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Research Article

Effects of Different Force Molting Methods on Post Molt Performance, Egg Quality Traits and Heterophil-Lymphocyte Ratio in Denizli Chickens

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A B S T R A C T

Background/Aim: Denizli chicken is an indigenous chicken breed of Turkey and there is limited information related to the effects of different force molting methods on production performance, egg quality traits and stress level of this breed. The aim of this study was to determine the effects of different force molting methods on post-molt performance, egg quality traits and heterophil-lymphocyte ratio in Denizli chickens.

Material and Methods: A total of 144 Denizli chickens, 58 weeks old of age, were used as the material in this study. Hens were randomly divided into three groups according to the force molting program. In the first group, feed was withdrawn for 10 days, and hens were fed with cracked corn diet *ad libitum* from d 11 to 28 (California method). The hens in the second group were fed with feed supplemented 15,000 mg zinc oxide to kg ration for 10 d and they were provided 100 g of a layer diet from d 11 to 28 (Zn method). Hens in third group were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were provided 100 g of a layer diet from d 11 to 28 (Alfalfa method). All groups were fed with standard layer diet *ad libitum* from 29 days of age to the end of the study.

Results and Conclusion: Egg weight and heterophil-lymphocyte ratio in post-molt period were higher in California group than those in the other groups. There were no statistically significant different among molting groups in terms of mortality rate, egg production, egg quality, feed intake and feed conversion ratio. In conclusion, Zn and alfalfa methods was more suitable than to California method which caused to a high level stress in Denizli chickens.

Keywords: Denizli chicken, molting, performance, egg quality traits, heterophil-lymphocyte ratio.

Denizli Tavuklarında Farklı Tüy Dökümü Yöntemlerinin Tüy Dökümü Sonrası Performans, Yumurta Kalite Özellikleri ve Heterofil-Lenfosit Oranı Üzerine Etkileri

Ö Z E T

Özbilgi/Amaç: Denizli tavuğu, Türkiye'nin yerli bir ırkıdır ve farklı tüy döküm yöntemlerinin bu ırkın verim performansı, yumurta kalite özellikleri ve stres düzeyi üzerine etkileri ile ilgili sınırlı sayıda çalışma bulunmaktadır. Bu araştırmanın amacı, Denizli tavuklarında farklı tüy dökümü yöntemlerinin tüy dökümü sonrası performans, yumurta kalite özellikleri ve heterofil-lenfosit oranı üzerine etkilerinin belirlenmesidir.

Materyal ve Metot: Araştırma materyali olarak 58 haftalık yaştaki toplam 144 adet Denizli tavuğu kullanılmıştır. Tavuklar, tüy dökümü metoduna göre tesadüfi olarak üç gruba ayrılmıştır. Birici gruptaki tavuklara 10 gün yem verilmemiş ve 11.-28. günler arasında *ad libitum* olarak kırılmış mısır verilmiştir (California metodu). İkinci gruptaki tavuklara 10 gün süreyle 15 mg/kg Zn içeren ticari yumurtacı tavuk yemi, 11.-28. günler arasında günde tavuk başına 100 g ticari yumurtacı tavuk yemi verilmiştir (Zn metodu). Üçüncü gruptaki tavuklara 10 gün *ad libitum* yonca unu, 11.-28. günler arasında günde tavuk başına 100 g ticari yumurtacı tavuk yemi verilmiştir (yonca metodu). Tüm gruplardaki tavuklar, 29. günden deneme sonuna kadar ticari yumurtacı tavuk yemi ile *ad libitum* olarak beslenmişlerdir.

Bulgular ve Sonuç: Çalışmada, tüy dökümü sonrası dönemde Kaliforniya grubundaki tavukların, diğer gruptakilere göre önemli düzeyde daha yüksek yumurta ağırlığına ve heterofil-lenfosit oranına sahip olduğu belirlenmiştir. Yumurta verimi, yumurta kalite özellikleri, yem tüketimi ve yemden yararlanma oranı bakımından ise gruplar arasında istatistiksel olarak önem taşıyan bir farklılık bulunmamıştır. Bu araştırma sonucunda, Denizli tavuklarında, rasyona çinko ilave edilerek ve yonca unu kullanılarak yapılan tüy dökümü yöntemlerinin, hayvanlar üzerinde yüksek düzeyde stres yaratan Kaliforniya metoduna göre daha uygun olduğu sonucuna varılmıştır.

Anahtar Kelimler: Denizli tavuğu, tüy dökümü, performans, yumurta kalite özellikleri, heterofil lenfosit oranı

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Introduction

Force molting is a practice that has been used by the commercial egg industry to rejuvenate flocks for extending laying cycle and restoration of egg quality. The main objective of force molting is to cease egg production of hens and that they enter a non-reproductive state (Webster 2003, Aygun 2013). Induced molting can result in increased egg production and egg quality. It reduces mortality, production cost and investments in new batches and hatchers (Burton and Burton 1980, Reddy et al. 2008). Molting in laying hens can be induced by using photoperiod, feed withdrawal and mineral supplementation. The most commonly practiced method of molt induction is withdrawal of feed for several days. This method efficiently induces a molt because it is management-friendly and economically advantageous and results in satisfactory post molt performance for the commercial layer industry (Brake, 1993). However, increased public awareness of the animal stress associated with feed withdrawal has led researchers to investigate alternative molting processes (Brake 1993, Park et al. 2004). These alternative methods include high dietary zinc supplementation, diets with low sodium contents, wheat middling, barley, alfalfa and oat (Berry and Brake 1985, Alodan and Mashaly 1999, Bar et al. 2003, Donalson et al. 2005, Aygun 2013).

A number of studies have been conducted to compare to feed withdrawal and alternative molting methods in commercial laying hens. However, the knowledge related to the effects of different molting methods on post molt performance, egg quality and stress situation in Denizli chickens is limited. The aim of this study was to determine the effects of different molting programs on post molt performance, egg quality and heterophil-lymphocyte ratio in Denizli chickens.

Material and Methods

Animals and Molting Procedure

A total of 144 Denizli chickens, 58 weeks old, were used as the material in this study. Three hens were placed per cage (656 cm^2/hen). The experimental period was 20 week, consisting of 4 week acclimation period, 4 week molt period, followed by 12 week of production. All hens were provided the layer diet (2650 kcal ME/kg, 15% crude protein) *ad libitum* and received 16 h of light/day during the acclimation period. After the acclimation, the hens were divided into 3 groups with 4 replicates and they were allowed *ad libitum* access to water and respective diets during the molting period. Three molting methods were used in this study as California, high dietary Zn and 100 % alfalfa meal. The hens in the first group were subjected to California method. In this method hens were fasted during the first 10 days. They were given a cracked corn diet *ad libitum* from 11 to 28 days of age. Hens in second group were fed with layer diet containing 15,000 mg/kg of Zn for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age (Zn group). Hens in third group were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age (alfalfa group). Hens were placed on an artificial lighting program of 8 h light/16 h dark during the molt period. At the end of molting, all hens were fed with a layer diet *ad libitum* until the end of experiment and light was changed to 16 h light/8 h dark during this time.

Performance Parameters

Individual body weights of hens in each group were measured at the beginning of the experiment, at 10 and 28 days following the start of the molt programs and body weight loss was measured during the molting period. Prior to molting period, egg production, egg weight, feed intake and FCR (feed conversion ratio) were measured to determine their initial values. Mortality was recorded daily and eggs were collected daily. Egg production was calculated on a hen-day basis. All eggs collected daily were weighted to determine egg weight. Feed intake was measured weekly and FCR was calculated as the ratio of feed intake to the egg weight in pre-molt and post-molt periods.

Egg Quality Measurements

Twenty eggs from each group were randomly collected to determine egg quality traits prior to the molting and on the 1^{th}, 5^{th} and 10^{th}weeks of post molt period. Egg quality analyses were conducted within 24 h of collection. Egg weight, shape index, shell thickness, yolk color, yolk height and width, albumin height, width and length were measured as egg quality characteristics. After eggs were weighed, the length and width of eggs were measured with a micrometer caliper. Egg shape index was calculated using the formula: egg shape index (%) = 100 x (egg width/egg length). After all eggs were broken on to a flat surface, the heights of yolk and albumen were measured with a tripod micrometer (Mitutoyo, code no: 2052SB-19 Dial İndicator), and expressed in mm. The length and width of albumen and yolk diameter were measured by digital caliper to the nearest 0.01 mm (Mitutoyo, code no: 500-181 U, absolute digimatic caliper). Yolk color was determined using Roche color fan. Egg shells were weighed by using an electronic scale with an accuracy of 0.01 g to measure shell weight after albumen was removed. Shell thickness was measured at three areas (broad end, middle portion and narrow end of the shell) by using a micrometer, after inner and outer shell membranes were removed manually. The albumen and yolk index was determined as the ratio of the yolk and albumen height to the yolk and albumen width, respectively. Haugh unit was calculated from the records of albumen height and egg weight using the following formula (Anonymous 2003):

$$HU = 100. \text{Log} (H-1.7W^{0.37} + 7.6)$$

where,

HU = Haugh unit

H = Albumen height (mm)

W = Egg weight (g).

Heterophil-Lymphocyte Ratio

Blood samples were taken from the brachial vein of 10 hens in each group at the beginning of the experiment, and at 10 and 28 d following the start of the molting programs. To obtain the H/L ratio, blood samples were smeared on a glass slide. After drying, the smears were stained with May-Grünwald-Giemsa stain. One hundred leucocytes were counted on each slide, using a light microscope. The H/L ratio was calculated by dividing the number of heterophils by the number of lymphocytes (Gross and Siegel, 1983).

Statistical analysis

Chi square test was performed for the statistical analysis of mortality rate (Steel and Torrie 1980). The other performance parameters and egg quality characteristics were analyzed by one-way analysis of variance using SPSS 13.0 packed program

(SPSS, 2004). Significant differences among treatment means were determined using Duncan's multiple range test (Duncan, 1955).

Results

In the present study, no mortality in groups was observed during pre-molt period. The mortality rates recorded in the periods from 1 to 10 days and from 10 to 28 days of molting for California, Zn and alfalfa groups were 4.17%, 2.08%, 6.25% and 0.0%, 6.38%, 2,22%, respectively. Mortality rates for the same groups were 6.52, 4.55 and 2.27% during the post-molting period. The differences between groups in terms of this trait were not statistically significant.

The effect of different force molting programs on body weights during pre-molt period and at different times of molting period and body weight loss during molting period in Denizli chickens are presented in Table 1. There were no significant differences among groups in terms body weights during pre-molt period and at 10 days of molting period. However, the hens in California group displayed significantly higher weight loss than those in the other groups during molting period and thus, they had significantly lower body weight at the end of molting period (P<0.001).

There were no significantly differences among molting groups in terms of hen-day egg production, feed intake and feed conversion ratio during pre-molting and post-molting periods (Figure 1, Table 2). However, egg weight of hens in the California group during post-molting period was significantly higher than those in the other groups (P<0.001) (Table 3).

The effects of different molting programs on internal and external egg quality traits during pre-molt and post-molt periods are summarized in Table 4 and Table 5. No significant difference was found among three molting groups for egg quality traits except for albumen length during post-molt period. The mean value of this trait was significantly lower in hens in California group than those in Zn and alfalfa groups.

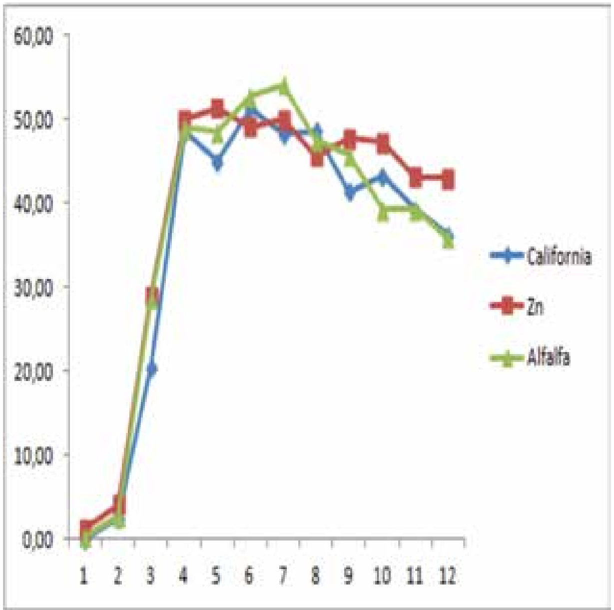

Figure 1. Weekly egg production in post-molt period.
Şekil 1. Tüy dökümü sonrası dönemdeki haftalık yumurta verimi.

Table 1. The effects of different molting programs on body weights and body weight loss during pre-molting and molting periods in Denizli chickens[1] (g)

Tablo1. Denizli tavuklarında farklı tüy dökümü yöntemlerinin tüy dökümü öncesi ve tüy dökümü dönemlerindeki canlı ağırlık ve canlı ağırlık kaybı üzerine etkileri

Traits	Treatments[2]						P
	California		Zn		Alfalfa meal		
	n	Mean ± SEM	n	Mean ± SEM	n	Mean ± SEM	
Body weight during pre-molting period (g)	48	2559.19 ± 60.40	48	2436.71 ± 47.28	48	2563.94 ± 48.09	0.153
Body weight at 10 days of molting period (g)	46	2051.83 ± 58.87	47	2064.22 ± 40.24	45	2094.20 ± 44.32	0.819
Body weight at 28 days of molting period (g)	46	1966.1^{b} ± 61.87	44	2151.9^{a} ± 43.58	44	2264.4^{a} ± 46.20	<0.001
Body weight loss (%)							
1 to 10 days	46	19.38 ± 1.79	44	15.21 ± 1.30	44	18.38 ± 1.32	0.125
1 to 28 days	46	22.21^{a} ± 2.58	44	10.58^{b} ± 1.86	44	11.28^{b} ± 2.07	<0.001

[1]Results are expressed as mean ± standard error. [a, b] Mean values within a row with no common superscript differ significantly (P<0.001).

[2]California method = Hens were fasted during the first 10 days and they were given a cracked corn diet ad libitum from 11 to 28 days of age. Zn = High dietary Zn method (Hens were fed with layer diet containing 15,000 mg/kg of Zn as ZnO for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age. Alfalfa = Whole alfalfa meal diet (Hens were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age.

Table 2. The effects of different molting methods on hen-day egg production, feed intake and feed conversion ratio during pre-molt and post-molt periods[1]

Tablo 2. Farklı tüy dökümü yöntemlerinin tüy dökümü öncesi ve tüy dökümü sonrası dönemlerdeki yumurta verimi, yem tüketimi ve yemden yararlanma oranı üzerine etkileri

Parameters	**Period**	**Treatments[2]**			P
		California	Zn	Alfalfa	
Hen-day egg production (%)	Pre-molt	35.57 ± 1.92	42.93 ± 2.80	38.17 ± 3.12	0.196
	Post-molt	31.71 ± 2.37	34.58 ± 0.76	33.16 ± 2.41	0.615
Feed intake (g/hen/day)	Pre-molt	102.45 ± 3.10	104.91 ± 1.84	105.44 ± 0.88	0.592
	Post-molt	103.50 ± 1.63	101.84 ± 2.47	100.37 ± 4.80	0.798
Feed conversion ratio (g feed/g egg)	Pre-molt	5.40 ± 0.28	4.64 ± 0.37	5.28 ± 0.64	0.477
	Post-molt	5.75 ± 0.40	5.39 ± 0.55	5.19 ± 0.53	0.737

[1]Data are presented as mean ± standard error of 4 replicates per treatment
[2]California method = Hens were fasted during the first 10 days and they were given a cracked corn diet *ad libitum* from 11 to 28 days of age. Zn = High dietary Zn method (Hens were fed with layer diet containing 15,000 mg/kg of Zn as ZnO for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age. Alfalfa = Whole alfalfa meal diet (Hens were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age.

Table 3. The effects of different molting methods on egg weight during pre-molt and post-molt periods[1] (g)
Tablo 3. Farklı tüy dökümü yöntemlerinin tüy dökümü öncesi ve tüy dökümü sonrası dönemlerdeki yumurta ağırlığı üzerine etkileri

Periods	**Treatments[2]**						P
	California		Zn		Alfalfa		
	n	Mean ± SEM	n	Mean ± SEM	n	Mean ± SEM	
Pre-molt	478	53.76 ± 0.15	577	53.57 ± 0.16	513	54.15 ± 0.22	0.060
Post-molt	1144	57.24[a] ± 0.13	1218	56.58[b] ± 0.13	1191	56.27[b] ± 0.14	<0.001

[1]Results are expressed as mean ± standard error. [a, b] Mean values within a row with no common superscript differ significantly (P<0.001).
[2]California method = Hens were fasted during the first 10 days and they were given a cracked corn diet *ad libitum* from 11 to 28 days of age. Zn = High dietary Zn method (Hens were fed with layer diet containing 15,000 mg/kg of Zn as ZnO for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age. Alfalfa = Whole alfalfa meal diet (Hens were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age.

There was no significant difference among groups in terms of heterophil-lymphocyte ratio during pre-molt period. However, heterophil-lymphocyte ratio at d 10 and 28 of molting period significantly higher for hens in California group than for those in other group.

Table 4. External and internal quality traits of pre-molting eggs[1]
Tablo 4. Tüy dökümü öncesi dönemdeki yumurta dış ve iç kalite özellikleri

Parameters	Treatments[2]			P
	California (n = 20)	Zn (n = 20)	Alfalfa (n = 20)	
External egg quality traits				
Shape index	73.86 ± 0.51	74.06 ± 0.70	73.20 ± 0.54	0.559
Egg shell weight (g)	5.05 ± 0.11	4.85 ± 0.10	5.07 ± 0.13	0.355
Egg shell thickness (mm)	0.35 ± 0.03	0.35 ± 0.03	0.36 ± 0.04	0.440
Internal egg quality traits				
Albumen length (mm)	97.51 ± 2.21	98.82 ± 2.41	101.1 ± 2.21	0.531
Albumen width (mm)	75.41 ± 1.75	74.79 ± 2.12	75.42 ± 2.25	0.970
Albumen height (mm)	5.34 ± 0.19	5.14 ± 0.30	5.09 ± 0.21	0.739
Albumen index (%)	6.25 ± 0.30	6.00 ± 0.41	5.82 ± 0.28	0.656
Yolk weight (g)	18.82 ± 0.32	18.79 ± 0.28	19.29 ± 0.34	0.469
Yolk width (mm)	42.02 ± 0.39	41.44 ± 0.47	42.42 ± 0.32	0.231
Yolk height (mm)	17.69 ± 0.24	17.60 ± 0.27	17.93 ± 0.25	0.649
Yolk index (%)	42.18 ± 0.70	42.56 ± 0.79	42.29 ± 0.64	0.926
Yolk color	13.02 ± 0.71	13.16 ± 0.59	12.88 ± 0.80	0.067
Hough unit	72.81 ± 1.52	71.18 ± 2.28	70.51 ± 1.73	0.670

[1]Results are expressed as mean ± standard error.

[2]California method = Hens were fasted during the first 10 days and they were given a cracked corn diet *ad libitum* from 11 to 28 days of age. Zn = High dietary Zn method (Hens were fed with layer diet containing 15,000 mg/kg of Zn as ZnO for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age. Alfalfa = Whole alfalfa meal diet (Hens were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age.

Discussion

The physiological responses such as weight loss in hens, feather molting, and complete cessation of egg laying that occur during traditional molting are used as indicators of molt effectiveness. However the key factor for improving post-molt egg quality is the regression and rejuvenation of the cells lining the reproductive tract (Soe 2007; Brake and Thaxton, 1979). It has been reported that body weight loss is a major factor contributing to the molt induction and 25 to 30% weight loss during molting is need to attain the maximum egg production post-molting (Baker et al. 1983, Hussain 1996). In the present study, maximum body weight loss during molting period for hens in California, Zn and alfalfa meal groups 22.21%, 11.28% and 10.58%, respectively, and significant differences were observed among groups (P<0.001). However, hen-day egg production during post-molt period was not significantly different among these three groups. This result could be explained that hens in California group stayed out of production for a longer period than hens in the other groups. Similar to the current study, Onbaşılar et al (2007) also reported that body weight loss was significantly higher in California group than in Zn group, but there was no significantly difference among these groups in terms of hen-day egg production. Hassanabadi and Kermanshahi (2007) also observed similar results for hens molted by Zn and feed withdrawal methods.

In this study, it was determined that egg production of hens molted by California and alfalfa meal methods ceased by eighth days, whereas egg production of hens molted by Zn method ceased by eleventh days of molting (data not shown). Hen-day egg production was 0% for hens molted by California method, whereas it was 0.30% and 1.22% for hens molted by alfalfa meal and Zn methods, respectively in first week of post-molting. From the 2th week of post-molt period, hens in all molted groups initiated egg production. Hen-day egg production in post-molt period was not significantly different among three molting groups (Table 2, Figure 1). This result is similar to the results of Onbaşılar et al (2007) who reported that post-molt egg production was not significantly different among groups molted by California, Zn and whole grain-barley diet methods and the results of Park et al. (2004) who found that there was no significant differences among groups molted by feed withdrawal, Zn acetate and Zn propionate in terms of post-molt egg production.

There was no significant difference for daily feed intake and feed conversion ratio in post-molt period among molting

Table 5. Interior and exterior quality traits of post-molting eggs[1]
Tablo5. Tüy dökümü sonrası dönemdeki yumurta dış ve iç kalite özellikleri

Parameters	Treatments[2]			P
	California (n = 20)	Zn (n = 20)	Alfalfa (n = 20)	
External egg quality traits				
Shape index	74.92 ± 0.27	74.78 ± 0.37	74.26 ± 0.32	0.314
Egg shell weight (g)	5.43 ± 0.07	5.38 ± 0.08	5.42 ± 0.07	0.863
Egg shell thickness (mm)	0.36 ± 0.03	0.37 ± 0.04	0.37 ± 0.03	0.374
Internal egg quality traits				
Albumen length (mm)	92.95^{b} ± 0.90	97.54^{a} ± 1.16	96.75^{a} ± 1.03	0.004
Albumen width (mm)	70.06 ± 0.80	72.71 ± 0.88	71.07 ± 0.84	0.081
Albumen height (mm)	5.95 ± 0.12	5.79 ± 0.12	5.72 ± 0.12	0.357
Albumen index (%)	7.38 ± 0.18	6.89 ± 0.17	6.93 ± 0.20	0.110
Yolk weight (g)	19.63 ± 0.26	19.04 ± 0.20	19.55 ± 0.17	0.110
Yolk width (mm)	42.00 ± 0.21	41.52 ± 0.21	42.21 ± 0.21	0.061
Yolk height (mm)	18.44 ± 0.11	18.16 ± 0.10	18.48 ± 0.09	0.056
Yolk index (%)	43.98 ± 0.32	43.81 ± 0.31	43.88 ± 0.33	0.936
Yolk color	13.89 ± 0.08	13.81 ± 0.07	14.00 ± 0.07	0.188
Hough unit	76.44 ± 0.95	75.37 ± 0.94	74.91 ± 0.91	0.493

[1]Results are expressed as mean ± standard error. [a, b] Mean values within a row with no common superscript differ significantly (P<0.01).

[2]California method = Hens were fasted during the first 10 days and they were given a cracked corn diet *ad libitum* from 11 to 28 days of age. Zn = High dietary Zn method (Hens were fed with layer diet containing 15,000 mg/kg of Zn as ZnO for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age. Alfalfa = Whole alfalfa meal diet (Hens were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age.

Tablo 6. Farklı tüy dökümü yöntemlerinin tüy dökümü öncesi ve tüy dökümü sonrası dönemlerdeki heterofil-lenfosit oranı üzerine etkileri[1]

Periods	Treatments[2]			P
	California	Zn	Alfalfa	
Pre-molt	0.69 ± 0.22	0.57 ± 0.04	0.61 ± 0.14	0.861
Molt				
Day 10	1.08^{a} ± 0.06	0.65^{b} ± 0.09	0.80^{b} ± 0.06	0.001
Day 28	0.97^{a} ± 0.09	0.69^{b} ± 0.05	0.72^{b} ± 0.09	0.037

[1]Results are expressed as mean ± standard error. (n = 10). [a, b] Mean values within a row with no common superscript differ significantly (P<0.05).

[2]California method = Hens were fasted during the first 10 days and they were given a cracked corn diet *ad libitum* from 11 to 28 days of age. Zn = High dietary Zn method (Hens were fed with layer diet containing 15,000 mg/kg of Zn as ZnO for 10 days and then they were fed 100 g/bird per day of the layer diet from 11 to 28 days of age. Alfalfa = Whole alfalfa meal diet (Hens were fed with 100 % alfalfa meal *ad libitum* for 10 days. They were fed 100 g/bird per day of the layer diet from 11 to 28 days of age.

groups. This finding is in agreement with those of Petek and Alpay (2008), Biggs et al. (2004) who determined that different forced molting methods did not significantly affect feed intake and feed conversion ratio.

In general, egg size is larger during the second cycle than during the first cycle (North and Bell 1990). In this study, also the higher egg weight was observed in post-molt period, compared with pre-molt period (Table 3). Previous studies reported that egg weight in post-molt period was not significantly affected by molting treatments in laying hens (Alodan and Mashaly 1999, Biggs et al. 2004, Hassanabadi and Kermanshahi 2007, Petek and Alpay 2008). However, in this study, it was found that egg weight in post-molt period was significantly higher in California group than the other groups. This finding could be due to the differences in genotype, the age of hen, experimental conditions in the studies. It is well known that the efficiency of a molting program depends on several factors such as strain of bird, body weight characteristics, age of the hens, and environmental conditions. Differences in response to forced molt are known to occur even between lines of the same strain (Baker 1983, Yardimci and Bayram 2008).

Consumer perception of a high quality eggs both for direct consumption as well as a food ingredient is becoming more essential. Therefore as the egg laying industry examines options for alternative molt diets for extending egg production in a second egg laying cycle, and egg quality must be considered as a part of the evaluation (Landers et al., 2005). Yolk color and hough unit are accepted as the most important quality parameters from the consumer point of view (Petek et al. 2008). The results in the current study indicated that external and internal egg quality traits were not significantly different among molt treatments. This result is in agreement with those obtained by Park et al. (2004) who found that there were no significant differences for egg quality traits among feed withdrawal, Zn acetate and Zn propionate molt treatments. Onbaşılar et al (2007) also reported that egg quality traits were not significantly different among California and Zn molt treatments.

Heterophil-lymphocyte ratio is used for estimating the level of stressful conditions resulted from long term changes in the environment (Gross and Siegel, 1983). In the present study, significantly higher H/L ratio was observed for hens in California group than those in the other groups on d 10 and on d 28 of molting ($P<0.001$, $P<0.05$). This result clearly indicates that hens molted by California method displayed the higher level stress than those molted by Zn and alfalfa methods.

As a result of this study, Zn and alfalfa methods resulted in comparable egg production performance, egg quality, feed intake and feed conversion ratio with California method. However, California method caused to the higher stress situation during molting period in Denizli chickens. From these results, it can be said that Zn and Alfalfa molting methods was more suitable than California method which caused to a high level stress in Denizli chickens.

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