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.

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
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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-Calculator 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

|                     | Starter | Grower | Finisher |
|---------------------|---------|--------|----------|
| 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      |

*Additive Mix contains: Vitamins: A: 1200000 IU; D3 2000000 IU; E: 10000 mg; K3: 2000 mg; B1: 10000 mg; B2: 5000 mg; B6: 1500 mg; B12: 10 mg; Biotin: 50 mg; Choline chloride: 25000 mg; Pantothenic acid: 10000 mg; Nicotinic acid: 3000 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:

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

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

\[ Y_{ijk} = \mu + S_i + L_j + (S*L)_{ij} + \varepsilon_{ijk} \]

Where: \(Y_{ijk}\) = trait measured, \(\mu\) = Overall mean, \(S_i\) = pellet size effect (i= 1, 2), \(L_j\) = CLS levels effect (j= 1, 2 and 3), \((S*L)_{ij}\) = interaction between size and levels, \(\varepsilon_{ijk}\) = 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 of Finisher Pellet | 2 Kg/ Ton | 4 Kg/ Ton | 8 Kg/ Ton | Overall |
|----------------|-----------------------------|-----------|-----------|-----------|---------|
| LBW (g) (1-33 days) | 3.5 mm                      | 1836.25   | 1833.68   | 1803.33   | 1824.42 |
|                | ±65.20                      | ±68.54    | ±80.67    |           |         |
|                | 4.5 mm                      | 1873.13   | 1661.49   | 1671.46   | 1735.36 |
|                | ±13.40                      | ±93.90    | ±37.31    |           |         |
|                | Overall                     | 1854.69   | 1747.58   | 1737.40   | 1753.70 |
| DWG (g/ day) (1-33 days) | 3.5 mm                      | 54.14     | 54.06     | 53.17     | 53.79   |
|                | ±2.02                       | ±2.04     | ±2.45     |           |         |
|                | 4.5 mm                      | 55.29     | 48.89     | 49.20     | 51.12   |
|                | ±0.44                       | ±2.84     | ±1.14     |           |         |
|                | Overall                     | 54.71     | 51.47     | 51.18     |         |
|                | 3.5 mm                      | 81.12     | 81.13     | 79.34     | 80.53   |
|                | ±1.52                       | ±3.14     | ±2.18     |           |         |
|                | 4.5 mm                      | 80.16     | 72.51     | 75.63     | 76.10   |
|                | ±0.74                       | ±2.72     | ±1.93     |           |         |
|                | Overall                     | 80.64     | 76.82     | 77.49     |         |
| FCR (g feed/ g gain) (1-33 days) | 3.5 mm                      | 1.50      | 1.50      | 1.49      | 1.49    |
|                | ±0.05                       | ±0.02     | ±0.08     |           |         |
|                | 4.5 mm                      | 1.45      | 1.50      | 1.53      | 1.49    |
|                | ±0.01                       | ±0.13     | ±0.02     |           |         |
|                | Overall                     | 1.47      | 1.50      | 1.51      |         |

**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.

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

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**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  | ±0.58  | ±1.26  | 70.93  |
|               | 4.5 mm  | 72.26     | ±1.11  | ±1.11  | ±1.88  | 71.67  |
|               | Overall | 72.05     | 2.28   | 2.24   | 2.09   |        |
| Liver%        | 3.5 mm  | 2.67      | ±0.12  | ±0.17  | ±0.07  | 2.20^b|
|               | 4.5 mm  | 2.67      | ±0.14  | ±0.11  | ±0.60  | 2.74^a|
|               | Overall | 2.47      | 0.99   | 0.99   | 1.12   |        |
| Gizzard%      | 3.5 mm  | 1.20      | ±0.05  | ±0.13  | ±0.06  | 1.03   |
| Heart%        | 3.5 mm  | 1.09      | 0.57   | 0.46   | 0.53   |        |
|               | Overall | 0.57      | ±0.03  | ±0.03  | ±0.05  | 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.
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 |
| PI²  | 3.5 mm    | 119.51     | 118.94    | 118.28   |
|      | ±8.0      | ±4.90      | ±11.24    |
|      | 4.5 mm    | 125.89     | 110.82    | 105.65   |
|      | ±2.42     | ±17.46     | ±3.23     |
|      | Overall   | 122.703    | 114.882   | 111.967  |
|      | 3.5 mm    | 78.93      | 78.94     | 77.20    |
|      | ±1.48     | ±3.05      | ±2.12     |
|      | 4.5 mm    | 77.99      | 70.55     | 73.59    |
|      | ±0.72     | ±2.64      | ±1.87     |
|      | Overall   | 78.465     | 74.748    | 75.398   |

Probability

| Trait | T | A | T*A |
|-------|---|---|-----|
| PI²   | NS| NS| NS  |
| PEF²  | NS| NS| NS  |

*Sig.: Significance, NS: Non-Significant;² PI: Performance Index, North (1981);³ 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 |
| PER³  | 3.5 mm    | 3.28      | 3.27      | 3.29     |
|       | ±0.11     | ±0.04     | ±0.18     |
|       | 4.5 mm    | 3.39      | 3.34      | 3.20     |
|       | ±0.04     | ±0.33     | ±0.05     |
|       | Overall   | 3.33      | 3.30      | 3.24     |
|       | 3.5 mm    | 4.53      | 4.53      | 4.52     |
|       | ±0.15     | ±0.06     | ±0.25     |
|       | 4.5 mm    | 4.38      | 4.52      | 4.64     |
|       | ±0.05     | ±0.41     | ±0.071    |
|       | Overall   | 4.45      | 4.52      | 4.58     |

Probability

| Trait | T | A | T*A |
|-------|---|---|-----|
| PER³  | NS| NS| NS  |
| EEU⁵  | NS| NS| NS  |

*Sig.: Significance, NS: Non-Significant;⁴ PER: Protein efficiency Ratio (g protein/ g gain);⁵ 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**                         | 18.58  | 18.59  |
| **Total Feed Cost² (LE)**     | 31.58  | 31.59  |
| **Total Production Cost³ (LE)** | 44.66 | 44.60  |
| **Total Return³ (LE)**        | 13.08  | 13.01  |
| **Economic Efficiency %**     | 41.41  | 41.13  |
| **Relative Economic Efficiency⁶** | 100   | 99.32  |

*180*
To improve the mechanical properties of pellets, a part from selection of technical parameters for the ppletization 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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