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EFFECT OF PELLETING SIZE AND PELLET BINDER LEVEL ON BROILER CHICKEN PERFORMANCE.

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SUMMARY

This study aimed to examine effects of pellet size and binder (calcium lignosulfonate, CLS) levels on performance and carcass during finisher period. About 180 one-day old *Arbo Acres* chicks were allocated on 6 groups of 30 birds each. Birds of all groups were offered the same starter and grower diets and then the experimental finisher diets were presented to birds. Starting from 29 days, finisher diets were offered in a (2*3) factorial design. (T1) diet was pelleted 3.5 mm with CLS 0.2% as control diet, (T2): 3.5 mm with CLS 0.4%, (T3): 3.5 mm with CLS 0.8%, (T4): 4.5 mm with CLS 0.2%, (T5): 4.5 mm with CLS 0.4%, (T6): 4.5 mm with CLS 0.8%. Results showed that live body weight (LBW), daily weight gain (DWG), daily feed intake (DFI) or feed conversion ratio (FCR), was insignificantly affected by treatments. Additionally, carcass traits; dressing percentage, gizzard, heart percentages, were insignificantly affected by neither pelleting size nor CLS levels. Also, performance index (PI), production efficiency factor (PEF), protein efficiency ratio (PER) and efficiency of energy utilization (EEU) were insignificantly affected by treatments. While relative economic efficiency (REE) recorded higher value with 4.5 mm pellets with CLS 0.2%. It could be concluded that using finisher diet pelleted in 4.5 mm is favorable for productive performance of birds and feed pelleting quality especially when CLS was added at level of 0.2%.

Keywords: *Pellet size, lignosulfonate, performance, broiler.*

INTRODUCTION

Feed mills are producing different types of broiler feeds for different ages (Jahan *et al.*, 2006). And as feed processing increases the feed cost, it can be balanced out by improved performance, which was reported by many researchers as broilers fed pelleted feed have higher body weight gain and improved feed conversion than those fed mash feed (McKinney and Teeter., 2004; Amerah et al 2008; Chewning et al, 2012). With regards to feed particle size, one traditional view was that a smaller particle size would be associated with a larger surface area of the feed particle, possibly resulting in improving digestibility due to a greater interaction with digestive enzymes in bird's gastrointestinal tract (Preston et al, 2000).

Buchanan *et al.* (2010) demonstrated that a thicker pellet die in relation to hole diameter increased starch gelatinization in feeds. However, these benefits tended to decrease when birds were fed low quality pellets or pellets with increase percentage of fines (McKinney and Teeter, 2004). A potential negative effect of reduced particle size is poor gizzard development, which has been found to be important for feed utilization and intestinal health (Ferket, 2000). However, results of studies concerning effects that particle size has on development of gizzard and feed utilization have been inconclusive.

Glover *et al.* (2016) indicated that improvement of pellet quality parameters as pellet durability index (PDI) from 50 to 70% had significantly improved FCR during starter (0 to 10 d) and finisher (22 to 38 d) periods.

Accordingly, the present study aimed to investigate effects of using different levels of CLS (2, 4, or 8 Kg/ Ton) along with two different pelleting sizes (3.5 mm and 4.5 mm) of broiler finisher feeds, on growth performance, carcass traits and economic efficiency

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MATERIALS AND METHODS

A total number of 180 as hatched one-day-old *Arbo Acres* broiler chicks were randomly distributed into 6 treatments. Each treatment comprised of 30 chicks which were separated into 3 replicates of 10 chicks each which were raised to 33 days on wire-floored battery cages. Three phase diets were presented to birds, as all groups were fed the same starter diet (1 - 14 days); then were fed the same grower diet (15 - 28 days); and the finisher diets (29 - 33 days) were presented accordingly with experimental design with different pellet diameter and with addition of different levels of calcium lignosulphonate. Accordingly, there were 6 experimental finisher diets; Control (T1) was pelleted in 3.5 mm with addition of CL 2 Kg/ Ton; (T2) pelleted in 3.5 mm with CL 4 Kg/ Ton; (T3) pelleted in 3.5 mm CL 8 Kg/Ton; (T4) pelleted in 4.5 mm with CL 2 Kg/ Ton;(T5) pelleted in 4.5 mm with CL 4 Kg/ Ton; (T6) pelleted in 4.5 mm with CL 8 Kg/ Ton. As shown in Table (1), diets used in this study were formulated to ensure adequate supply of nutrients suggested by guidebook of broilers according to NRC (1994). All chicks were reared under similar management conditions, with feed and water supply being provided *ad libitum.*

Table (1): Feed ingredients and chemical analyses of experimental basal diets.

Ingredients	Starter	Grower	Finisher
Yellow Corn Grains	58.03	61.69	65.55
Soybean Meal	35.05	27.00	19.70
Full-fat Soybean	3.39	8.30	11.85
Calcium Carbonate	1.21	1.12	1.03
Mono-Calcium Phosphate	0.91	0.57	0.51
DL-Methionine	0.30	0.25	0.26
Vitamin-Mineral Premix*	0.30	0.30	0.30
Salt (NaCl) & Sodium Sulphate	0.40	0.40	0.40
Lysine-HCl	0.14	0.11	0.13
L-Threonine	0.06	0.05	0.06
Additive Mix**	0.21	0.21	0.21
Total	100.00	100.00	100.00
Proximate Composition of Nutrients			
Metabolizable Energy (KCal/Kg)	2925	3015	3100
Crude Protein %	22.50	20.50	18.50
Calcium %	0.90	0.80	0.70
Available Phosphorus %	0.48	0.40	0.38
Lysine %	1.35	1.21	1.10
Methionine %	0.63	0.56	0.54
Methionine + Cysteine %	1.01	0.92	0.87
Threonine %	0.92	0.84	1.98
Diameter of Feed Pellets(mm)			
Standard diameter (SD)	1.5	2.5	3.5
Standard diameter (SD+1)			4.5

** Vitamin-Mineral premix contains: Vitamins: A: 12000000 IU; D3 2000000 IU; E: 10000 mg; K3: 2000 mg; B1:1000 mg; B2: 5000 mg; B6:1500 mg; B12: 10 mg; Biotin: 50 mg; Choline chloride: 250000 mg; Pantothenic acid: 10000 mg; Nicotinic acid: 30000 mg; Folic acid: 1000 mg; Minerals: Mn: 60000 mg; Zn: 50000 mg; Fe: 30000 mg; Cu: 10000 mg; I: 1000 mg; Se: 100 mg and Co: 100 mg. ** Additive Mix: Anti-toxin, Anti-coccidia*

Growth performance

Live body weight (LBW) of birds was recorded, and accordingly daily weight gain (DWG) was calculated by subtracting the initial LBW from final LBW, then divided by number of rearing days. Daily feed intake (DFI) was calculated from difference between amount of feed provided for each replicate and residual quantity, then divided by number of rearing days. Feed conversion ratio (FCR); g feed/ g gain; was calculated as a total feed consumed, in grams which is required to produce out one gram of weight gain. Performance index (PI), and production efficiency factor (PEF) were calculated according to Brody (1945), North (1981), and Emmert (2000), respectively as follows:

$$PI = \frac{\text{Live Body Weight (Kg)}}{\text{Feed Convesion Ratio}} X\ 100$$

$$PEF = \frac{\text{Livability X Mass (Kg)}}{\text{FCR X Age in Days}} X\ 100$$

Where:

Livability = 100 – Mortality Rate (%)

Mass (Kg) = Final LBW (Kg)

Carcass measurements

At 33 days, six birds representing each group were randomly taken, weighed, and slaughtered for carcass evaluation. After slaughter, birds were eviscerated, and giblets (gizzard, liver, and heart) were separated from viscera. The dressed carcass and giblets were weighed and then expressed as a percentage of the live body weight.

Economic values

The economic characters were estimated according to prices of local market as follows:

Total cost = feed cost + price of one-day old chick + incidental expenses

Total return = price per one Kg live weight × final LBW

Net return = total return – total cost

Economic efficiency = [net return / total cost] × 100

Statistical analysis

Data were analyzed using two-way analysis of variance for pellet size (S) and CLS levels (L) and their interaction using the General Linear Model (GLM) procedure of SAS (2004) as the following model:

$$Yijk = \mu + Si + Lj + (S*L)ij + eijk$$

Where: Yijk = trait measured, μ = Overall mean, Si = pellet size effect (i= 1, 2), Lj = CLS levels effect (j= 1, 2 and 3), (S*L)ij = interaction between size and levels, eijk = experimental error.

When significant differences among means were found, means were separated using Duncan's multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance:

Results presented in Table (2) revealed an insignificant increment of LBW for birds fed 4.5 mm finisher diets. This result was in accordance with that of. Dozier *et al.* (2010), who studied the effect of different feed form on the feed quality and broiler efficiency and identified that crumble feed improved feed efficiency and consume more feed over the corresponding mash feed. Also, Jahan *et al.* (2006) reported that higher, middle and lower values of body weight were observed by feeding crumble; pellet and mash feed forms, respectively. While other researchers stated that chicks fed diets as crumbles or as small pellets (1.59- or 3.17-mm die) for 0 to 13 d of age had significantly higher LBW and better FCR at 13 days than birds fed the same diet in mash form (Cerrate *et al.*, 2009).

Daily weight gain (DWG) results presented in Table (2) showed no significant ($P>0.05$) differences among all tested groups. On the other hand, there was a significant ($P<0.05$) increment in DWG with birds of (T4) that were fed 4.5 mm finisher diets. It has been demonstrated that birds fed pellets increase their metabolizable energy intake compared with less expended energy for eating and improve the net energy value of the feed (McKinney and Teeter., 2004; Nir *et al.*, 1994; Skinner-Noble *et al.*, 2005). In more recent study, Abdollahi *et al.* (2012) revealed that pellet binder addition to the diet conditioned at 90° C increased weight gain and feed intake and, also improved feed conversion ratio compared with those conditioned at 90° C without the pellet-binder inclusion.

Regarding pellet quality, Lilly *et al.* (2011) reported that birds fed high-quality (90% pellet) and medium-quality (70% pellet) feeds gained more live weight than those fed low-quality (30% pellet) and re-ground (100% fine) feeds.

However, daily feed intake (DFI) values presented in Table (2) showed no significant ($P>0.05$) differences among all tested groups, results revealed a significant ($P<0.05$) increase of DFI for birds fed 3.5 mm finisher diets specially in (T2) group. The magnitude of the body weight gain and FI responses of broilers fed pelleted feeds reflect a balance between the negative effect of conditioning at higher temperatures on nutrient availability and the positive effect on overall pellet quality. In general, the effect of thermal treatment on better feed efficiency is partly due to the fact that higher proportion of whole pellets facilitates broiler feed consumption and decreases feed waste, thereby reducing feed energy used for maintenance (Abdollahi *et al.*, 2012).

In earlier studies, it was stated that birds fed diets pelleted with the 1.59 mm die consumed greater amount of feed for 0-7 day's period while those fed diets pelleted with 3.17 mm die consumed less feed. The higher weight gain and feed intake with 1.59 mm diameter pellets were attributed to a more appropriate pellet size for oral cavity of birds at that age (Moran, 1989) and to improved nutritive value due to higher gelatinization of starch as pellet die diameter is reduced (Heffner and Pfost, 1973).

Values of overall feed conversion ratio (FCR) presented in Table (2) showed that there were no significant (P>0.05) differences among all tested groups. In accordance with several studies fines or ground pellets adversely affect feed conversion of broilers (Scott, 2002; Proudfoot and Hulan 1982; Plavnik *et al.*, 1997).

Table (2): Effect of dietary treatments on growth performance (1-33 days of age).

Items	Thickness (T) of Finisher Pellet	Pellet Binder Additive (A)			Overall
		2 Kg/ Ton	4 Kg/ Ton	8 Kg/ Ton	
LBW (g) (1-33 days)	3.5 mm	1836.25 ±65.20	1833.68 ±68.54	1803.33 ±80.67	1824.42
	4.5 mm	1873.13 ±13.40	1661.49 ±93.90	1671.46 ±37.31	1735.36
	Overall	1854.69	1747.58	1737.40	
DWG (g/ day) (1-33 days)	3.5 mm	54.14 ±2.02	54.06 ±2.04	53.17 ±2.45	53.79
	4.5 mm	55.29 ±0.44	48.89 ±2.84	49.20 ±1.14	51.12
	Overall	54.71	51.47	51.18	
DFI (g/ day) (1-33 days)	3.5 mm	81.12 ±1.52	81.13 ±3.14	79.34 ±2.18	80.53^a
	4.5 mm	80.16 ±0.74	72.51 ±2.72	75.63 ±1.93	76.10^b
	Overall	80.64	76.82	77.49	
FCR (g feed/ g gain) (1-33 days)	3.5 mm	1.50 ±0.05	1.50 ±0.02	1.49 ±0.08	1.49
	4.5 mm	1.45 ±0.01	1.50 ±0.13	1.53 ±0.02	1.49
	Overall	1.47	1.50	1.51	
Probability					
Trait	T	A		T*A	
LBW (33 days)	NS	NS		NS	
DWG (1-33 days)	NS	NS		NS	
DFI (1-33 days)	*	NS		NS	
FCR (1-33 days)	NS	NS		NS	

Means within the same row or column with different superscripts are significantly different. NS = Non Significant
*Sig.: Significance, NS: Non-Significant, * LBW: Live Body Weight, #DWG: Daily Weight Gain, ¥DFC: Daily Feed Consumption, $ FCR: Feed Conversion Ratio.*

Carcass traits

Data representing some of carcass characteristics taken at 33 days are showed in Table (3). Results showed no significant (P>0.05) differences among all tested groups. Contrastingly, results revealed a significant (P≤0.01) increase in liver percentage for birds fed 4.5 mm diets specially group (T6). While, the values of other carcass traits indicated that, all groups were significantly (P>0.05) similar. In the same trend, Moradi *et al.* (2018) indicated that higher carcass weight was recorded with broilers fed high-quality (90% intact pellets) and medium quality (70% intact pellets) feeds, rather than ground pellets feeds (100% fine). Also, Corzo *et al.* (2011) observed heavier carcasses in birds fed 64% pellets compared with 32% pellets and mash diets. On the other hand, no significant change in dressed carcass value within all tested groups, as Ebrahimi *et al.* (2010) and Sogunle *et al.* (2013) reported that feed forms and feed particle size had no effect on carcass dressing percentage, and the effects found were due to the interaction of feed forms and particle sizes effect.

Table (3): Effect of dietary treatments on some carcass parameter.

Items	Thickness (T) of Finisher Pellet	Pellet Binder Additive (A) level			Overall
		2 Kg/ Ton	4 Kg/ Ton	8 Kg/ Ton	
Dressed Carcass%	3.5 mm	71.84 ±1.21	70.68 ±0.58	70.27 ±1.26	70.93
	4.5 mm	72.26 ±1.11	72.63 ±1.11	70.13 ±1.88	71.67
	Overall	72.05	71.65	70.20	
Liver%	3.5 mm	2.28 ±0.12	2.24 ±0.17	2.09 ±0.07	2.20^{b}
	4.5 mm	2.67 ±0.14	2.27 ±0.11	3.28 ±0.60	2.74^{a}
	Overall	2.47	2.25	2.68	
Gizzard%	3.5 mm	0.99 ±0.07	0.99 ±0.10	1.12 ±0.06	1.03
	4.5 mm	1.20 ±0.05	1.07 ±0.13	1.05 ±0.06	1.10
	Overall	1.09	1.03	1.08	
Heart%	3.5 mm	0.57 ±0.03	0.46 ±0.03	0.53 ±0.03	0.52
	4.5 mm	0.57 ±0.08	0.49 ±0.03	0.51 ±0.05	0.52
	Overall	0.57	0.48	0.52	
Probability					
Trait	T	A		T*A	
Dressed Carcass%	NS	NS		NS	
Liver%	*	NS		NS	
Gizzard%	NS	NS		NS	
Heart%	NS	NS		NS	

Means within the same row or column with different superscripts are significantly different. NS = Non-Significant

Similarly, as no significant changes were observed in gizzard value within all groups, Engberg *et al.* (2002) showed that pellet-fed birds had lower gizzard and pancreas weights than mash-fed birds. The same authors also reported higher pancreatic activities for amylase, lipase and chymotrypsin in mash-fed birds compared to pellet-fed birds. In this regard, several authors found that carcass traits (dressing percentage, thigh, breast, drumsticks and abdominal fat) were not affected by feed form (Mirghelenj and Golian, 2009; Beg *et al.*, 2011; Ahmed and Abbas, 2013; Farghly *et al.*, 2014). And correspondingly, no significant changes were existed in total edible parts percent within all tested groups in the present trial.

Production efficiency

Data presented in Tables (4) and (5) showed that performance index (PI) was improved in (T4) group that was fed 4.5 mm with adding CL 2 kg/ton while performance efficiency factor (PEF) was higher in group (T2) that was fed 3.5 mm with adding CL 4 kg/ton. Also, no significance changes in protein efficiency ratio (PER) was high in (T4) group while efficiency of energy utilization (EEU) was high in (T6) group when compared to other groups.

Economic efficiency

As shown in Table (6), under conditions of the present study, birds fed (T3), (T5), or (T6) diets presented lower economic efficiency (EE) values, when contrast with other groups. However, there was a clear decline in the net return for these groups in comparison with other treatments. In contrast, birds fed (T1), (T2), or (T4) diets recorded better EE values as corresponding net return rates were higher when compared to that of other groups. Higher relative economic efficiency (REE) value recorded by (T4) group (+9.73%) is correlated to lower feed costs for this group, as birds recorded marginally higher values of final LBW.

Table (4): Effect of dietary treatments on production efficiency (1-33 days of age).

Item	Thickness (T) of finisher Pellet	Pellet Binder Additive (A)			Overall
		2 Kg/ Ton	4 Kg/ Ton	8 Kg/ Ton	
PI#	3.5 mm	119.51 ±8.0	118.94 ±4.90	118.28 ±11.24	118.911
	4.5 mm	125.89 ±2.42	110.82 ±17.46	105.65 ± 3.23	114.123
	Overall	122.703	114.882	111.967	
PEF¥	3.5 mm	78.93 ±1.48	78.94 ±3.05	77.20 ±2.12	78.359
	4.5 mm	77.99 ±0.72	70.55 ±2.64	73.59 ±1.87	74.049
	Overall	78.465	74.748	75.398	
Probability					
Trait	T	A	T*A		
PI#	NS	NS	NS		
PEF¥	NS	NS	NS		

Sig.: Significance, NS: Non-Significant; #PI: Performance Index, North (1981); ¥PEF: Production Efficiency Factor, Emmert (2000).

Table (5): Effect of dietary treatments on production efficiency (1-33 days of age).

Item	Thickness (T) of finisher Pellet	Pellet Binder Additive (A)			Overall
		2 Kg/ Ton	4 Kg/ Ton	8 Kg/ Ton	
PER€	3.5 mm	3.28 ± 0.11	3.27 ±0.04	3.29 ±0.18	3.28
	4.5 mm	3.39 ±0.04	3.34 ±0.33	3.20 ±0.05	3.31
	Overall	3.33	3.30	3.24	
EEU$	3.5 mm	4.53 ±0.15	4.53 ±0.06	4.52 ±0.25	4.53
	4.5 mm	4.38 ±0.05	4.52 ±0.41	4.64 ±0.071	4.51
	Overall	4.45	4.52	4.58	
Probability					
Trait	T	A	T*A		
PER€	NS	NS	NS		
EEU$	NS	NS	NS		

Sig.: Significance, NS: Non-Significant; € PER: Protein efficiency Ratio (g protein/ g gain); $ EEU: Efficiency of Energy Utilization (1000 Kcal/ g gain).

Table (6): Effect of dietary treatments on some economic traits.

Parameter	Dietary Treatment					
	3.5 mm			4.5 mm		
	1	2	3	4	5	6
Total Feed Cost$ (LE)	18.58	18.59	18.17	18.36	16.61	17.32
Total Production Cost¥ (LE)	31.58	31.59	31.17	31.36	29.61	30.32
Total Return# (LE)	44.66	44.60	43.86	45.61	40.33	40.58
Net Return (LE)	13.08	13.01	12.68	14.24	10.72	10.26
Economic Efficiency %	41.41	41.13	40.76	45.44	36.67	33.82
Relative Economic Efficiency¤	100	99.32	98.43	109.73	88.55	81.67

$Feed cost includes processing costs; ¥Total production cost= [feed cost + price of one-day-old live chick (8 LE) + incidental costs (5 LE)]; #Total return is calculated according to local price of Kg sold live birds which was 25.00 LE; ¤Relative economic efficiency is determined assuming that relative economic efficiency of control (T1) group equals 100.

To improve the mechanical properties of pellets, a part from selection of technical parameters for the palletization process, binding agents are used that increase pellet hardness (Emadi *et al.*, 2017). This inclusion level helped in reduction of energy use of the pellet mill which decrease pelleting costs and increase overall pellet quality (Corey *et al.*, 2014). Pelleting reduces feed wastage, which may be attributed to less particles falling from beak onto the floor or into the water (Jensen, 2000). In general, economics of selection of dietary nutrient density should be taken into considerations prior to realization of improvement of production parameters (Saleh *et al.,* 2004). It is widely known that feed costs are about 60-65% of the total cost of any broiler operation; therefore it is advisable to minimize manufacturing costs (Cutlip *et al.*, 2008). Because cost of feed is a substantial portion of producing meat, even small increases in feed conversion can increase economic returns as observed with data recorded with birds fed (T2) diet with CL 2 Kg/ Ton.

CONCLUSION

It could be supposed that adding CL at 2 Kg/ Ton with finisher pelleted feeds with 4.5 mm for broilers could be economically utilized. This statement is realized after reviewing all obtained results which present no bad effects of dietary treatments on all recorded data of performance and carcass with good feed quality.

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تأثير حجم التصبيع ومستوى رابط المصبعات على أداء دجاج التسمين

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استهدفت الدراسة الحالية دراسة تأثير حجم المصبعات، ونسبة إضافة الكالسيوم ليجنوسلفونات (CLS) كمادة رابطة للمصبعات على أداء النمو، وخصائص الذبيحة لدجاج التسمين خلال فترة الناهي وكذلك كفاءة تصبيع العلف. إستمرت التجربة المزرعية 33 يوم بإستخدام 180 كتكوت من سلالة Arbor Acres عمر يوم واحد، تم تقسيمهم على 6 مجموعات تجريبية من 30 طائرًا لكل منها، والتي تم تقسيمها تباعاً إلى 3 مكررات بكل منها 10 طيور. تم تقديم في مرحلة البادئ وبداية من عمر يوم واحد نفس العلف البادئ لكل مجموعات الطيور وذلك حتى عمر 14 يومًا، وكذلك تم تقديم نفس عليقة النامي لكل المجموعات حتى عمر 28 يوما، ثم بعد ذلك وخلال فترة الناهي، تم تقديم العلائق التجريبية للطيور وفقاً لتصميم التجربة. وزعت المعاملات في تصميم عاملي (2 * 3) لتقديم علائق الناهي للطيور، بدءاً من 29 يوماً وحتى 33 يوماً من العمر، بالمواصفات التالية: مجموعة (T1) علف مصبع بحجم 3.5 ملم مع CLS (2 كجم / طن)، مجموعة (T2)علف مصبع بحجم 3.5 ملم مع CLS (4 كجم / طن)، مجموعة (T3) علف مصبع 3.5 ملم مع CLS (8 كجم / طن)، مجموعة(T4) علف مصبع 4.5 ملم مع CLS (2 كجم / طن)، مجموعة (T5) علف مصبع 4.5 ملم مع CLS (4 كجم / طن)، مجموعة (T6) علف مصبع 4.5 ملم مع CLS (8 كجم / طن). أظهرت النتائج أن وزن الجسم الحي ، زيادة الوزن اليومية ، الإستهلاك الغذائي اليومي أو نسبة التحويل الغذائي لم تتأثر معنوياً بالمعاملات الغذائية. بينما حقق وزن الجسم الحى مع تقديم العلف الناهي في مصبعات بحجم 3.5 مم قيمة أعلى. وبالمثل، فإن وزن الجسم اليومى خلال فترة الناهي، سجل قيمة أعلى بشكل ضئيل للطيور التي غذيت على علف مصبع 3.5 ملم. كذلك أظهرت قيم الغذاء اليومى المأكول مع تصبيع العلف بحجم 3.5 ملم زيادة معنوية. لم يلاحظ فروق معنوية بين عليقتي الناهي (3.5 أو 4.5 ملم) على قيمة معدل التحويل الغذائى بالإضافة إلى ذلك، فإن مواصفات الذبيحة (نسبة التصافي، القانصة أو القلب) في عمر 33 يومًا لم تتأثر معنوياً بحجم المصبعات ولا بمستويات إضافة CLS بينما كانت هناك زيادة معنوية في نسبة الكبد في المجموعات المغذاة على علف مصبع بحجم 4.5 ملم. لم تتأثر قيم مؤشر الأداء وعامل كفاءة الإنتاج ونسبة كفاءة البروتين وكفاءة استخدام الطاقة بالمعاملات الغذائية. سجلت الكفاءة الاقتصادية النسبية بالإضافة إلى ذلك قيمة أعلى مع تغذية الطيور على علف مصبع بحجم 4.5 ملم وذلك مع إضافة CLS 2 كجم / طن.

يمكن الاستنتاج من هذه التجربة أن استخدام عليقة الناهي المصبعة بحجم 4.5 ملم تبدو مناسبة لتحقيق أداء إنتاجي جيد للطيور خاصة عند إضافة مستحضر CLS بمعدل 2 كجم / طن.