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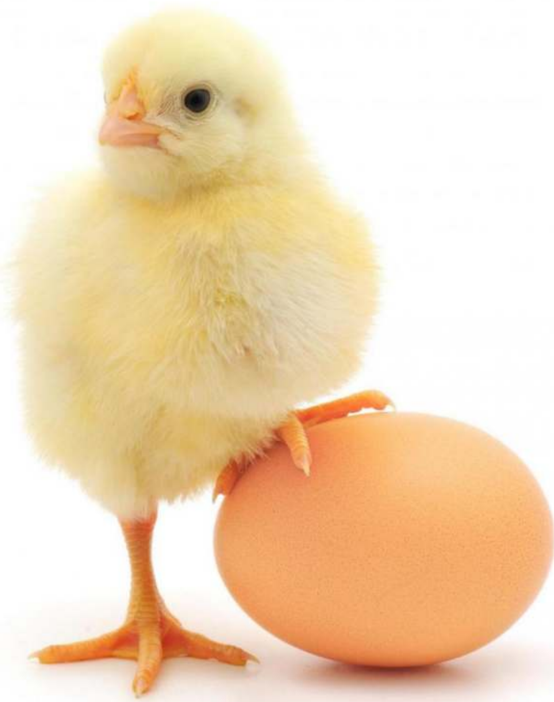

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The Effect of Body Weight Prior to Molting in Brown Laying Hens on Egg Yield and Quality During Second Production Cycle

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Abstract: This study focused on the effect of different BW in moulted brown laying hens (Isa-brown) on egg yield and quality during second production cycle. A total of 240 hens after the completion of first production cycle were classified into 4 BW groups; Light (L; 1529-1823 g), Mid-light (ML; 1824-1977 g), Mid-heavy (MH; 1990-2120 g) and Heavy (H; 2124-2797). Groups were consisted of 6 replications and in each replication there were 10 hens reared in individual cages. Moult was induced by feeding hens a commercial compound feed containing high levels of added Zn (15,000 ppm) as Zn oxide during the first 10 days, and following 40 days they were fed laying diet (17% crude protein and 2700 kcal ME/kg; 75 g/day). At the end of moulting period, BW loss was higher (P<0.01) in hens in MH (%17.30) and H (18.42%) groups compared to those in L (11.41%) and ML (11.42%) groups. In second production cycle (147 days), no differences were found among groups in terms of egg yields, but the peak yield of the H hens did not reach those of other groups (P< 0.05). Egg weight of L hens (69.5 g) was lower (P<0.05) than that of ML (70.8 g), MH (71.9 g) and H (71.9 g) hens. Heavy groups had higher feed consumption (P<0.01) and feed conversion ratio (P<0.05) compared to light groups. These results show that mid-light BW of flock prior to molting result in better egg weight, feed consumption and feed conversion ratio in the second production cycle.

Key words: Laying hen, induced molting, live weight, egg yield, egg quality

Introduction

Domestic hens are often induced to moult by a variety of procedures (Bar *et al.*, 2003), in order to prevent the age-related declines in egg production and eggshell quality (Bar and Hurwitz, 1987; Bar *et al.*, 2001; Bar *et al.*, 2003; Bell, 2003). Thanks to this practice, total productivity of flock raises due to the increases in egg yield and egg quality during second production cycle (Hurwitz *et al.*, 1998; McDaniel and Aske, 2000; Bell, 2003).

During the moulting 25 to 30% weight loss is required to attain the maximum egg production post moulting (Baker *et al.*, 1983; Buhr and Cunningham, 1994; Hussein, 1996; Hazan and Yalcin, 1988). Effectiveness of the induced moulting changes according to the methods (Hussein, 1996; Keshavarz and Quimby, 2002; Bar *et al.*, 2003), breed (Hurwitz *et al.*, 1998) and age (Aksoy *et al.*, 1997; Hurwitz *et al.*, 1998, Bar *et al.*, 2001). The most commonly used procedures for moult inducing are based on feed withdrawal, with or without light restriction (Hurwitz *et al.*, 1995; Hussein, 1996; Ruszler, 1998). Induction of moult by dietary manipulation of certain minerals such as zinc, iodine, sodium, chloride, calcium, aluminium and copper have been shown to result in satisfactory post moult performance (Berry *et al.*, 987; Ruszler, 1998; Alodan and Mashaly, 1999).

Post moult performance may be dependent on pre moult body weight (BW), since flock BW at the end of the first production cycle influence body weight loss during moulting period. The loss of BW and the egg yield in second production cycle appeared to change with Isa-Brown layers of different BW (light, medium and heavy) induced to moulting by fasting (Aksit *et al.*, 2003). Moreover, effectiveness of an induced moulting method may depend on BW of the flock prior to moulting. This study was conducted to determine the second production cycle egg yield and egg qualities of the brown layers (Isa-Brown) with different BW induced to moulting via dietary inclusion of Zn.

Materials and Methods

In the study 80 wk-old Isa-Brown hybrid layers completed the first production cycle were used. The experiment was conducted in a three-tier cage system, with one bird in each cage. They were located in a deep pit house ventilated both naturally and mechanically, and illuminated both artificially and naturally through the windows. Totally 240 healthy hens were weighed and allocated to 4 groups as light (L, 1529-1823 g), mid-light (ML; 1824-1977 g), mid-heavy (MH; 1990-2120 g) and heavy (H; 2124-2797 g) weights based on the standard deviations of the mean. Groups were composed of 6 replicates of 10 hens caged individually (60 hens for each of groups). Moult was induced by feeding hens a commercial compound feed containing high levels of added Zn (15,000 ppm) as Zn oxide (Park *et al.*, 2004) during first 10 days and then fed on commercial layer diet (17% crude protein and 2700 kcal ME/kg; 75 g/day) for 40 days. Moulting period lasted for 49 days for all the groups and during this period all of the hens were

Table 1: The body weight and body weight changes of brown laying hens with different body weight prior to molting

	L	ML	MH	H	SEM	P
Body weight, g						
On 1 day	1730.2[a]	1906.7[b]	2057.9[c]	2306.9[d]	15.38	**
On 10 day	1348.2[a]	1515.0[b]	1621.6[c]	1822.2[d]	13.48	**
On 50 day	1531.4[a]	1688.2[b]	1701.3[b]	1878.1[c]	13.96	**
On 147 day	1807.7[a]	2014.4[b]	2110.2[c]	2325.1[d]	16.28	**
Body weight changes, %						
Days 1 to 10	-22.06	-20.54	-21.21	-21.08	0.232	NS
Days 1 to 49	-11.41[a]	-11.42[a]	-17.30[b]	-18.42[b]	0.607	**
Days 1 to 147	4.56[a]	5.64[a]	2.56[b]	0.92[b]	0.512	**

L: light, ML: mid-light, MH: mid-heavy, H: heavy, SEM: standard error of the mean, NS: not significant.

[a, b, c, d]: Superscripts within row with different letters differ significantly (**P < 0.01).

exposed to normal day-light (approximately 12 hours).

Hens were weighed on 10th, 50th days, and 147th day of second production cycle and BW changes for each period were computed. During the moulting period, the last day of egg production, total egg production and cracked egg counts were recorded. Days to the 50% yield, egg yield (hen/day, % and number) and cracked egg numbers were recorded during the second production cycle. Feed consumption (weekly) and mortality were recorded during the moulting period and second production year. Feed conversion ratios of the groups were computed by dividing the total egg weights by the total feed consumptions. After the hens reached the 50% yield age all the eggs for 3 consecutive days of individuals were collected at 28-day intervals and weighed during the second production year. Of these eggs, randomly selected 15 were used to determine internal and external quality characteristics (egg weight, shape index, shell thickness, Haugh Unit and cracking resistance).

At the end of the study (147th day) 6 birds from each group (totally 24 birds) were slaughtered, and slaughter weight, carcass weight, dressing percentage, number of total follicle, abdominal fat and edible inner organs' weight (hearth, liver and gizzard) of these animals were determined. Abdominal fat and edible organs' weights were expressed as proportional of BW (g/100 g BW).

Data from the experiment were subjected to one-way analysis of variance (ANOVA) using the SPSS PC programme. All percentage data were converted Arcsines prior to analysis and non-transferred means are presented.

Results

Changes of BW observed during moulting period and second production cycle were presented in Table 1. Groups had similar BW losses during the Zn-feeding period, but BW losses of hens in MH and H groups were higher (P< 0.01) than those of L and ML groups on 49th day. At the end of the second production cycle L and ML hens had higher (P<0.01) BW than the MH and H hens.

Findings related to egg yields and mortality during pre moulting, moulting and second production cycle were presented in Table 2. No differences were found among egg yields of treatment groups for all 3 periods, but the peak yield of the H hens did not reach those of other groups (P< 0.05). During the moulting period hens in the H group had higher broken egg production, and lower unshelled egg production compared to hens in the L group (P< 0.05). There were no differences among the groups in terms of the days to the cease of egg production, but H group reached more quickly the 50% egg production age compared to other groups (P< 0.05). No mortality was observed in any group during moulting period and no difference was found in terms of mortality among the groups during second production cycle. While feed consumptions were not different among the groups during moulting period, feed consumptions (P<0.01) and feed conversion ratios (P<0.05) of MH and H groups were higher than those of L and ML groups.

Egg quality characteristics were not affected by pre-moulting BW (Table 3). Egg weight of the L hens was found higher than those of other groups (P<0.05).

Final BW and carcass weights of the groups were significantly different (P<0.01), which they have been shown to increase with parallel to increases in BW, but not dressing percentages (Table 4). Similarly, there were no differences in terms of edible organs' weights and total follicle numbers among the groups, but abdominal fat weight has been shown to increase with parallel to increases in BW (P<0.05).

Discussion

Results of the present study showed that egg yields and egg quality characteristics during second production year were not affected by pre moulting BW and also that egg weight was lower in light group and peak yield was lower in heavy group. Contrary to these results, Aksit *et al.* (2003) showed that second production cycle egg yields of the light hens were higher than those of heavy birds. This can be attributed to the fact that BW losses in light birds were higher compared to the medium and heavy birds during stress conditions. However, while Aksit *et al.* (2003) used the fasting method to induce

Table 2: The egg yield during pre-molting, molting and second production cycle, and feed consumption, feed conversion ratio and mortality of brown laying hens with different body weight prior to molting

	L	ML	MH	H	SEM	P
Pre molting period						
Egg yield, hen-day, %	40.08	43.33	45.01	45.08	2.618	NS
Molting period						
Egg yield, hen-day						
Number	7.4	6.3	8.0	8.1	0.51	NS
%	14.73	12.53	16.00	16.27	1.013	NS
Cracked egg, %	19.62^{b}	22.02^{ab}	26.88^{a}	31.48^{a}	2.279	*
Unshelled egg, %	11.36^{a}	9.69^{a}	5.28^{b}	2.97^{b}	1.992	*
Last day of egg production	4.33	4.33	4.67	4.85	0.321	NS
Feed consumption, g/hen/d	87.4	87.6	87.2	87.0	0.26	NS
Second production cycle						
Egg yield, hen-day						
Number	107.4	105.2	104.8	100.5	2.46	NS
%	72.17	71.56	71.53	68.78	1.638	NS
Cracked egg, %	4.20	3.87	3.51	2.91	0.981	NS
Unshelled egg, %	2.89	2.90	2.29	1.63	0.468	NS
Days to the 50% egg yield	13.17^{a}	12.67^{a}	10.67^{ab}	9.67^{b}	0.434	*
Peak yield, %	81.71^{a}	83.65^{a}	80.27^{a}	75.54^{b}	1.028	*
Feed consumption, g/hen/d	120.8^{a}	122.1^{a}	135.5^{b}	139.1^{b}	1.72	**
Feed conversion ratio	2.42^{a}	2.38^{a}	2.71^{b}	2.92^{b}	0.28	*
Mortality, %	5.82	5.20	6.67	6.67	1.051	NS

L: light, ML: mid-light, MH: mid-heavy, H: heavy. SEM: standard error of the mean, NS: not significant.
a, b: Different superscripts within a row differ significantly at the P value within the same raw (*: $P < 0.05$, **: $P < 0.01$).

moulting, in present study diet enriched with Zn was used to achieve this purpose. While use of Zn-enriched diet as moulting method has been shown to give similar results with the moulting methods of feed withdrawal with or without water and/or lighting restriction (Ramos *et al.*, 1999), concentrate feeding (Biggs *et al.*, 2003) or *ad libitum* feeding of low-energy diet (Ramos *et al.*, 1999), the BW losses achieved by using Zn-enriched diets in birds with different BW during pre moulting period (20 to 22%) were lower compared to the feed restriction method (22 to 27%; Aksit *et al.*, 2003). The lack of difference in terms of egg yield among the different BW groups with similar BW losses may be explained by the fact that the birds with higher BW losses during moulting period have good performance during the second production cycle (Buhr and Cunninghan, 1994; Hussein, 1996; Hazan and Yalcin, 1988).

Although the egg yields of the groups were not different at the end of the second production cycle, H group had lower peak yield. This observation can be related to the BW during the moulting period. As a matter of fact, a negative correlation reported between second production cycle egg yield and BW during the moulting period (Buhr and Cunningham, 1994; Hussein, 1996), and the birds which have insufficient BW losses during moulting reach the second production cycle with higher BW compared to the birds with sufficient losses (Buhr and Cunningham, 1994; Hussein, 1996; Hazan and Yalcin, 1988).

In present study, although the BW losses of the groups were not different (ranges from 20 to 22%) during Zn feeding period, H groups had higher BW losses at the end of the moulting period due to the fact that H groups had higher BW losses during the resting period. Responses to fasting fall into three distinct phases (Webster, 2003), which are the initial adaptation phase, phase of long-term economy and phase of rise in rate of specific body mass loss due to increased protein catabolism. The transition from Phase 2 to Phase 3, therefore, is characterized by the fact that proteins are no longer spared, and the fasting bird experiences accelerated loss of muscle mass. Significant lipid reserves remain at the start of the phase and fat catabolism continues concurrent with protein catabolism to supply energy needs. During the Phase 3, lipid reserves become depleted, and muscle loss from protein catabolism reaches a point at which debilitation occurs and hence, the fasting bird cannot be re-fed, beginning an irreversible progression to death. Therefore, the low BW prior to moulting delayed the 50% of egg yield age compared to high BW hens due to possible high fat content of high BW hens, which it may be protected hens from negative effect of Phase 1 and 2. On the other hand, results respect to mortality during the moulting period indicates that moulting program applied in present study protected hens in all groups from the effect of Phase 3.

Table 3: The egg weight, shell quality characteristics of brown laying hens with different body weight prior to molting during the second production cycle

	L	ML	MH	H	SEM	P
Egg weight, g	68.5^a	70.8^b	71.9^b	71.9^b	0.39	*
Egg shape index, %	75.55	75.86	76.04	77.09	0.248	NS
Cracking resistance, kg/cm^2	2.74	2.42	2.42	2.12	0.116	NS
Eggshell weight, g	9.08	9.27	9.08	9.31	0.106	NS
Eggshell thickness, µ	399.33	399.67	385.17	401.00	3.454	NS
Haugh units	81.36	80.28	79.86	78.73	1.011	NS

L: light, ML: mid-light, MH: mid-heavy, H: heavy. SEM: standard error of the mean, NS: not significant.
$^{a, b}$: Superscripts within row with different letters differ significantly (*: $P < 0.05$).

Table 4: The carcass characteristics and number of total follicle of brown laying hens with different body weight prior to molting at the end of second production cycle

	L	ML	MH	H	SEM	P
Slaughter weight, g	1591.0^a	1850.3^b	1990.6^c	2213.0^d	41.34	**
Carcass weight, g	1117.4^a	1279.5^b	1375.6^c	1552.6^d	29.89	**
Dressing percentage, %	70.23	69.15	69.13	70.12	0.384	NS
Number of total follicle	21.8	19.3	19.9	23.3	0.98	NS
Abdominal fat pad, %	3.01^a	4.29^b	5.61^c	6.49^d	0.339	**
Edible inner organs, %	4.06	4.01	3.75	3.62	0.075	NS

L: light, ML: mid-light, MH: mid-heavy, H: heavy. SEM: standard error of the mean. NS: not significant.
$^{a, b, c, d}$: Superscripts within row with different letters differ significantly (**: $P < 0.01$).

Decreasing of egg yields up to 0 to 1% and therefore having access of the hens into the resting period as soon as possible is an indicator of efficiency of induced moulting. In present study, egg yield of the all groups decreased up to 0% at the same time (4-5 days), but H group attained 50% production level more quickly compared to the L groups. The fact that H group attains the 50% production level more quickly compared to the L groups might be related to the BW of the hens, because BW is the most important factor in determining the onset of the egg production (Dunnington and Siegel, 1984).

Previous studies reported that mortality rates of the hens exposed to induce moulting ranged from 0 to 12% depending on the moulting programmes during the moulting period and second production cycle (Bell, 2003). In current study, the similarity of the mortality rates in the groups during the moulting period and second production cycle might be related to the fact that the physiologic stress parameters were not affected by the BW prior to moulting (Aksit *et al.*, 2003).

Aksit *et al.* (2003) reported that pre moulting BW did not affect egg weight, egg shape index and shell thickness. In this study, examined egg quality parameters were not affected by the pre moulting BW although the egg weight of the L group was lower compared to those of the other groups. A lower egg weight in the L group compared to the other groups support the hypothesis that egg weight is dependent on BW of the hens. Some improvements can be observed in egg quality due to increase in calcium absorption through the small intestines (Albatshan *et al.*, 1994) and rejuvenation in oviductal tissue (Heryanto *et al.*, 1997). In present study, there are no differences among the groups in terms of examined egg quality parameters. This result indicates that pre-moulting BW did not affect post moulting calcium absorption and the rejuvenation of oviduct. Improvement of egg quality is the consequence of the oviductal tissue rejuvenation and hence, the enhancement of ovarian functions may result in the improvement of egg production (Heryanto *et al.*, 1997). In fact, it has been reported that the losses of ovarian and oviduct tissue weights are similar in hens with different pre moulting BW (Aksit *et al.*, 2003).

Results respect to number of total follicles support the hypothesis that pre-moulting BW does not affect second production cycle egg weight after 3 months (Aksit *et al.*, 2003). The higher feed consumption and feed conversion ratio of H groups compared to the L groups with similar egg weights might be related to the higher maintenance requirements and abdominal fat ratios of the H groups compared to the L groups. Moreover, the lower feed consumption of L group can be explained by the egg weight, which is lower in L group as the egg weight is one of the factors affecting the feed consumption.

In conclusion, the higher peak yields and lighter eggs of the light hens, and the higher feed consumption and feed conversion ratio and the earlier egg production of heavy hens should be taken into consideration, although the pre-moulting BW does not affect the second production cycle egg production and quality, Also, flock must be avoided to become heavier at the end of the first production year in order to attain higher performance during second production cycle.

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