing period have higher viability and this is more distinctive in heavy layers and broiler parents (Renema *at al*., 2004). Similar results were found in this study; restricted feeding showed same effect in all genotypes. Kim *et al.* (2004),

Table 6: Effects of feed restriction programs and genotypes on laying period feed consumption and FCR

Genotype	Feed restriction	Feed consumption (g day^{-1})			FCR	
		18-40 weeks	41-72 weeks	18-72 weeks	Hen/day	Hen/house
ATAK	C	100.32	118.79	109.55	2.40	2.40
	T1	101.57	121.62	111.60	2.46	2.47
	T2	104.13	125.26	114.70	2.46	2.46
ATAK-S	C	113.03	131.63	122.33	2.50	2.51
	T1	114.19	136.13	125.16	2.50	2.52
	T2	114.71	135.99	125.36	2.62	2.62
ATABEY	C	92.59	109.75	101.17	2.26	2.26
	T1	95.42	115.25	105.34	2.38	2.39
	T2	94.52	113.99	104.25	2.30	2.31
Genotype						
ATAK		102.01b	121.88b	111.95b	2.44b	2.45b
ATAK-S		113.97a	134.58a	124.28a	2.54a	2.56a
ATABEY		94.18c	112.99c	103.59c	2.31c	2.32c
Feed restriction						
C		101.98b	120.06b	111.02b	2.38b	2.39b
T1		103.73ab	124.33a	114.03a	2.45ab	2.46a
T2		104.46a	125.08a	114.77a	2.46a	2.47a
Sx		0.36	0.54	0.38	0.01	0.02
Effects						
Genotype		**	**	**	**	**
Restriction		*	**	**	*	*
Genotype x restriction		NS	NS	NS	NS	NS

FCR: Feed conversion ratio; *p<0.05; **p<0.01; NS: Insignificant differences. Value with different letter(s) are shown significant difference

defined that feed restriction in the early ages of the rearing period affected feed efficiency positive in the laying period in brown layers. But most of the studies showed that feed restriction in the rearing period does not affect feed consumption and feed conversion ratios in the laying period, the differences depend on genotype (Sandoval and Gernat, 1996; Leeson *et al*., 1997; Leeson *et al*., 2005, Renema *et al*., 2004).

Increase in the live weights of the hens in the laying period, had affect in the feed consumptions of this period, in feed restricted groups. This increase in the body weight can be explained as a compensation of marginal weights in the rearing period.

In this study one or two days feed restriction in a week caused partially increase in the viability in accordance with control group. Robinson and Sheridan (1982) showed that restricted feeding has positive effect on viability, but Sandoval and Gernat (1996) found no effect on viability.

The differences among the genotypes were found significant in egg quality traits such as; shell breaking strength, shell thickness, albumen height, Haugh Unit score, albumen index and yolk colour ($p<0.01$). But there were no significant differences in specific gravity. Also, the differences among the feed restriction groups were significantly found only in shell thickness and all of these traits had higher values in C groups. In addition, genotype x restriction interaction effects were significantly found on the Haugh Unit score and albumen index ($p<0.05$, Table 7). Similar results were executed by Kim *et al.* (2004) and Tolkamp *et al.* (2005), particularly, confirmed that, feed restriction in the rearing period had effect on egg weight at the onset of laying and some quality traits.

The differences among the body weights of the genotypes at the end of the laying period were found significant as in the rearing and laying period ($p<0.01$). The differences were found significant among the restriction groups, hens of the T2 groups had higher weights, except light genotype (Table 8).

Table 7: Effects of feed restriction programs and genotypes on external egg quality traits

Genotype	Feed restriction	Specific gravity (g cm^{-3})	Shell breaking strenght ($kgcm^{-1}$)	Shell thickness (mm)	Albumen height (mm)	Haugh unit Score	Albumen index (%)	Haugh colour (Roch)
ATAK	C	1.086	3.34	0.358	7.04	81.95	8.82	10.81
	T1	1.159	3.27	0.356	8.63	81.60	8.73	10.78
	T2	1.086	3.25	0.351	7.16	83.50	9.21	11.06
	C	1.081	2.82	0.333	7.58	85.73	9.83	11.63
ATAK-S	T1	1.081	2.80	0.332	7.55	85.62	9.60	11.60
	T2	1.080	2.57	0.326	7.16	83.62	8.94	11.58
	C	1.086	2.76	0.345	8.22	91.17	11.36	10.75
ATABEY	T1	1.085	2.70	0.344	8.20	91.14	11.20	10.69
	T2	1.084	2.66	0.343	7.88	89.50	10.86	10.59
Genotype								
ATAK		1.110	3.28a	0.354a	7.02c	82.35c	8.92c	10.86b
ATAK-S		1.080	2.73b	0.331c	7.43b	84.99b	9.46b	11.60a
ATABEY		1.085	2.70b	0.344b	8.10a	90.60a	11.14a	10.67b
Feed restriction								
C		1.085	2.97a	0.345a	7.61	86.27	9.99	11.06
T1		1.108	2.93ab	0.344ab	7.54	86.09	9.84	11.03
T2		1.083	2.83b	0.340b	7.40	85.55	9.67	11.08
Sx		0.01	0.03	0.001	0.04	0.24	0.07	0.05
Effects								
Genotype		NS	**	**	**	**	**	**
Restriction		NS	NS	*	NS	NS	NS	NS
Genotype x Restriction		NS	NS	NS	NS	*	*	NS

*p<0.05; **p<0.01; NS: Insignificant differences. Value with different letter(s) are shown significant difference

Table 8: Effects of feed restriction programs and genotypes on body weights and feathers scores in 72 weeks of age

			Feather score					
Genotype	Feed restriction	Body weight (g)	Neck	Chest	Dorsal	Wings	Tail	Total
	C	2047.91	2.08	2.78	3.44	3.53	3.43	15.26
ATAK	T1	2054.02	2.12	2.88	3.57	3.66	3.57	15.80
	T2	2121.83	2.24	3.00	3.63	3.73	3.63	16.23
	C	2460.84	2.60	3.27	3.84	3.98	3.96	17.66
ATAK-S	T1	2491.44	2.65	3.35	3.98	4.00	3.99	17.96
	T2	2540.72	2.87	3.39	4.00	4.00	3.99	18.26
	C	1750.31	3.07	3.73	3.85	3.72	3.51	17.88
ATABEY	T1	1782.90	3.13	3.88	3.96	3.81	3.58	18.36
	T2	1780.05	3.25	3.89	3.99	3.88	3.85	18.85
Genotype								
ATAK		2072.70b	2.15c	2.88c	3.54b	3.64c	3.54c	15.74c
ATAK-S		2496.97a	2.71b	3.33b	3.94a	3.99a	3.98a	17.96b
ATABEY		1770.90c	3.15a	3.83a	3.93a	3.88b	3.64b	18.35a
Feed restriction								
C		2131.35b	2.55b	3.22b	3.70b	3.76b	3.66c	16.89c
T1		2153.98b	2.59b	3.32a	3.83a	3.83a	3.74b	17.32b
T2		2199.59a	2.76a	3.39a	3.87a	3.88a	3.83a	17.74a
Sx		7.92	0.02	0.02	0.01	0.01	0.01	0.06
Effects								
Genotype		**	**	**	**	**	**	**
Restriction		**	**	**	**	**	**	**
Genotype x Restriction		NS	NS	NS	NS	NS	**	NS

**p<0.01; NS: Insignificant differences. Value with different letter(s) are shown significant difference

The differences of the feather scores graded from different body parts of the hens and the sum of these scores were found significant among the genotypes ($p<0.01$). Light genotype had the highest score in all body parts besides tail and wings. The effect of feed restriction on the feather score was found significant ($p<0.01$) and T2 groups had higher scores. Feather loss which occurs after rearing period in general, effects egg production, feed consumption and pecking tendency (Ramadan and Von Borell, 2008). Also, there can be

differences in laying hens depending on age and more feather loss can be occur in elder hens (Huber-Eicher and Sebö, 2001).

CONCLUSION

As a result; restricted feeding and total feed consumption in the rearing period, body weights and viabilities are found different among the genotypes in different body weights ($p<0.05$). Feed restrictions had effect on feed consumption in the rearing period, but had no effect on body weight at 17 weeks of age. Body weight uniformity at the age of 17 weeks was increased by feed restriction and viability was found lower in restricted groups. Also, feed restriction in the rearing period affected some laying traits. T1 or T2 groups had increased viability, body weights, shell thickness and plumage condition on some body parts in the laying period. In contrast, feed consumptions and FCR values were negatively affected by feed restrictions.

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