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IMPACT OF PELLET BINDER ON BROILER PERFORMANCE AND FEED PROCESSING ECONOMICS

M.A.M. Abdelaziz

Poult. Prod. Dept., Fac. of Agric., Ain Shams Univ., Egypt

Corresponding author: Mrwan Abdelaziz; E-mail: mrwanabdelaziz@agr.asu.edu.eg

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ABSTRACT: Total number of 216 one-day-old, unsexed Hubbard broiler chicks were used to study effects of pellet binder level together with pelleting diameter on growth performance, carcass measurements, and economic efficiency. Experimental birds were distributed over 6 groups, each group comprised of 36 chicks in 6 replicates of 6 chicks each. The experimental dietary treatments were as follows: control (T1) basal diet (BD) that is pelleted in standard diameter (SD) with addition of calcium lignosulfonate (CL) 2 Kg/ Ton; (T2) BD pelleted in SD with CL 4 Kg/ Ton; (T3) BD pelleted in SD with CL 8 Kg/ Ton; (T4) BD pelleted in a diameter thicker that SD by 1.0 mm (SD+1) with CL 2 Kg/ Ton; (T5) BD pelleted in SD+1 with CL 4 Kg/ Ton; and (T6) BD pelleted in SD+1 with CL 8 Kg/ Ton. Obtained results showed that all parameters of growth performance; live body weight (LBW), daily weight gain (DWG), daily feed consumption (DFC), and feed conversion ratio (FCR) were not significantly affected (P>0.05) by dietary treatments. Also, values of growth efficiency; relative growth rate (RGR),performance index (PI), production efficiency factor (PEF), protein conversion ratio (PCR), and energy conversion ratio (ECR) indicated no significant differences (P>0.05) within all tested groups. Moreover, data of carcass traits; dressed carcass, abdominal fat, giblets, total edible parts appeared significantly similar (P>0.05) among all treatments. Additionally, data of economic evaluation showed better economic efficiency with T2, T5, or T6 groups when compared to other groups. It could be concluded that using CL as a pellet binder in SD conditions, could be more beneficial with inclusion level of 4 Kg/Ton. Moreover, it might be advised to include CL at 8 Kg/ Ton in diets only when pelleting feedatSD+1 as these conditions positively maintained performance and carcass of birds.

Key words: calcium lignosulfonate, broiler, pellet diameter, performance, carcass.

INTRODUCTION

The pelleting process of feeds is a hydrothermal procedure in feed processing (Abdollahi*et al.*, 2013).The benefits of pelleting feeds have been well documented with decreased feed wastage, reduced selective feeding, decreased ingredient segregation, less time and energy spent on prehension, and improved palatability (Moritz *et al.*, 2002; Behnke and Beyer, 2002).Earlier research and investigations about pelleted feeds, have proven advantages that are associated with improved feed handling characteristics, increased feed consumption and body weight gain, and improved feed conversion ratio (Behnke, 1996; Jensen*et al.*, 1962).In Addition, McKinney and Teeter (2004) revealed that pelleted feeds reduce energy required by birds that is actually spent on acquiring feed. And according to quality of pelleted feed, broilers that were fed hard pellets recorded improved nutrient retention and subsequent growth performance when compared with broilers fed soft pellets (Parsons *et al.*, 2006). Theses authors also stated that pellet consistency might affect broilers in an approach like that of particle size of feed ingredients. One of well-known techniques that are used to resolve poor pellet quality is the utilization of pellet binders as most feed manufacturers use lignin, as lignosulphonate as feed pellet binder (Baurhoo*et al.*, 2008). Calcium lignosulfonate (CL) has been used in a wide range of industries, as lignosulfonates have specific dispersing, binding, and emulsifying properties (Cecilia *et al.*, 2008). Due to the binding properties of CL, it is used as a pellet binder in feed processing to improve pellet quality (Acar*et al.*, 1991). To exploit benefits of CL usage, feed must not only be pelleted simply, but it should be produced using specific techniques that maintain nutrient availability as inclusion of CL in pelleted feed reduced energy use of the pellet mill, pellet temperature after extrusion, and increased pellet quality (Corey *et al.*, 2014).Furthermore, Abadi *et al.* (2019b) stated that diets containing 0.5% CL had better physical pellet quality values. In general, most studies done for examining CL as a pellet binder mostly focus on absolute pellet quality rather than the effect of pelleting diameter. Accordingly, the present study aimed to investigate effects of using different levels of CL (2, 4, or 8 Kg/ Ton) along with two different pelleting diameters [standard diameter (SD) or 1.0 mm thicker than standard diameter (SD+1)] of broiler feeds, on growth performance, carcass traits and economic features.

MATERIALS AND METHODS

Birds and experimental diets

A total number of two hundred sixteen unsexed one-day-old *Hubbard* broiler chicks were randomly distributed into 6 treatments. Each treatment comprised of 36 chicks which were divided into 6 replicates of 6 chicks each which were reared up to 33 days of age in wire-floored batteries. Three periodical diets were presented as starter diet (1 - 11 days); grower diet (12-22 days); and finisher diet (23 - 33 days). During each of these three phases, pelleted feed is presented in two diameters according to experimental design: standard diameter (SD) or standard diameter + 1 mm (SD+1).Diameters of (SD) pelleted feeds were 1.5, 2.5, and 3.5 mm for starter, grower, and finisher diets, respectively. While diameters of (SD+1) pelleted feeds were 2.5, 3.5, and 4.5 mm for starter, grower, and finisher diets, respectively. Furthermore, the studied pellet binder material; Calcium lignosulfonate (CL) was added to diets in three levels. CL is a product of GREEN AGROCHEM CO., LTD, China. This pellet binder is designed to be added to finished feed mix by about 2 Kg/ Ton. There were 6experimental diets; Control (T1) basal diet (BD) that is pelleted in SD with addition of CL 2 Kg/ Ton; (T2) BD pelleted in SD with CL 4 Kg/ Ton; (T3)

BD pelleted in SD with CL 8 Kg/ Ton; (T4) BD pelleted in SD+1 with CL 2 Kg/ Ton; (T5) BD pelleted in SD+1 with CL 4 Kg/ Ton; and (T6) BD pelleted in SD+1 with CL 8 Kg/ Ton. As shown in Table 1, diets used in the present study were formulated to ensure adequate supply of nutrients suggested by guidebook of Hubbard broilers according to NRC (1994). All birds were reared under similar management conditions, with feed and water being provided *ad libitum*.

Growth performance

Live body weight (LBW) of birds was recorded, and daily weight gain (DWG) was calculated per by subtracting the initial LBW from final LBW, then divided by number of rearing days. Daily feed consumption (DFC) 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 the amount of feed consumed, in grams which is required to produce out one gram of weight gain. Relative growth rate (RGR), performance index (PI), and production efficiency factor (PEF) were calculated according to Brody (1945), North (1981), and Emmett (2000), respectively as follows:

$$RGR=\frac{w2-w1}{½(w1+w2)}\times 100$$

w1: initial live weight, w2: final live weight

$$PI=\frac{\text{Live body weight (Kg)}}{\text{Feed Conversion Ratio}}\times 100$$

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

Livability = 100 – Mortality rate (%), Mass (Kg) = Final live body weight.

Carcass measurements

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

Economic values

The economic characters were calculated according to prices of local market at the time of the study as follows:

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

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

Net return= total return – total cost

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

Statistical analysis

All data were analyzed by one-way analysis of variance (ANOVA) followed by Duncan to compare the means between individual treatments using statistical analysis system (SAS, 2004) version 9.1 for Windows at P<0.01 level and presented as mean values with ± standard error of the mean (S.E.M, r=3). The data were subjected to statistical analysis according to the following model: $Y_{ij}= \mu + T_i + e_{ij}$ Where:Y_{ij}= the experimental observation, μ= overall mean, T_i= dietary treatment, e_{ij}= experimental error. Then, individual effects of experimental groups were compared using Duncan (1955) multiple range tests at α level equal to 0.05 or 0.01.

RESULTS AND DISCUSSION

Growth performance:

Effects of different dietary treatments on live body weight (LBW), daily weight gain (DWG), daily feed consumption (DFC) and feed conversion ratio (FCR) are presented in Table 2. Data shows that final LBW was not significantly affected by treatments. Similarly values of DWG (g/ day) were significantly similar (P>0.05) among all treatments. However, valuesof LBW and

DWG recorded mathematically higher values with birds of T6 group. In the same way, data of DFC (g/ day) present insignificant differences within different test groups. Also, all groups appeared significantly similar regarding values of FCR (g feed/ g gain). Though birds of T2grouprecorded numerically better FCR value when compared to other experimental groups. Results of current study agree with those of Abadi *et al.*, (2019a), who stated that level of pellet binder of broiler feed had no significant effect on LBW and FCR up to 42 days of age. On the other hand, obtained results disagree with Corey *et al.* (2014) who stated that broilers fed diets pelleted with variant levels of CL, presented increment in feed consumption and body weight gain. However, Acar*et al.* (1991) found that broiler feed consumption was increased with using CL as pellet binder; with worsened FCR values. Although no significant differences, the numerical positive response on LBW of T6 group can be described as pellet size fits bird's oral cavity (Moran, 1989) and consequently less activity that is required throughout eating and resting activities (Skinner-Noble*et al.*, 2005). In the same way and according to earlier study, Cerrate*et al.* (2008) stated that thicker presenting thicker pellets to broilers during grower phase recoded higher feed consumption. Several previous studies are in accord with these results (Engberg *et al.*, 2002; Maiorka*et al.*, 2005; Salari*et al.*, 2006; Jahan *et al.*, 2006)

Growth efficiency:

Table 3 presents data of relative growth rate (RGR), performance index (PI), production efficiency factor (PEF), protein conversion ratio (PCR), and energy conversion ratio(ECR) as affected by dietary treatments. The results indicated that all experimental groups recorded significantly similar (P>0.05) values of RGR. Similarly values of PI appeared unaffected by any of test diets. However, the group of birds that were fed T6 diet (SD+1 & CL 8 Kg/ Ton) showed numerically better PI value. In the same way, PEF of the group fed T6 diet (SD+1 & CL 8 Kg/ Ton) present mathematically higher value, though all groups appeared significantly similar. Regarding values of both PCR (g protein/ g gain) or ECR (1000 Kcal/ g gain), all groups seemed significantly the same. These results are in a partial agreement with those of Abadi *et al.*, (2019a), who reported that PEF of broilers at 42 days of age was not significantly affect by the level of pellet binder. Values representing RGR, PI or PEF had almost the same pattern as those of growth performance; LBW and FCR, as treatments higher body weight also recorded better growth efficiency values. Despite insignificance of tested parameters, improved body weight in relation to increased dietary nutrient density might be attributed to short time of feeding (Cerrate*et al.*, 2008).

Carcass traits:

Data of percentile carcass traits as affected by experimental treatments are presented in Table 4. Values of dressed carcass were not significantly (P>0.05) affected by any of test diets. Also, abdominal fat values seemed significantly similar within all groups. Likewise, there were no significant variations among tested groups concerning percentages of giblets or total edible parts. It is widely known that feed particle size greatly affects gastrointestinal development specially the gizzard (Hetland*et al.*, 2002). Consequently, fine feed will lead to a poorly developed gizzard (Taylor and Jones, 2004), while large and tough particles improve gizzard muscles (Svihus, 2014). Despite pelleted feed might differ in diameter, all feed ingredients are ground finely prior to mixing and pelting which make pellet feed ineffective in gizzard development regardless the pellet diameter (Aguzey*et al.*, 2018). Results of the current study agreed with those of Glover *et al.* (2016) who stated that breast yield was not significantly affected by presenting either high- or low-quality pelleted feed for broilers. Also, carcass yield and abdominal fat percentages were not affected by neither feed form nor feed particle size (Mingbin*et al.*, 2015).Moreover, abdominal fats remained rather unaffected by increased dietary nutrient density (Saleh *et al.*, 2004). In accordance with earlier studies, Acar*et al.* (1991) stated that carcass yield of broilers was not affected by dietary inclusion of CL as pellet binder. On the other hand, Saleh *et al.* (2004) declared that higher nutrient density levels tended to decrease dressing percentage of broilers. While other study showed that abdominal fat percentage was increased with added CL in pelleted feeds for broilers (Acar*et al.*, 1991).

Economic efficiency:

As shown in Table 5, under conditions of the present study, birds fed T1 (control), T3, or T5 diets presented lower economic efficiency(EE) values, when compared with other groups. As there was a clear decline in the net return for these groups in comparison with other treatments. On the other hand, birds fed T2, T4, or T6 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 T2 group (+7.54%) is correlated to lower feed costs for this group, as birds recorded slightly lower value of DFC. Alternatively, better REE recorded for T4 and T6 groups (+8.61% and 10.65%) was attributed to a clear increase in total return for these groups, as birds recorded marginally higher values of final LBW. Dietary treatments T2 or T6 include higher level of CL, being 4, 8 Kg/ Ton, respectively. 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).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 the 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 (SD & CL 2 Kg/ Ton).

CONCLUSION

It could be concluded that, pelleted feed for broilers at standard pelleting diameter(SD) could be economically utilized with the addition of CL at 4 Kg/ Ton. And to present more economical feed processing and utilization, it could be advised to add CL at 8 Kg/ Ton with pelleting feed with 1.0 mm thicker diameter (SD+1). This statement is realized after reviewing all obtained results which present no adverse effects of dietary treatments on all recorded data of performance and carcass.

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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 + 1 mm (SD+1)	2.5	3.5	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

Table (٢): Effect of dietary treatments on growth performance (1-33 days of age).

Parameters	Dietary Treatments						
	1	2	3	4	5	6	Sig.
Initial LBW* (g)	46.83 ±0.83	48.12 ±0.95	47.96 ±0.08	49.16 ±1.10	47.83 ±0.79	48.83 ±0.43	NS
Final LBW* (g)	1650.42 ±100.05	1655.42 ±55.22	1616.95 ±75.39	1747.84 ±32.35	1686.04 ±49.98	1792.38 ±22.93	NS
DWG# (g/ day)	48.59 ±3.01	48.70 ±1.64	47.54 ±2.28	51.47 ±0.94	49.64 ±1.49	52.89 ±0.70	NS
DFC¥ (g/ day)	74.91 ±6.19	72.94 ±2.96	75.57 ±2.31	79.86 ±3.16	77.62 ±1.35	82.05 ±1.18	NS
FCR$ (g feed/ g gain)	1.53 ±0.05	1.50 ±0.08	1.59 ±0.05	1.55 ±0.08	1.56 ±0.03	1.55 ±0.04	NS

Sig.: Significance, NS: Non-Significant, *LBW: Live Body Weight, #DWG: Daily Weight Gain, ¥DFC: Daily Feed Consumption, $FCR: Feed Conversion Ratio.

Table (3): Effect of dietary treatments on production efficiency (1-33 days of age).

Parameters	Dietary Treatments						
	1	**2**	**3**	**4**	**5**	**6**	**Sig.**
RGR[*]	188.89 ±0.60	188.69 ±0.17	188.42 ±0.54	189.05±0.04	188.95 ±0.18	189.39 ±0.22	NS
PI[#]	107.39 ±6.90	111.21 ±8.86	101.99 ±8.04	113.23±7.22	107.92 ±5.24	115.82 ±4.35	NS
PEF[¥]	306.85 ±19.72	317.75 ±25.33	291.41 ±22.99	323.52±20.66	308.33 ±14.98	330.91 ±12.44	NS
PCR[€]	0.30 ±0.01	0.30 ±0.01	0.32 ±0.01	0.32 ±0.02	0.31 ±0.01	0.31 ±0.01	NS
ECR[$]	45.40 ±1.42	44.82 ±2.69	47.80 ±1.67	47.58 ±3.26	46.95 ±1.16	45.90 ±1.27	NS

Sig.: Significance, NS: Non-Significant; [*]RGR: Relative Growth Rate, Brody (1945); [#]PI: Performance Index, North (1981); [¥]PEF: Production Efficiency Factor, Emmert (2000); [€]PCR: Protein Conversion Ratio (g protein/ g gain); [$]ECR: Energy Conversion Ratio (1000 Kcal/ g gain).

Table (4): Effect of dietary treatments on some of carcass characteristics, 33 days.

Items (%)	Dietary Treatments						
	1	**2**	**3**	**4**	**5**	**6**	**Sig.**
Dressed Carcass	70.67 ±1.74	70.58 ±1.68	68.99 ±0.69	71.81 ±0.92	69.51 ±0.55	74.15 ±1.58	NS
Abdominal Fat	1.43 ±0.18	1.65 ±0.12	1.61 ± 0.22	1.66 ±0.12	1.88 ±0.39	1.82 ±0.21	NS
Giblets[*]	3.58 ±0.30	4.15 ±0.03	4.08 ±0.09	5.16 ±0.72	4.50 ±0.30	3.99 ±0.09	NS
Total Edible Parts[#]	74.26 ±1.45	74.73 ±1.68	73.08 ±0.60	76.98 ±1.65	74.01 ±0.26	78.14 ±1.61	NS

Sig.: Significance, NS: Non-Significant, [*]Giblets = Liver + Gizzard + Heart, [#]Total Edible Parts = Dressed Carcass + Giblets

Table (5): Effect of dietary treatments on some economic traits.

Items	Dietary Treatments					
	1	**2**	**3**	**4**	**5**	**6**
Total Feed Cost[$] (LE)	17.25	16.81	17.51	18.39	17.88	19.02
Total Production Cost[¥] (LE)	30.25	29.81	30.51	31.39	30.88	32.02
Total Return[#] (LE)	41.26	٤١.٣٨	٤٠.٤٢	٤٣.٦٩	٤٢.١٥	٤٤.٨٦
Net Return (LE)	11.01	11.57	9.91	12.30	11.27	12.84
Economic Efficiency	36.27	39.01	32.41	39.40	36.45	40.14
Relative Economic Efficiency[¤]	100.00	107.54	89.36	108.61	100.49	110.65

[$]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 ٢٥.00 LE; [¤]Relative economic efficiency is determined assuming that relative economic efficiency of control (T1) group equals 100.

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الملخص العربي

تأثير رابط المصبعات على الأداء الإنتاجي لدجاج التسمين وإقتصاديات تصنيع الأعلاف

مروان عبدالعزيز محمود عبدالعزيز
قسم إنتاج الدواجن - كلية الزراعة - جامعة عين شمس - مصر

تم استخدام ٢١٦ كتكوت تسمين غير مجنسعمر يوم واحد من سلالةهبرد لدراسة تأثير مستوى رابط المصبعات وقطر المصبعات على الأداء الإنتاجي وقياسات الذبيحة والكفاءة الاقتصادية. في هذه الدراسة تم توزيع الطيور عشوائيا على ٦ مجموعات، بحيث تحتوي كل مجموعة ٣٦ كتكوت في ٦ مكررات من ٦ كتاكيتبكل مكررة. العلائق التجريبيةكانت عبارة عن عليقة control (T1) عليقة قاعدية (basal diet - BD) تم تصبيعها بالقطر قياسي (standard diameter - SD) مع إضافة رابط المصبعات (calcium lignosulfonate - CL) بمعدل ٢ كجم/ طن؛BD (T2) مصبعة بقطرSDومضاف إليهاCLبمعدل 4 كجم/ طن؛ BD(T3) مصبعة بقطرSDومضاف إليهاCLبمعدل ٨ كجم/ طن؛ BD (T4) بقطر أكثر سمكًا من SD بمقدار ١.٠ ملم (SD+1) مع إضافةCL بمعدل ٢ كجم/ طن؛ BD(T5) مصبعة بقطر(SD+1)ومضاف إليهاCLبمعدل ٤ كجم/ طن؛ و BD(T6) مصبعة بقطر(SD+1)ومضاف إليهاCLبمعدل 8كجم/ طن. أظهرت النتائج المتحصل عليها أن جميع مؤشرات أداء النمو: وزن الجسم الحي، الزيادة الوزنية اليومية، المستهلك اليومي من العلف، ومعامل التحويل الغذائي لم تتأثر معنويا (P>0.05) بالمعاملات الغذائية. كذلك فإن قيم كفاءة النمو: معدل النمو النسبي،دليل الأداء،معامل كفاءة الإنتاج، معامل تحويل البروتين ومعامل تحويل الطاقة، أشارت إلى عدم وجود إختلافات معنوية (P>0.05) بين جميع المجموعات التجريبية. علاوة على ذلك، فإن بيانات خصائص الذبيحة:النسبة المئوية للذبيحة، دهن البطن، الحوائج، والأجزاء الكلية المأكولة،قد أظهرت تشابه معنوي (P>0.05) بين جميع المعاملات. بالإضافة إلى ذلك، أظهرت بيانات التقييم الاقتصادي كفاءة اقتصادية أفضل مع الطيور التي غذيت على علائق T5،T2أو T6 بالمقارنة مع الطيور من المجموعات الأخرى. يمكن استنتاج أن استخدام CL كمادة رابطة للمصبعاتذات القطر القياسي، يمكن أن يكون أكثر فاعلية مع مستوى ٤ كجم/ طن. علاوة على ذلك، فإنه يُنصح بإضافةCLبمعدل ٨ كجم/ طن فقط عند تصبيع العلف عند قطر يزيد عن القطر القياسي بمعدل ١ ملم، حيث استطاعت العلائق بتلك المواصفات أن تدعم الأداء الإنتاجي وخصائص الذبيحة بشكل إيجابي.