

Evaluation of High Dietary Aluminum as a Force Resting Agent in Laying Hens

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ABSTRACT. A total of 416 Saudi Arabian Baladi hens were divided into four experimental groups and subjected to the following treatments: Commercial laying ration (17 % CP, 3.6 % Ca and 0.343 available P) fed ad libitum as a control (C); Conventional force molting, feed removal for 10 days followed by 18 days full feed of cracked corn (F); 15 days ad libitum intake of the control ration supplemented with 0.35 % Al as the sulfate (AIS) or chloride (AIC).

During the force resting period, egg production of F and Al fed groups was significantly ($P < .05$) lower than that of the control. F ceased production 10 days following feed withdrawal, whereas AIS and AIC were producing at 10.62% and 14.42 % at the end of the force resting period. AIS, AIS and (C) by the end of the force resting period. AIS, Al and F had significantly ($P < .05$) lower weights than the control (C) by the end of the treatment and lost 13.04, 10.27 and 20.04 % of their initial weight, respectively. Al fed groups consumed significantly ($p < .05$) less feed compared with the control and their feed intake was about 62 % of that of the control.

Conventional force molting of laying hens by restriction of feed and/or water, along with or without light restriction is a common practice, to cause a temporary cessation of egg production and subsequently rejuvenate laying performance of hens, which has been in continuous production for 10 to 18 months (Wakeling 1977, Wolford 1984). Various methods of inducing force resting have been suggested. These include the use of progesterone (Ingram and Zehr 1986), enheptin (Hansen 1960), D-Trp-6-LHRH; a synthetic analogue of avian luteinizing hormone releasing hormone (Hoyle *et al.* 1988) and gonadotropin releasing hormone agonist (Dickerman and Bahr 1989) and excessive dietary minerals;

namely iodine (Smith 1980), magnesium (Shippee *et al.* 1979) and zinc (McCormick and Cunninghas 1987, Hussein *et al.* 1988). It was found that restriction of dietary calcium (Mather *et al.* 1982) and salt (Said *et al.* 1984) produce similar effect.

Excessive dietary aluminium (Al) have been shown to reduce growth and to interfere with phosphorus metabolism. Storer and Nelson (1968) reported that levels of 0.1 to 0.4 % Al as the sulfate or chloride reduced growth, bone ash and feed efficiency in Single Comb White Leghorn chicks. Miles and Rossi (1985) found that feed intake, egg production and blood phosphorus decreased as Al increased (0.2, 0.4 or 0.6 % as the acetate) in diet containing 0.5% phosphorus, but not 1.0% phosphorus. However egg production almost ceased when laying hens were fed ration containing 0.5% phosphorus with 0.6% aluminum for a period of 13 days. Hussein *et al.* (1988a) found that the inclusion of 0.3% Al as the sulfate in layer diet containing 0.5% available phosphorus and 3.3% calcium for 42 days led to a significant decrease in plasma inorganic phosphorus in samples collected immediately following oviposition after 10 and 42 days of treatment, and in egg production and feed intake during days 1 through 21, but not during days 22 through 42. Hussein *et al.* (1989b) also reported that the addition of 0.3% Al as the sulfate to diet containing 0.35% available phosphorus and 3.5% calcium depressed feed intake, body weight and plasma total calcium of Single Comb White Leghorn hens and almost led to a complete pauses in egg production (3 %) by day 15. The present study was therefore conducted to investigate the effect of high dietary Al (as the sulfate or chloride) for inducing rest in egg production and its effect on plasma inorganic phosphorus and plasma total calcium. Also to compare the response of Al treated hens with that of the control and hens subjected to conventional force molting.

Materials and Methods

A total of 416 leg-banded laying hens were used in this study. The hens were obtained from Baladi flock which has been randomly bred for several years in the experimental poultry and livestock farm, King Saud University, Saudi Arabia. The experimental birds were randomly allotted to 16 floor pens in an environmentally controlled house (26 birds/pen). The pens were then divided into four experimental groups of four pens per group. Birds had been in production for 52 weeks and were 17 months of age at the beginning of the experimental period. The different experimental groups were randomly assigned to each of the following dietary treatments:

- 1- Commercial laying ration (Table 1) as a control (C).
- 2- Conventional force molting (F): feed removal for 10 days followed by 18 days full feed of cracked yellow corn.

3- 15 days ad libitum intake of the control laying ration supplemented, to initiate forced-rest, with either 0.35% aluminum as the sulfate " $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ " (AIS) or the chloride " AlCl_3 " (AIC).

The level of Al was approximately equal to the calculated level of available phosphorus (0.343 %) in diet. Light was maintained constantly at 15hr light : 9hr dark. After the termination of the treatments, experimental birds received the commercial laying ration described in Table 1.

The trials started one week before initiation of forced-rest to record pre-rest egg production. Individual body weight was measured to the nearest gram at the beginning and at the end of the treatment, at 2 and 4 weeks following the treatment. Daily egg production was also recorded to calculate hen-day egg production (HD) during the treatment. Feed intake per pen basis and mortality were recorded

Table 1. Composition of the commercial laying ration.⁽¹⁾

Ingredient	%
Alfalfa (CP 17%)	1.5
Yellow corn	39.250
Soyabean meal (CP 48%)	18.765
Wheat (CP 12.5%)	14.540
Weat bran	9.345
D.C.P.	0.670
Local limestone (28-30% Ca)	11.375
Fat	1.205
Salt	0.285
Fish meal (CP 61%)	2.500
Vitamin-mineral premix	0.400
Red carotin (Kemoglo Red)	0.100
Methionine	0.065
Calculated nutrient composition :	
ME kcal/kg	2585
Crude protein %	17.476
Crude fat %	4.225
Crude fiber %	3.104
Calcium	3.601
Total phosphorus %	0.604 ⁽²⁾
Available phosphorus %	0.343

(1) Manufactured by : Grain Silos and Flour Mills Organization, Riyadh.

(2) Analysed 0.585 % (AOAC, 1984).

during the experimental period. Livability was then calculated as the percent of live birds at the end of the experimental period. On the 5th and 10th day of the treatment and on the 10th day following the treatment period, blood samples, from five randomly selected hens per replicate were obtained by heart puncture. Plasma was separated by centrifuging blood samples for 10 min. at approximately 3000 rpm. Plasma inorganic phosphorus (P_i) was determined colorimetrically using a single reagent procedure employing vanadomolybdate as a coloring agent (AOAC 1984). Plasma total calcium (Ca_t) was determined according to the method reported by Pasehen (1970). Data collected were subjected to statistical analysis using general linear model procedures, according to the following model :

$$Y_{ij} = U + T_i + e_{ij}$$

where the Y_{ij} is the j^{th} observation of the i^{th} treatment, U is the general mean and e_{ij} is the random error associated with Y_{ij} observation (SAS 1986).

Results

Hen-day Egg Production (HD). Overall production mean of the feed-restricted group (F) was significantly ($P < .05$) lower than that of the Al sulfate (AIS) and Al chloride (AIC) fed groups (Table 2). On the other hand, egg production from AIS and AIC groups was similar but significantly ($P < .05$) lower than that of the control (C). The decline in egg production of F group was at faster rate than that of AIS and AIC groups during the treatment period. Egg production of the F group completely ceased by day 10 while that of AIS & AIC was reduced to a level of 10.62 and 14.42 %, respectively (Table 2).

Body Weight (BW). Initial body weight averages were similar for the different experimental groups (Table 3). However, at the end of the treatment AIS and AIC groups had significantly ($P < .05$) lower weights compared with the control, whereas group F had significantly ($P < .05$) the lowest weight average (Table 3). AIS and AIC groups had similar weights as the control (C) two weeks following the treatment. However, group F had still significantly ($P < .05$) lower weight than AIS, AIC and the control groups by week 4 following the treatment period.

Feed Intake (gm F/B/D). Table 3 shows that feed consumed by AIS and AIC groups was similar but significantly ($P < .05$) lower than that of the control. AIS and AIC ate about 62 % of that of the control. Hens in the F group were fully feed-restricted for 10 days and thereafter received only cracked corn for 18 days. *Livability (LV)*. During the force resting period livability was generally high for

the different experimental groups (Table 3). Though, there were no significant differences in livability, F tended to have numerically the lowest whereas AIC and C the highest livability percent during the force-rest period (Table 3).

Plasma Inorganic Phosphorus (P_i) and Total Calcium (Ca_t). Table 4 shows that F group had significantly ($P < .05$) lower plasma P_i than the control by day 5 of the treatment. On the other hand, there were no significant differences between AIS, AIC and the control. Similar results were observed between F, AIS and AIC groups. By day 10 of the treatment AIC had significantly ($P < .05$) the lowest plasma P_i while there were no significant differences between AIS and the control, F showed significantly ($P < .05$) lower amount than the control but similar to AIS

Table 2. Effect of force resting induced conventionally (F) or by high dietary aluminum as the sulfate (AIS) or chloride (AIC) on hen-day egg production (HD) during the force rest period

Parameter HD, % No. Birds	Treatment			
	F 104	AIS 104	AIC 104	C 104
Pre-rest	37.50 ± 1.76	38.32 ± 1.76	40.66 ± 1.76	37.78 ± 1.76
Force rest Period (Days)				
1	33.65 ± 4.14	33.65 ± 4.14	28.85 ± 4.14	38.46 ± 4.14
2	34.62 ± 4.14 ^a	36.54 ± 4.14 ^{ab}	46.15 ± 4.14 ^b	42.30 ± 4.14 ^{ab}
3	34.62 ± 4.14	40.38 ± 4.14	41.35 ± 4.14	43.27 ± 4.14
4	25.00 ± 4.14 ^a	44.23 ± 4.14 ^b	26.92 ± 4.14 ^a	46.15 ± 4.14 ^b
5	12.50 ± 4.14 ^a	36.00 ± 4.14 ^b	31.73 ± 4.14 ^b	40.38 ± 4.14 ^b
6	14.42 ± 4.14 ^a	36.88 ± 4.14 ^b	35.58 ± 4.14 ^b	51.92 ± 4.14 ^c
7	7.69 ± 4.14 ^a	23.38 ± 4.14 ^b	26.92 ± 4.14 ^b	33.65 ± 4.14 ^b
8	4.81 ± 4.14 ^a	32.96 ± 4.14 ^b	26.92 ± 4.14 ^b	45.19 ± 4.14 ^c
9	2.88 ± 4.14 ^a	19.38 ± 4.14 ^b	20.19 ± 4.14 ^b	46.50 ± 4.14 ^c
10	0.00 ^a	16.58 ± 4.14 ^b	20.19 ± 4.14 ^b	48.08 ± 4.14 ^c
11	0.96 ± 4.14 ^a	10.69 ± 4.14 ^{ab}	18.27 ± 4.14 ^b	42.31 ± 4.14 ^c
12	0.96 ± 4.14 ^a	11.65 ± 4.14 ^{ab}	15.38 ± 4.14 ^b	47.12 ± 4.14 ^c
13	0.00 ^a	13.58 ± 4.14 ^b	20.19 ± 4.14 ^b	44.23 ± 4.14 ^c
14	0.00 ^a	12.62 ± 4.14 ^b	15.38 ± 4.14 ^b	49.04 ± 4.14 ^c
15	0.00 ^a	10.62 ± 4.14 ^{ab}	14.42 ± 4.14 ^b	56.73 ± 4.14 ^c
Overall Mean	11.47 ± 1.07 ^a	25.28 ± 1.07 ^b	25.90 ± 1.07 ^b	45.02 ± 1.07 ^c

a,b,c Means within the same row with different superscript differ significantly ($P < 0.05$)

group (Table 4). Plasma Ca_t was significantly ($P < .05$) the lowest for group F by day 5 of the treatment. However, there were no significant differences between AIS and AIC and the control group. By day 10 F and AIC groups had significantly ($P < .05$) lower plasma Ca_t compared with the control, AIS had plasma Ca_t amount similar to that of the control and the other experimental groups (Table 4). Ten days following the treatment, there were no significant differences in plasma P_i between the different experimental groups. However, the control tended to have higher value. With regard to Ca_t the control had significantly ($P < .05$) the highest amount of plasma Ca_t whereas AIS had significantly ($P < .05$) higher plasma Ca_t than F but similar to that of AIC. AIC and F had no significant differences with regard to plasma Ca_t (Table 4).

Discussion

Hens in the feed-restricted group completely ceased egg production 10 days following feed withdrawal. They lost about 20% of their initial weight by the end of the treatment and additional 10% when they fed solely cracked corn for a

Table 3. Effect of force resting induced conventionally (F) or by high dietary aluminum as the sulfate (ALS) or chloride (ALC) on feed intake/bird/day (F/B/D), body weight (BW) and livability (LV)

Parameter	Treatment			
	F ⁽¹⁾	AIS	AIC	C
F/B/D, gm Force-rest Period	--	48.42 ± 1.05 ^a	48.32 ± 1.05 ^a	77.81 ± 1.05 ^b
BW, gm				
Initial	1452 ± 20	1419 ± 20	1432 ± 20	1418 ± 20
Force-rest Period	116 ± 20 ^a	1234 ± 20 ^b	1285 ± 20 ^b	1394 ± 20 ^c
Weight loss%	20.04	13.04	10.27	1.69
Post-rest Period				
Week 2	1120 ± 20 ^a	1333 ± 21 ^b	1328 ± 20 ^b	1357 ± 21 ^b
Week 4	1232 ± 20 ^a	1311 ± 21 ^b	1329 ± 21 ^b	1320 ± 21 ^b
LV, %				
Force-rest Period	97.12 ± 0.9	99.04 ± 0.9	100.0 ± 0.9	100.0 ± 0.9

^{a,b,c} Means within the same row with different superscript differ significantly ($P < 0.05$)

(1) Birds were fully feed-restricted for 10 days and thereafter received only cracked corn for 18 days.

period of 18 days after the fasting period. Livability was 97.12% during the force resting period. Many investigators reported that hens fasted for 10-12 days stopped egg production within 6-12 days of the start of the treatment (Thomas and Bray 1976, Shippee *et al.* 1979, Nordstrom 1980, Ross and Herrick 1981, Lee 1982, Said *et al.* 1984, Goodman *et al.* 1986, McCormick and Cunningham, 1987, Hussein *et al.* 1989b). Said *et al.* (1984) observed that hens subjected to feed and water restriction lost 17 % of their initial weight and had 6% mortality during the rest period. Hussein *et al.* (1989b) and McCormick and Cunningham (1987) reported similar results when they fasted hens for a period of 10 days; hens lost 24-25% of their initial weight, had 0-1% mortality following the force-rest period. In our study, feed-restricted hens had significantly ($P < .05$) lower weight than the control and other groups by week 4. This might be due to the fact that they received only cracked corn 18 days following the fast period.

Inclusion of 0.35% Al as the sulfate or chloride to the diet containing 0.343% available phosphorus depressed feed intake and body weight of Saudi Arabian Baladi hens. Similar results were obtained by feeding alum-flocculated algae to Leghorn x Rhode Island crossbred hens (Lipstein and Hurwitz 1981) and 0.3% Al as the sulfate to Japanese quail and SCWL laying hens (Hussein *et al.* 1988 and

Table 4. Effect of force resting induced conventionally (F) or by high dietary aluminum as the sulfate (AIS) or chloride (AIC) on plasma inorganic phosphorus (P_i) and plasma total calcium (Ca_i)

Parameter	Treatment			
	F ⁽¹⁾	AIS	AIC	C
P_i , mg/L				
Force-rest Period				
Day 5	95.4 ± 8.04 ^a	111.9 ± 10.3 ^{ab}	99.2 ± 8.04 ^{ab}	119.3 ± 8.37 ^b
Day 10	103.1 ± 7.75 ^b	105.2 ± 7.49 ^{bc}	78.8 ± 8.04 ^a	125.4 ± 8.05 ^c
Post-rest Period				
Day 10	109.1 ± 9.17	108.5 ± 8.37	97.1 ± 10.3	122.5 ± 9.67
Ca_i , mg%L				
Force-rest Period				
Day 5	106.5 ± 15.7 ^a	154.8 ± 17.9 ^b	167.3 ± 15.8 ^b	163.4 ± 16.4 ^b
Day 10	115.3 ± 15.2 ^a	121.1 ± 14.7 ^{ab}	109.5 ± 15.8 ^a	152.9 ± 15.8 ^b
Post-rest Period				
Day 10	114.1 ± 17.1 ^a	176.4 ± 15.8 ^b	138.4 ± 20.1 ^{ab}	227.8 ± 16.4 ^c

a,b,c Means within the same row with different superscript differ significantly ($P < 0.05$)

1989b). The reduction of feed intake was also observed by Miles and Rossi (1985) and Hussein *et al.* (1989a) with laying hens when fed different levels of Al as acetate or sulfate, respectively. In previous studies with Japanese quail and SCWL laying hens, Al had a negative effect on egg production (Lipstein and Hurwitz 1981, Miles and Rossi 1985, Hussein *et al.* 1988, 1989 a and b). The adverse effect of Al on egg production was expected due to the reduced feed intake which was in our case about 62% of the control. Using a pair-feeding trial, Hussein (1987) found that the decrease in growth of broiler chicks fed Al was mostly due to reduced feed intake, but was also due to metabolic effect of Al *per se*. In the present study, the Al as the sulfate or chloride fed groups were similarly affected but did not completely ceased production within two weeks from the start of the treatment period, whereas feed-restricted group completely stopped laying 10 days following feed withdrawal. These results disagree with Hussein *et al.* (1988 and 1989b) who reported that Japanese quail and SCWL laying hens fed diet containing 0.3% Al as the sulfate and 0.35% available phosphorus had almost went out of lay (1.8 and 3%) after 5 and 15 days upon administration of dietary Al, respectively. These results discrepancy might be attributed to species and breed differences. Hussein *et al.* (1989b) observed significant weight differences between feed-restricted and Al treated hens upto the second week, whereas in our case these differences prevailed toward 4 weeks, following the treatment period. This might be due to the fact that feed-restricted hens in our case lost more weight because they were fed solely cracked corn 18 days following the fasting period.

In the present study, feed-restricted hens had significantly lower plasma P_i and Ca_t than the control during the force resting period. With regard to Ca_t , differences also prevailed 10 days after the treatment. Similarly was observed for plasma P_i (Hussein *et al.* 1989a), serum calcium and inorganic phosphorus (Gildersleeve *et al.* 1983) during the molting period. Francis and Roberson (1980) and Roland and Brake (1982) reported similar results with respect to inorganic phosphorus and serum calcium, respectively. However, Roland and Brake (1982) and Hussein *et al.* (1989b) observed no changes in serum and plasma inorganic phosphorus level during the molting period.

Hens fed Al as the chloride had significantly lower plasma P_i and Ca_t levels, whereas aluminum sulfate fed group tended to have lower levels compared with the control. However, Al treated hens had significantly lower Ca_t level than the control 10 days after the treatment. This might be due to the unexpected rise in Ca_t level of the control. These results partially agree with those of Hussein *et al.* (1988 and 1989a) who reported a reduction in plasma P_i of Japanese Quail and SCWL laying hens fed 0.3% aluminum as the sulfate but plasma Ca_t of hens was not affected compared with the control. In another experiment, the same authors (1989b) reported reduced plasma Ca_t for aluminum sulfate fed hens whereas plasma P_i was not affected and approximately similar to that of feed-restricted group.

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تقويم اضافة مستويات عالية من الألومينيوم للعليقة كمرغم للتوقف المؤقت عن الانتاج في الدجاج البلدي

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أجريت هذه الدراسة على عدد ٤١٦ طائراً من إناث الدجاج البلدي عمر ١٧ شهراً التي قسمت إلى أربع مجموعات تجريبية من أربعة مكررات واخضعت للمعاملات التالية:

- ١ - التغذية على عليقة بياض تجارية (١٧٪ بروتين خام، ٣,٦٪ كالسيوم، ٣٤٣,٠٪ فوسفور متاح) كمجموعة مشاهدة (C).
- ٢ - نظام قلش تقليدي عن طريق التصويم لمدة ١٠ أيام ومن ثم قُدِّم للطيور ذرة صفراء مجروشة لمدة ١٨ يوماً (F).
- ٣ - ١٥ يوماً تغذية على عليقة مجموعة المشاهدة مضاف إليها ٣٥,٠٪ ألومينيوم سلفات (AIS) أو كلورايد (AIC).

تهدف هذه التجربة إلى تقويم اضافة مستويات عالية من الألومينيوم للعليقة كمرغم للتوقف المؤقت عن الانتاج ومدى تأثير ذلك على مستوى الفوسفور غير العضوي (P_i) والكالسيوم الكلي (Ca_i) في بلازما الدم وعلى وزن الجسم (BW)، استهلاك العلف (F/B/D) والحيوية (LV) خلال فترة المعاملة ومقارنة هذه النتائج مع نتائج مجموعتي المشاهدة والتصويم.

خلال فترة المعاملة دلت النتائج على أن إنتاج البيض للمجموعات التجريبية AIS, F و AIC كان أقل معنوياً من مجموعة المشاهدة. مجموعة التصويم (F) توقفت كلياً عن الانتاج في اليوم العاشر من التصويم بينما استمرت مجموعتا الألومينيوم في الانتاج بمعدل منخفض نسبياً ١٠, ٦٢٪ لمجموعة السلفات (AIS) و ١٤, ٤٢٪ لمجموعة الكلورايد (AIC) عند نهاية فترة المعاملة. وزن المجموعات AIS, F و AIC كان أقل معنوياً من وزن مجموعة المشاهدة عند نهاية فترة المعاملة حيث فقدت ٢٠, ٠٤, ١٣, ٠٤ و ١٠, ٧٢٪ على التوالي من وزنها قبل المعاملة. كذلك استهلكت مجموعة الألومينيوم كمية أقل من استهلاك مجموعة المشاهدة حيث وصل استهلاكها إلى حوالي ٦٢٪ من استهلاك مجموعة المشاهدة.

بالنسبة لمستوى الفوسفور غير العضوي والكالسيوم الكلي في بلازما الدم فإن المجموعة (F) كانت هي الأقل في اليوم الخامس والعاشر من فترة المعاملة بالمقارنة مع المشاهدة، وكذلك كانت المجموعة (AIC) عند اليوم العاشر من فترة المعاملة، وبعد عشرة أيام من المعاملة كان مستوى الكالسيوم الكلي في بلازما الدم في المجاميع AIS, F و AIC أقل معنوياً بالمقارنة بمجموعة المشاهدة.

نستنتج من هذه الدراسة أن التصويم لمدة عشرة أيام تحت ظروف التجربة أدى إلى الانقطاع الكلي في إنتاج البيض بينما إضافة ٠, ٣٥٪ الألومينيوم أدى إلى خفض إنتاج البيض فقط.