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INTERACTION EFFECTS BETWEEN FEED PHYSICAL FORM AND FEED RESTRICTION ON PERFORMANCE AND CARCASS CHARACTERISTICS OF BROILERS

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SUMMARY

One hundred and ninety two, one day old Cobb broiler chicks were randomly distributed into eight treatments to evaluate the effect of feed physical form and feed restriction on body weight, body weight gain, feed intake, gain: feed ratio and carcass characteristics of broilers.

Birds were distributed into two diet forms (mash and pellets). Both mash and pellet diet groups were subdivided into 4 treatments each (T1, T2, T3, T4 and T5, T6, T7, T8, respectively).

In the mash or pellets group, feed was offered to birds as following: T1, T5: birds were fed ad libitum, T2 and T6 (feed removed from 12:00 to 18:00 h during a day), T3 and T7 (feed removed from 23:00 to 7:00 h during a day) and T4 and T8 (removed feed from 23:00 to 9:00 h during a day).

Feed restriction for 6 hour as in the present study resulted in a better gain: feed ratio without reducing carcass weights, and a significant benefit of feeding the mash diet over the pelleted diet was noted in terms of body weight gain, feed intake gain: feed ratio.

Based on these results, it can be concluded that restriction of feed for 6 hours of feeding mash diet increased body weight, body gain and significantly reduced gain: feed ratio but had no consistent effect on overall carcass traits.

***Keywords:* broilers, feed form, feed restriction, carcass, performance**

INTRODUCTION

Recently, poultry feed industry continues to search for ways to optimize feed utilization, thereby improving production efficiency, with efforts being focused on changes in diets physical form (Kamphues, 2011). The expected benefits from optimal particle size in feed manufacturing processes include greater surface area, improved handling of most feed ingredients, mixing characteristics of feed ingredients, pelleting efficiency and quality (Mosenthin and Sauer, 2011). Jacobs *et al.* (2010) stated that it may be beneficial to expose chicks to diets containing large corn particle sizes as early as possible to maximize gizzard size and activity at a younger age; this may help to improve nutrients digestibility.

Early-life fast growth rate is usually accompanied by a number of problems, namely increased body fat deposition, higher incidence of metabolic disorders, higher mortality, and higher incidence of skeletal diseases. To tackle with these problems early nutrient restriction programmes are usually utilized (Lipens *et al.*, 2000; Mazzuco *et al.*, 2000; Lee and Leeson, 2001). Limiting feed intake depresses growth during the period of restriction, but reduced growth can be later compensated by re- alimentation (Govaerts *et al.*, 2000).

Feed restriction programs have shown the potential to reduce the incidence of such problems and can be used to modify birds growth patterns by reducing their maintenance requirements, which consequently should improve feed efficiency (Urdaneta and Leeson, 2002). There are only limited studies that had been conducted using feed restriction systems on broilers and results were insignificant either on growth performance and carcass characteristics (Petek, 2000; Ozkan *et al.*, 2003; Demir *et al.*, 2004; Khetani *et al.*, 2008; Onbasilar *et al.*, 2009). Due to the limitation of data conducted to study effects of combinations of feed physical forms and feed restrictions on broilers performance, the aim of the present study was to evaluate the interaction effects of feed physical form and feed restriction on growth performance and carcass yield of broilers.

MATERIALS AND METHODS

Experimental animals and housing:

This study was carried out in South Valley University, Qena, Egypt to determine feed intake, growth performance and carcass characteristics of broiler chicks fed two physical feed forms (Mash or Pellets) along with different feed restriction programs. One hundred and ninety-two one-day old Cobb broiler chicks were used and were randomly utilized in a 2x4 factorial arrangement. Broilers were divided into two main groups each in 4 sub groups (2 physical diet forms x 4 feed restrictions programs) with 3 replicates of 8 birds each. The eight dietary treatments were classified as follow:

Treatment 1 (**T1**) a basal diet in mash form and the feed was offered to birds *ad-libitum*
Treatment 2 (**T2**) a basal diet in mash form and the feed was removed for 6 hrs (from 12:00 to 18:00 h)
Treatment 3 (**T3**) a basal diet in mash form and the feed was removed for 8 hrs (from 23:00 to 7:00 h).
Treatment 4 (**T4**) a basal diet in mash form and the feed was removed for 10 hrs (from 23:00 to 9:00 h).
Treatment 5 (**T5**) a basal diet in pellet form and the feed was offered to birds *ad-libitum*.
Treatment 6 (**T6**) a basal diet in pellet form and the feed was removed for 8 hrs (from 12:00 to 18:00 h).
Treatment 7 (**T7**) a basal diet in pellet form and the feed was removed for 10 hrs (from 23:00 to 7:00 h).
Treatment 8 (**T8**) a basal diet in pellet form and the feed was removed for 10 hrs (from 23:00 to 9:00 h).

Diets and management:

The starter and grower diets (Table 1), were formulated to meet the nutrient requirements of broiler chicks according to (NRC 1994). Both starter and grower diets were in mash or in pellets forms. Birds in each replicate were weekly weighed and the feed consumed was recorded, while feed efficiency (g. gain/ g. feed) was calculated during different experimental periods being starter (1-21 days) , grower (21-42 days) and whole periods (1-42 days). Mortality was recorded daily and calculated for the entire experimental period.

Table 1. Composition and calculated analysis of the experimental diets

Ingredients, g/ kg	Starter diet (0-3 weeks)	Grower diet (4-6 weeks)
Yellow corn	531.7	565.2
Soybean meal (44%, CP)	320.0	300.0
Corn gluten meal (60%, CP)	90.0	60.0
Vit & Min. Premix*	3.0	3.0
Sunflower oil	20.0	40.0
Di-calcium phosphate	20.0	18.0
Limestone	10.0	10.0
NaCl	3.8	3.8
DL-Methionine	0.5	---
L- Lysine HCl	1.0	---
Total	1000	1000
Calculated analysis:		
ME, MJ/ kg	12.6	13.17
Crude Protein, (g./ kg)	241	215
Crude fibre, (g./ kg)	0.316	0.305
Crude fat, (g./ kg)	0.462	0.665
Ca, (g./ kg)	0.093	0.088
P (Available, g./ kg)	0.052	0.048
Lysine, (g./ kg)	0.127	0.104
Methionine, (g./ kg)	0.062	0.041

*A list of the active ingredients used in this feed obtained from the manufacturer: 2.5 kg/ton 6000 mg; Vitamin A, 1200 mg; Vitamin D, 10000 mg; Vitamin E, 1000 mg; Vitamin K_3, 1000 mg; Vitamin B_1, 5000 mg; Vitamin B_2, 1500 mg; Vitamin B_6, 50 mg; Biotin, 10000 mg; Pantothenic, 1000 mg; folic acid, 30000 mg; Nicotinic acid, 60 gm; Mn, 50 gm; Zinc, 30 gm; Fe, 4 gm; Cu, 3 gm; I, 0.1 gm; Selenium, 0.1 gm; Co.

Carcass traits:

At 6 weeks of age, five birds from each treatment representing the average body weight of such treatment were slaughtered (8 treatments x 5 birds = 40 birds). After slaughtering and complete bleeding, birds were scalded and feathers were plucked. Carcasses were eviscerated; heads and shanks were separated, then carcasses were chilled in a tap water for about 10 minutes. Eviscerated carcasses were individually weighed and dressing percentage was calculated (weight of carcass + giblet + abdominal fat/ pre-slaughter weight x 100). Percentage of liver, gizzard, spleen and abdominal fat were measured related to live weight.

Statistical analysis:

Data was subjected to analysis of variance using general linear model (**GLM**) described in SAS User's Guide (SAS, 2005) as in the following model:

$\mathbf{Y}_{ik} = \mathbf{U} + \mathbf{D}_i + \mathbf{F}_j + \mathbf{D}_i\mathbf{F}_j + \mathbf{E}_{ijK}$

Where:-

$\mathbf{Y}_{ik}$ = an observed value of the concerned trait.
U = an observed mean for the concerned trait.
D= the fixed effect due to diet physical form
$\mathbf{F}_j$= the fixed effect due to fasting system

$\mathbf{D}_i\mathbf{F}_j$ = the fixed effect due to diet form and fasting period.

$\mathbf{E}_{ijk}$ = experimental Random error.

Differences among all means of individual treatments were tested with Duncan multiple range test (Duncan, 1955), P values less than 0.001 were expressed as '< 0.001' rather than the actual value.

RESULTS AND DISCUSSION

Feed intake and growth performance:

The effects of mash or pellets diet form and fasting time on broilers performance is shown in (Table 2) which revealed that the higher body weight (BW) and body weight gain (BWG) were observed in birds fed on mash diets in comparison to those fed pellet diets. The highest feed intake and growth performance were observed in birds restricted for 6 hours. Data in (Table 3) show the interaction between the feed physical form and restriction the heaviest BWG (2237 g and 2218 g) were observed in birds fed T1 and T2, respectively during whole experimental period. Moreover, the biggest reduction in BWG (1717 g) was noted for T8 (pellet form + fasting for 10 hours) as compared by all other dietary treatments.

These results are in agreement with those of Sandilandsa *et al.* (2006) who found that birds' weight in all restricted treatments increased faster than that of control birds. On the contrary, Scheideler and Baughman (1993) and Deaton (1995) stated that restricting feed supply was found to have no significant effect on broiler performance during growing period. However, Benyi and Habi (1998) reported that chicks fed *ad libitum* grew faster and were found to be heavier than those on restricted feeding regimes. Also, in the study of Sandilandsa e*t al.* (2006) with broiler chickens BW of the control treatment in starter period was improved than that of the restricted feeding treatments.

Data in (Tables 2 & 3) showed that, fasting times significantly reduced (P < 0.001) feed intake in all treatments fasted for 6 or 8 hours as compared by control treatment in mash or pellets feed form during the whole experimental period. The present result was in agreement with Lee and Leeson (2001) who reported that birds subjected to transient feed restriction, generally ate less feed than did full-fed (control birds). Feed intake was influenced by particle size, with the intake of fine ground diets being greater than those of coarse ground diets (Amerah *et al.*, 2008). Data in Tables (2 & 3) indicated that, the feed mashform significantly improved (P<0.05) broilers gain/ feed ratio during the 1-21 days of age period. The best feed efficiency was observed in birds that continuously fasted 6 as compared by control treatment and all restricted groups (Table 2). However, birds fed pelleted feed and restricted for 6 hours (T6) exhibited the best feed efficiency (Table 3). The improvements in feed efficiency may be related to moderate grinding of feed ingredients that beneficially affect composition of the intestinal microbiota and production of microbial metabolites in the intestine (Mosenthin and Sauer, 2011). Therefore, especially for small feed particle size, higher costs of mechanical processing as well as possible reduction in gut health must be offset by improved nutrient and energy digestibility as well as feed conversion ratio. Amerah *et al.*, (2008) reported that pelleting evened out the differences in particle size distribution in pelleted diets, which resulted in a lack of a wheat particle size effect on broiler performance.

Carcass measurements:

Concerning the carcass characteristics (Tables 4 & 5), results indicated that there were significant differences due to diet form on live BW, carcass and gizzard weights. Using different feed restriction systems did not significantly affect carcass weights or liver relative percentages (Table 4). Interestingly, a linear reduction in abdominal fat percent (1.18% to 0.47%) for mash groups and (1.02 to 0.87%) for pellet groups were observed among dietary tested treatments. This observation could be due to feed restriction which have been shown to exert a reducing feed intake and subsequently abdominal fat% in the carcass. This finding agreed with those reported by Palo *et al.* (1995) who indicated that restricted feeding did not affect the carcass characteristics and the relative weights of different organs, except the relative weight of liver. Pelleting evened out the differences in particle size distribution of wheat-based diets, with no effects observed on performance and gizzard development (Engberg *et al.*, 2002; Svihus *et al.*, 2004; Amerah *et al.*, 2007). There were no significant (P> 0.05) main effects of particle size and grain type on the relative weight of gut components (Amerah *et al.*, 2008). In contrast, the particle size distribution in wheat-based diets remained after pelleting, with positive effects on carcass and gizzard development (Peron *et al.*, 2005 and Lentle *et al.*, 2006).

Table 2. Effects of feed physical form and feed restrictions on feed intake, feed efficiency and growth performance of broilers from 1to 42 days of age

Treatment	Body weight (g.)			Body weight gain (g.)			Feed intake (g.)			Gain / feed (g./ g.)		
	Initial 1d[2]	21 d	42 d	1-21 d	21-42 d	1-42 d	1-21 d	21-42 d	1-42 d	1-21 d	21-42 d	1-42 d
Mash diet	44	860 [a]	2161 a	816 a	1302 a	2117 a	1143	2361 a	3575 a	0.714 a	0.552	0.592
Pellets diet	43	737 [b]	1926 b	692 b	1189 b	1881 b	1097	2090 b	3258 b	0.633 b	0.569	0.578
SEM[1]	0.227	18.04	35.86	18.04	20.32	35.87	17.59	42.28	51.65	0.002	0.021	0.020
P-value	0.156	0.001	0.001	0.001	0.001	0.001	0.059	0.001	0.001	0.001	0.076	0.139
Fasting 0	44	840 a	2164 a	795 a	1324 a	2119 a	1173 a	2416 a	3660 a	0.679 b	0.545	0.580 b
Fasting 6 hours	44	860 a	2158 a	815 a	1299 a	2114 a	1130 ab	2203 b	3404 b	0.722 a	0.590	0.621 a
Fasting 8 hours	44	780 b	1940 b	736 b	1160 b	1897 b	1118 ab	2130 b	3318 b	0.657 bc	0.545	0.571 b
Fasting 10 hours	43	712 c	1910 b	668 c	1199 b	1867 b	1059 b	2154 b	3283 b	0.638 c	0.557	0.567 b
SEM[1]	0.227	18.04	35.86	18.04	20.32	35.87	17.59	42.28	51.65	0.001	0.166	0.020
P-value	0.561	0.001	0.001	0.001	0.001	0.001	0.020	0.001	0.001	0.001	0.083	0.139

Values in each column are means for 3 replicates of each treatment

[1]SEM: Standard error of means

[2]d: day

[a, b, …] Means with different superscripts in the same column are significantly different P≤ 0.05.

Table 3. Effects of interaction between feed physical form and feed restriction on feed intake (FI) and growth performance of broilers from 1- 42 days of age

Treatment [2]	T1	T2	T3 [1]	T4	T5	T6	T7	T8	SEM[1]	P-value
Body weight (.g)										
Initial weight 1 day	44	44	44	43	45	45	43	44	0.227	0.413
21 day	905 a	893 a	864 b	776 d	776 d	826 c	697 e	648 f	18.04	0.001
42 days	2281 a	2261 a	2043 b	2059 b	2047 b	2055 b	1838 c	1762 c	34.86	0.001
Body gain (g.)										
1-21 days	861 a	849 a	820 b	733 d	731 d	781 c	654 e	603 f	17.04	0.001
21-42 days	1377 a	1369 a	1179 cd	1284 b	1271 b	1229 bc	1140 d	1114 d	20.32	0.001
1-42 days	2237 a	2218 a	1999 b	2016 b	2002 b	2010 b	1795 c	1717 c	34.87	0.001
Feed intake (g.)										
1-21 days	1209 a	1183 a	1189 a	991 c	1137 ab	1077 bc	1048 bc	1127 bc	16.56	0.009
21-42 days	2610 a	2351 b	2181cbd	2304 b	2223 bc	2056 cd	2078 cd	2004 d	41.32	0.001
1-42 days	3889 a	3605 b	3431 bc	3365 bc	3431 bc	3265 bc	3196 c	3201 c	50.56	0.001
Gain/ feed (g./ g.)										
1-21 days	0.712 a	0.717 a	0.689 bc	0.739 a	0.646 cd	0.727 a	0.624 d	0.536 d	0.035	0.001
21-42 days	0.527	0.582	0.541	0.557	0.574	0.597	0.550	0.556	0.020	0.543
1-42 days	0.575 bcd	0.615 ba	0.581 abc	0.599 abc	0.586 abc	0.627 a	0.561 cd	0.536 d	0.018	0.040

[a, b, …] Means with different superscripts in the same column are significantly different ($P \leq 0.05$).
Values in each row are means for 3 replicates of each treatment
[1]: SEM: Stander error of means
[2]Treatments:
T1: fed mash diet + *ad libtum*
T2: fed mash diet + 6 h fasting
T3: fed mash diet + 8 h fasting
T4: fed mash diet + 10 h fasting
T5: fed pellets diet + *ad libtum*
T6: fed pellets diet + 6 h fasting
T7: fed pellets diet + 8 h fasting
T8: fed pellets diet + 10 h fasting

Table 4. Effects of feed physical form and feed restrictions on some carcass traits of broilers at 42 days of age

Treatments	Live body weight (g.)	Carcass weight (g.)	Dressing %	Abdominal fat %	Liver %	Gizzard%	Spleen %	Small intestine weight %	Small intestine length (cm.)
Mash diet	2224 [a]	1830 [a]	82.44	0.840	3.24	3.05a	0.361	6.81	179
Pellets diet	2011 [b]	1677 b	82.37	0.856	3.36	2.62b	0.334	6.52	180
[1]SEM	65.80	60.17	0.695	0.060	0.190	0.221	0.163	0.754	1.527
P-value	0.012	0.026	0.372	0.856	0.615	0.040	0.544	0.105	0.695
Fasting 0	2140	1844	86.20 a	1.11 a	3.17	2.51	0.300	6.29	185
Fasting 6 hours	2194	1791	81.79 bc	0.975 a	3.44	2.85	0.335	7.17	178
hours 8 Fasting	2082	1739	83.74 ab	0.636 b	3.59	3.00	0.407	6.70	178
Fasting 10 hours	2082	1641	79.88 c	0.676 b	3.00	2.98	0.347	6.49	177
[1]SEM	81.88	67.01	2.354	0.068	0.203	0.211	0.666	0.906	1.452
P-value	0.623	0.181	0.004	0.002	0.270	0.346	0.324	0.468	0.616

[a, b, …] Means with different superscripts in the same column are significantly different ($P \leq 0.05$).
Values in each column are means for 5 replicates of each treatment
[1]: SEM: Stander error of means

Table 5. Effects of interaction of feed physical form and feed restriction on some carcass traits of broilers at 42 days of age

Treatment [2]	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**SEM[1]**	**P-value**
Live body weight (g)	2279	2341	2143	2135	2002	2047	2021	1976	41.47	0.246
Carcass weight (g)	1944	1879	1755	1743	1744	1703	1724	1540	34.75	0.149
Dressing%	85.33[ab]	80.46 [bc]	82.03 abc	81.67 abc	87.07 a	83.13 abc	85.47 ab	78.09 c	0.695	0.012
Abdominal fat%	1.18 a	1.07 a	0.63 bc	0.47 c	1.02 ab	0.88 ab	0.64 bc	0.87 ab	0.055	0.004
Liver%	3.08	3.39	3.44	3.06	3.25	3.49	3.75	2.94	0.114	0.682
Gizzard%	2.59	2.21	2.75	2.89	2.43	3.47	3.24	3.06	0.327	0.084
Spleen %	0.259	0.323	0.462	0.289	0.340	0.348	0.352	0.406	0.345	0.622
Small %	5.85	7.25	7.31	6.82	6.73	7.09	6.08	6.15	0.456	0.372
Small intestine length (cm)	181	182	176	175	188	174	180	179	2.119	0.810

[a, b, …] Means with different superscripts in the same column are significantly different ($P \leq 0.05$).
Values in each row are means for 5 replicates of each treatment
[1]: SEM: Stander error of means
[2]: Treatments:
T1: fed mash diet + *ad libtum*, T2: fed mash diet + 6 h fasting, T3: fed mash diet + 8 h fasting, T4: fed mash diet + 10 h fasting, T5: fed pellets diet + *ad libtum*
T6: fed pellets diet + 6 h fasting, T7: fed pellets diet + 8 h fasting, T8: fed pellets diet + 10 h fasting

CONCLUSION

In conclusion, the results of this study suggest that interaction between feed physical form and feed restriction systems significantly improved live body weights, weight gains, and feed efficiency at starter, grower and whole experimental periods. Feed restriction significantly reduced feed consumption and abdominal fat without any side effects on carcass traits and digestive organs. However, more detailed studies are still needed to determine the optimal particle size and the mode of action of these feed physical forms to achieve the optimal growth performance, nutrient utilization and gut health in broiler production.

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تاثير التداخل بين شكل العليقة وتحديد الغذاء علي الأداء الإنتاجي وصفات الذبيحة لدجاج التسمين

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استخدم 192 طائر cobb من دجاج التسمين عمر يوم لتقيم تاثير التداخل بين شكل العليقة وتحديد الغذاء علي وزن الجسم والغذاء الماكول والكفاءة الغذائية وموصفات الذبيحة لدجاج التسمين. تم تقسيم الطيور الي مجموعتين تم تغذية احدهما علي عليقة محببة والاخري علي عليقة ناعمة. ثم قسمت كل مجموعة الي تحت أربع مجموعات تحديد غذاء مختلفة (6 , 8 , 10 ساعات) استمرت التجربة حتي عمر 42 يوم. اوضحت النتائج ان هناك تأثير معنوي لشكل العليقة عند منع التغذية لمدة 6 ساعات علي الاداء الانتاجي لدجاج التسمين, دون اي أثار جانبية علي موصفات الذبيحة. أدي التفاعل بين شكل العليقة وتحديد الغذاء الي تحسين وزن الجسم والغذاء المأكول وكذلك الكفاءة الغذائية بشكل ملحوظ. كما أدي تحديد الغذاء الي تقليل الغذاء المستهلك ودهن البطن بصورة معنوية بدون أي تأثير ضار علي صفات الذبيحة و أعضاء الجهاز الهضمي.