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EFFECT OF PHOSPHORUS RESTRICTION IN PRESENCE OF ORGANIC ACID SALT ON BONE QUALITY AND MINERAL DIGESTIBILITY OF BROILERS

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ABSTRACT: Five-weeks feeding trial using 252 one-day-old unsexed Hubbard broiler chicks, was carried out to study effects of feeding different restriction levels of calcium and phosphorus with different levels of formic acid salt on productive performance, blood parameters, tibia measurements, mineral retention and economic efficiency of broilers. Seven dietary treatments were applied in a complete random design on 7 groups of birds, each group comprised of 36 chicks in 6 replicates of 6 chicks each. Experimental diets were; control (T1): contains 100% Ca and available phosphorus (AP) requirements with no sodium di-formate (NDF) added; (T2): contains 50% Ca and AP requirements with 1.5 Kg/ ton NDF; (T3): contains 40% Ca and AP requirements with 1.5 Kg/ ton NDF; (T4): contains 30% Ca and AP requirements with 1.5 Kg/ ton NDF; (T5): contains 50% Ca and AP requirements with 3.0 Kg/ ton NDF; (T6): contains 40% Ca and AP requirements with 3.0 Kg/ ton NDF and (T7): contains 30% Ca and AP requirements with 3.0 Kg/ ton NDF. Results indicated that live body weight (LBW), body weight gain (BWG) and feed conversion ratio (FCR) were insignificantly affected by test diets, while feed intake (FI) was significantly affected by experimental diets. Values of serum Ca and P levels indicated no significant differences between all groups. While birds fed (T1) diet showed higher ALP activity when compared to those fed (T4), (T5) or (T6) diets, whereas, birds fed (T2), (T3) or (T7) diets remained significantly similar. Percentages of wet or dry tibia weight or tibia ash, Ca or P percentages were not significantly affected by dietary treatments. In the same manner, tibia length, tibia width, tibia Seedor index or robusticity index were not significantly affected by dietary treatments. While, tibia breaking force was significantly reduced with birds fed (T2), (T3) or (T6) diets. All of dietary treatments (T2: T7) recorded better relative retention of Ca and P when compared to (T1) group, except for those fed (T2) diet regarding Ca relative retention percentage. Results of economic evaluation showed that NDF could be included at different levels (T2: T7) in broiler diets without any adverse effect on productive performance.

In conclusion, it could be recommended that using NDF as feed acidifier in different levels could keep better utilization of both Ca and P to maintain performance, mineral retention and tibia quality as well as to economize feed costs.

Key words: Phosphorus, Sodium Di-Formate, Bone, Digestibility, Broilers.

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INTRODUCTION

The mineral phosphorus (P) found in plant feedstuffs, is not completely available for poultry because its complexity in phytate compound (Scott et al., 1982). As a result, there is an opposite relationship between availability of P and dietary phytate (Kornegay et al., 1996). Phytate-bound P is poorly utilized by monogastric animals, due to either insufficient quantity or a lack of intestinal phytase secretion (Rafacz-livingston et al., 2005a). Using plant feedstuffs in poultry diets, results in excretion of excess P that is bound with phytate in high levels and might cause ecologic contamination. And, formulating low P diets for poultry presents lower feed costs and less P excretion (Nahm and Carlson, 1998). Adaptation of birds to a specific deficient nutrient has been widely known. In this regard, poultry responds to nutrient restriction by increasing absorption and utilization, which in turn, decreases excretion of restricted nutrient (Yan et al., 2005; Abdelaziz, 2011; Thabet et al., 2014; Abdelaziz et al., 2015). There is a clear evidence stating better phytate P availability from plant feedstuffs at deficient concentrations of P (Onyango et al., 2006) with reducing costs of supplemented inorganic P and minimizing P excretion (Rama Rao et al., 2006; Rama Rao et al., 2007). Diets deficient by either -10%, -20% or -30% in P of control diet, had depressed growth rate and feed efficiency (Fernandes et al., 1999; Li et al., 2000). Furthermore, deficiencies of Ca and P led to their reduction in bone (Hemme et al., 2005). Additionally, Ibrahim et al. (1999) reported that average LBW was reduced with lower dietary P levels. On the other hand, lower levels of both Ca and AP can be fed up to the finisher phase without retarding productive performance (Skinner and Waldroup, 1992; Chen and Moran, 1995; Dhandu and Angel, 2003).

Organic acids have made a great contribution to the profitability of poultry production affecting the intestinal micro-biota, intestinal mucosa and immune system of birds, protein digestibility, pancreatic secretion, mineral utilization and as a result, improving productive performance (Adil et al., 2010). Several studies indicated that addition of citric acid to broiler diets improved weight gain (Afsharmanesh and Pourreza, 2005), increased feed consumption (Moghadam et al., 2006) and improved feed efficiency (Abdel-Fattah et al., 2008). Using organic acids increased mineral utilization due to the complex of the acid anion with Ca, P, magnesium and zinc, resulting in higher levels of these minerals in the blood stream (Andreopoulou et al., 2014). In the same way, several authors have reported positive effects of citric acid on phytate degradation (Boling et al., 2000; Liem et al., 2008; Connelly, 2011). Likewise, efficiency of phytate P utilization in broilers was improved when the diets were deficient in non-phytate P (Boling-Frankenbach et al., 2001; Snow et al., 2004). Regarding gut acidity, most of organic acids, lower the pH of digesta, improve capacity of digestive enzyme and phytase activity, and beneficially affect gastrointestinal functions which implies, better absorption and utilization of dietary P (Jongbloed et al., 2000; Dibner and Buttin, 2002). In the same way, Boling et al. (2000) reported that citric acid improved phytate P utilization by competitively chelating Ca, reducing the formation of insoluble Ca-phytate complexes. In regard to bone quality, Chowdhury et al. (2009) reported increased tibia ash in broilers fed 0.5 % citric acid, being in agreement with Snow et al. (2004) and Liem et al. (2008) who tried citric, malic and fumaric acid in P deficient diets. Tibia ash was significantly increased only in the citric acid group, while P utilization was significantly affected by citric acid and less by malic acid. Similarly, Houshmand et al. (2011) tried an organic acid mixture in a low-Ca diet and they observed significant improvement of tibia traits that helped chickens overcome tibial dyschondroplasia syndrome. These results strengthen the suggestion that feed additives like organic acids might be more efficient when nutrient content is less than optimum level or even being deficient (Torres-Rodriguez et al., 2005). However, Citric acid improved P utilization as well as the mineral concentration in tibia by increasing bone ash (Rafacz-Livingston et al., 2005a) and enhanced bone strength in broilers by improving total digestibility of Ca, P (Islam et al., 2012). Similar results were recorded by Rafacz-Livingston et al. (2005b) who indicated that by means of a positive effect on P utilization, citric acid, increased crude ash content in tibiae of broilers fed a P-deficient diet. Additionally, in an experiment with quails, short chain fatty acid improved both the absorption of dietary P and tibia bone mineralization (Sacakli et al., 2006). Accordingly, bone strength has been primarily associated with adequate formation and maintenance of bone organic matrix, collagen cross-linking, collagen fiber orientation (Rath et al., 1999; Rath et al., 2000). Consequently, bone stability and breaking strength are mainly determined by degree of mineralization of bone matrix (Boivin and Meunier, 2002).

The current study aimed to examine the effects of using different levels of sodium di-formate (NDF), combined with different restriction level of Ca and P in broiler diets, on productive performance, blood parameters, tibia measurements and composition, mineral digestibility and some economic traits.

MATERIALS AND METHODS

The current study was conducted at Poultry Experimental Unit, Agricultural Research Station, Faculty of Agriculture, Ain Shams University.

Experimental diets and birds:

Two hundred and fifty two unsexed one-day-old Hubbard broiler chicks were randomly distributed into 7 treatments. Each treatment comprised of 36 chicks which were subdivided into 6 replicates of 6 chicks each. Chicks were reared up to 5 weeks of age in wire-floored batteries. Two periodical diets were formulated as starter from 1 to 14 days of age and grower from 15 to 35 days of age. Diets used for starter phase (Table, 1) and for grower phase (Table, 2), were formulated to ensure adequate supply of nutrients suggested by guidebook of Hubbard broilers to be isocaloric and isonitrogenous according to NRC (1994) and were offered in mash form. The test diets were as follows; control (T1) contains 100% Ca and available phosphorus (AP) requirements with no sodium di-formate (NDF) added; (T2) contains 50% Ca and AP requirements with 1.5 Kg/ ton NDF; (T3) contains 40% Ca and AP requirements with 1.5 Kg/ ton NDF; (T4) contains 30% Ca and AP requirements with 1.5 Kg/ ton NDF; (T5) contains 50% Ca and AP requirements with 3.0 Kg/ ton NDF; (T6) contains 40% Ca and AP requirements with 3.0 Kg/ ton NDF and (T7) contains 30% Ca and AP requirements with 3.0 Kg/ ton NDF. Feed and water were provided ad libitum. Formi® NDF is a product of ADDCON, GmbH, Germany, which is manufactured under patented technology as a unique combination of formic acid and sodium formate. This additive is designed to be added to finished broiler feed mix by about 1.5 Kg/ ton as feed acidifier. All chicks were reared under similar management and hygienic conditions, and they were vaccinated by drinking-water-based vaccines against Newcastle and Gumboro diseases, purchased form veterinary serum and vaccine research institute.

Growth performance:

Live body weight (LBW) of each replicate was recorded, and body weight gain (BWG) was calculated per replicate by subtracting initial LBW of birds from corresponding final LBW. Average of feed intake (FI) was calculated from difference between amount of feed provided for each replicate within treatments and residual quantity for the same replicate. 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.

Blood serum parameters:

At 5 weeks of age, six birds from each treatment having LBW around the average of treatment were selected and sacrificed by severing the carotid artery and the jugular vein. Blood samples (about 15 ml) were collected simultaneously with slaughtering. Blood samples were immediately centrifuged at 3000 r.p.m. for 10 minutes to separate serum. Concentrations of serum Ca, P (Tietz, 1995) and alkaline phosphatase (ALP) activity (Young, 2000) were assayed by colorimetric method using commercial diagnosing kits of LINEAR chemicals S.L., Spain.

Tibia composition and measurements:

After slaughtering, bleeding and scalding, viscera were removed manually. Tibia bones of both sides were then removed, cleaned of all soft tissues and weighed, length and width were determined using a digital micrometer according to the method described by Samejima (1990). The Seedor index (SI) was determined according to Seedor et al. (1991). SI value represents an indication of tibia density: the higher the value, the denser the tibia. Robusticity index (RI) also gives an indication of tibia mineral density as an absolute figure. RI was calculated according to Reisenfeld (1972). In contrast to SI value, the lower RI value, the denser the tibia bone. Tibia breaking force (TBF) was determined on tibiae at wet-basis following method of Crenshaw et al. (1981) by applying simple three-point bending concept using an Instron Universal Testing Machine (Instron, Canton, MA). Tibiae samples were oven-dried at 105º C until constant weight, ashed at 600º C for 3 hour, dissolved by using concentrated HCl for digestion and 2 N HCl for washing, and then filtered. Ca and P content of tibia were then assayed in the filtrate by a colorimetric method according to AOAC (1995).

Mineral retention:

Total excreta were collected two days prior to the end of the experiment (34 - 35 days of age) to determine Ca and P retention. Also, total feed intake during digestive trial period was recorded. Samples of diets and excreta were firstly dried and then analyzed for Ca and P using AOAC (1995) methods 945.03 and 957.02, respectively. Each nutrient was analyzed in quadruplicate.

Economic values:

The economic characters were calculated according to North (1981) in relation to prices of local market at the time of the study.

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:

Data were subjected to one way ANOVA analysis of variance general linear model (GLM) procedure of SAS software SAS (2004) user’s guide according to the following model: $Y_{ij} = \mu + T_i + e_{ij}$

Where; Y_{ij}= dependent variable, μ= overall mean, T_i= dietary treatment, e_{ij}= experimental error. 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:

Results presented in Table (3) showed insignificant differences among initial weight (IW) values for all groups at the beginning of the trial. Similarly, values of final live body weight (LBW) showed no significant differences among all groups. Values of body weight gain (BWG) indicated also that differences between all groups remained insignificant. Regarding feed intake (FI) values, data obtained showed that birds of (T2) consumed significantly ($P \leq 0.05$) more feed during overall test period when compared to those of (T4), (T5), (T6) or (T7) groups, while remained similar to those of (T1) or (T3) groups. Values of feed conversion ratio (FCR), indicated no significant differences among all test groups. When comparing birds of different groups, it is clear that no adverse effects were observed on LBW, BWG, FI or FCR of birds when Ca and P levels were reduced by 50%, 60% or 70%. The corresponding values for final LBW ranged between 1621 and 1506 (g), while FI ranged between 2729 and 2485 (g/ bird), while FCR ranged between 1.75 and 1.61. Results of productive performance are in agreement with those of Abdelaziz et al. (2015) who stated that using restriction as much as 50% of Ca and P requirements, presented results nearly matching those of control group. Current results are also in conformity with those of Angel et al. (2000); Dhandu and Angel (2003); Thabet (2010); Abdelaziz (2011) and Thabet et al. (2014). The fact that birds of (T7) presented productive performance partially similar to those of (T1), (T3) or (T5) would be clarified by data presented in Table (4) which indicate that birds fed (T1) consumed significantly ($P \leq 0.05$) more Ca and non-phytate phosphorus NNP during starter and grower periods compared to all other groups. According to Yan et al. (2005) these results would be explained by concept stating that chicks fed diet with low Ca and AP demonstrated ability to adapt to deficiency by increasing digestive and absorptive capacity. As presented in Table (4), intake of Ca and AP was significantly ($P \leq 0.05$) affected by different groups of birds, and it would be as the following ascending order: (T1), (T2, T5), (T3, T6), then (T4, T7) during starter period. Whereas, during grower period, ascending order was as follows: (T1), (T2), (T5), (T3), (T6), (T4) then (T7). Throughout the overall test period, ascending order of Ca and AP intake was as follows: (T1), (T2), (T5), (T3, T6), then (T4, T7). According to mineral intake and data of productive performance, addition of sodium di-formate (NDF) might help birds to maintain better phytate P degradation, as described by Liem et al. (2008). Additionally, as described by Snow et al. (2004), bird's capacity of phytate P utilization was further improved when diets were deficient in AP.

Blood serum parameters:

Data of serum Ca and P concentrations and alkaline phosphatase (ALP) activity, are presented in Table (5). Values of serum Ca and P concentrations indicated no significant differences among all groups. While data of ALP activity presented a significant effect of testing diets. In that, birds fed (T1) diet showed higher ALP activity when compared to those fed (T4), (T5) or (T6) diets, whereas, birds fed (T2), (T3) or (T7) diets remained significantly similar. Even though birds fed different diets (T2: T7) consumed considerably lower amount of both Ca and AP (Table, 4), and finally recorded significantly similar blood serum levels of both Ca and P. It would be clarified by the fact that using organic acids as a form of formic acid; namely NDF, would increase mineral utilization due to a complex of acid anion with Ca and P, resulting in higher levels of these minerals in blood stream (Andreopoulou et al., 2014). Logically, birds fed diets low in Ca and AP firstly present lower serum levels of both Ca and P, and when blood Ca level decreases, parathyroid hormone (PTH) motivates Ca and P transfer from body skeleton to blood stream and, at the same time, impress kidneys to produce endogenous form of vitamin D_3 which promotes small intestine to increases Ca and P absorption (Kheiri and Rahmani, 2006). The present results are in agreement with those of Abdelaziz et al. (2015) who stated that using restriction as much as 50% of Ca and P requirements, presented no significant effect on serum minerals when compared to control group. Also, data attained are in partial harmony with those obtained by Bolu et al. (2006); Papeosva et al. (2008); Abdelaziz (2011) and Thabet et al. (2014).

Tibia composition and measurements:

Data regarding tibia composition and measurements at 35 days of age are presented in Table (6). It is noticed that values of tibia wet weight percentage; tibia dry weight percentage, tibia ash, Ca and P percentages appear comparable within all experimental groups. These data are in harmony with those of Thabet et al. (2014) and Abdelaziz (2011). Data of tibia length (cm), tibia width (cm), tibia Seedor index (SI) or tibia robusticity index (RI) showed insignificant differences among all groups. On the other hand, values of tibia breaking force (N) indicated that only birds fed (T2) diet had weaker tibiae when compared to other groups. In Accordance with Yan et al. (2005), birds of all treatments recorded nearly similar tibia ash content. These authors indicated that, when expressing tibia ash in relation to consumed Ca or AP (Table 4), birds fed (T4) or (T7) had higher ash weight as Ca or AP consumed when compared to birds of other groups. This could be attributed to considerable utilization of dietary Ca and AP. These observations are in agreement with those of Coto et al. (2008a and b); Fritts and Waldroup (2003). Data of tibia measurements are generally in harmony with several authors in regard to tibia length and width (Thabet, 2010), tibia SI (Abdelaziz, 2011), tibia RI (Thabet et al., 2014) and tibia breaking force (Abdelaziz et al., 2015).

Mineral retention:

Table (7) shows mineral retention values of experimental treatments. It is evident from these results that adding higher than recommended level of NDF (3.0 Kg/ ton) make birds of (T5), (T6) or (T7) treatments retain relatively more Ca and P compared with those fed (T2), (T3) or (T4) diets with lower (recommended) NDF level (1.5 Kg/ ton). All of dietary treatments (T2: T7) recorded better relative retention when compared to the control group (T1), except for those fed (T2) diet regarding Ca relative retention percentage which recorded significantly similar value. These results agree with those of Boling et al. (2000) who reported that citric acid improved phytate P utilization by competitively chelating Ca, reducing the formation of insoluble Ca-phytate complexes. As high levels of NDF had positively affected Ca retention, the same tendency was observed in P retention but it was less noticeable than in case of Ca, which might be related to the fact that Ca is more digestible than other minerals in the presence of organic salts (Islam et al., 2012). According to the fact that organic acids lower the pH of digesta and provoke gut acidity, these conditions might improve digestive enzyme and internal phytase activity, which implies better absorption and utilization of dietary P (Jongbloed et al., 2000; Dibner and Buttin, 2002).

Economic efficiency:

Profitability of apply NDF as feed additive in poultry feeding depends to a great extent on economic competences as presented in Table (8). As of data representing feed cost (L.E.), it is generally observed that birds fed different diets (T2: T7), have been fed less costly compared to those fed (T1) diet. Additionally, (T5), (T6) or (T7) diets presented lower price although containing higher level of NDF that is because of restricted phosphorus (most costly macro-mineral) in these formulations, compared to (T2), (T3) or (T4) diets, respectively. Data concerning net return (L.E.), showed that birds fed (T7) diet were more profitable compared to those fed (T5) or (T3) diet, which in turn, are better compared to those fed (T1), (T2), (T4) or (T6) diet. Economic efficiency (EE) and relative economic efficiency (REE) values indicated that birds of all dietary treatments were significantly similar to those fed (T1) diet with superiority to those fed (T7) diet. Generally, data of economic efficiency are in harmony with those of Abdelaziz (2011); Thabet et al. (2014) and Abdelaziz et al. (2015) .

It would be anticipated that using lower levels of AP coupled with 1.5 - 3.0 Kg/ ton NDF in broiler diets would give better economic solution.

CONCLUSION

Finally, after reviewing all these results, it might be advisory to state that NDF would be valuable feed acidifier that helps broilers to effectively overcome dietary Ca and AP restriction in order to reduce feed costs without any adverse effect on productive performance, blood serum constituents or tibia features. Additionally, dietary mineral utilization of broiler chicks would be also maintained by feeding close to requirements dietary Ca and AP levels in the presence of NDF.

Table (1). Feed ingredients and chemical composition of diets presented to birds during starter phase (0-14 days of age).

Ingredients	Dietary Treatments						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Yellow Corn (grains)	52.79	55.41	55.83	56.28	55.26	55.68	56.13
Soybean Meal (44%)	30.80	31.75	31.75	32.40	31.75	31.75	32.40
Corn Gluten Meal (60%)	9.00	8.00	8.00	7.50	8.00	8.00	7.50
Soybean Oil	2.57	2.00	2.00	1.85	2.00	2.00	1.85
Calcium Carbonate	1.80	0.85	0.66	0.48	0.85	0.66	0.48
Mono-Calcium Phosphate	1.82	0.63	0.40	0.15	0.63	0.40	0.15
Premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
HCL Lysine	0.34	0.32	0.32	0.30	0.32	0.32	0.30
DL- Methionine	0.18	0.19	0.19	0.19	0.19	0.19	0.19
Anti-mycotoxins	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Formi®NDF (Sodium Di-Formate)	-	0.15	0.15	0.15	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition**							
Crude Protein %	23.02	23.04	23.07	23.09	23.03	23.06	23.08
Metabolizable Energy Kcal/ Kg	3004	3028	3042	3041	3023	3037	3036
Calcium %	1.00	0.50	0.40	0.30	0.50	0.40	0.30
Available Phosphorus %	0.50	0.25	0.20	0.15	0.25	0.20	0.15
Lysine %	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Methionine %	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Methionine + Cystein %	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Price/ Ton (L.E.)	3727	3675	3672	3644	3710	3707	3679

* Each 3 Kg of premix contains: Vitamins: A: 12000000 IU; Vit. D3 2000000 IU; E: 10000 mg; K3: 2000 mg; B1:1000 mg; B2: 5000 mg; B6:1500 mg; B12: 10 mg; Biotin: 50 mg; Coline 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. ** According to NRC, 1994.

Table (2): Feed ingredients and chemical composition of diets presented to birds during grower phase (15-35 days of age).

Ingredients	**Dietary Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Yellow Corn (grains)	55.11	57.41	57.80	58.15	57.26	57.65	58.00
Soybean Meal (44%)	30.00	31.00	31.00	31.00	31.00	31.00	31.00
Corn Gluten Meal (60%)	6.00	5.00	5.00	5.00	5.00	5.00	5.00
Soybean Oil	4.50	4.00	4.00	4.00	4.00	4.00	4.00
Calcium Carbonate	1.60	0.77	0.59	0.42	0.77	0.59	0.42
Mono-Calcium Phosphate	1.62	0.52	0.32	0.13	0.52	0.32	0.13
Premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
HCL Lysine	0.24	0.22	0.21	0.22	0.22	0.21	0.22
DL- Methionine	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Anti-mycotoxins	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Formi® NDF (Sodium Di-Formate)	-	0.15	0.15	0.15	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition**							
Crude Protein %	21.04	21.06	21.09	21.12	21.05	21.08	21.11
Metabolizable Energy Kcal/ Kg	3113	3134	3147	3158	3129	3142	3153
Calcium %	0.90	0.45	0.36	0.28	0.45	0.36	0.28
Available Phosphorus %	0.45	0.23	0.18	0.14	0.23	0.18	0.14
Lysine %	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Methionine %	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Methionine + Cystein %	0.97	0.96	0.96	0.96	0.96	0.96	0.96
Price/ Ton (L.E.)	3657	3608	3604	3603	3643	3639	3638

* Each 3 Kg of premix contains: Vitamins: A: 12000000 IU; Vit. D3 2000000 IU; E: 10000 mg; K3: 2000 mg; B1:1000 mg; B2: 5000 mg; B6:1500 mg; B12: 10 mg; Biotin: 50 mg; Coline 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. ** According to NRC, 1994.

Table (3): Effect of different dietary treatments on productive performance of broilers (0 - 35 days of age).

Items	Dietary Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**Sig.**
Initial body weight (g)	41.75±0.10	39.65±0.67	41.45±0.67	42.65±0.55	44.40±0.57	42.90±.61	42.25±1.12	NS
Final body weight (g)	1614.75±25.92	1601.75±21.06	1621.75±54.89	1506.25±42.29	1581.75±40.84	1524.75±35.39	1583.25±19.05	NS
Body weight gain (g)	1572.75±25.92	1557.25±20.87	1580.01±55.24	1463.50±41.99	1537.01±50.33	1482.01±45.79	1541.01±19.92	NS
Feed intake (g)	2694.25^{ab}±5.77	2729.25^{a}±13.29	2687.01^{ab}±6.60	2518.75^{c}±10.53	2485.50^{c}±6.95	2571.25^{bc}±4.56	2485.50^{c}±7.18	**
Feed conversion ratio	1.71±0.03	1.75±0.02	1.71±0.06	1.72±0.04	1.63±0.06	1.74±0.08	1.61±0.01	NS

a, b, c Means within the same row with different superscripts are significant1y different. Sig. = Significance ** (P≤0.01). NS = Non Significant.

Table (4): Effect of different dietary treatments on calcium and non-phytate phosphorus intake during starter and grower phases.

Items	Dietary Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**Sig.**
Starter (0-3 weeks of age)								
Ca intake (g)	3.97^{a}±0.15	1.82^{b}±0.06	1.22^{c}±0.04	0.85^{d}±0.04	1.63^{b}±0.04	1.31^{c}±0.08	0.84^{d}±0.02	**
NPP intake (g)	1.98^{a}±0.07	0.91^{b}±0.03	0.61^{c}±0.02	0.42^{d}±0.02	0.82^{b}±0.02	0.65^{c}±0.04	0.42^{d}±0.01	**
Grower (4-5 weeks of age)								
Ca intake (g)	20.68^{a}±0.09	10.63^{b}±0.03	8.57^{d}±0.02	6.04^{f}±0.01	9.94^{c}±0.11	8.16^{e}±0.20	5.69^{g}±0.01	**
NPP intake (g)	10.33^{a}±0.04	5.32^{b}±0.01	4.28^{d}±0.01	3.13^{f}±0.01	4.97^{c}±0.05	4.08^{e}±0.10	2.95^{g}±0.01	**
Overall (0-5 weeks of age)								
Ca intake (g)	24.65^{a}±0.06	12.46^{b}±0.06	9.80^{d}±0.02	6.88^{e}±0.03	11.57^{c}±0.12	9.48^{d}±0.28	6.52^{e}±0.02	**
NPP intake (g)	12.32^{a}±0.03	6.23^{b}±0.03	4.90^{d}±0.01	3.55^{e}±0.01	5.79^{c}±0.06	4.74^{d}±0.14	3.36^{f}±0.01	**

a, b, c, d, e, f, g Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P<0.01), NS= Non Significant

Table (5): Effect of different dietary treatments on some of blood parameters at 35 days of age.

Items	Dietary Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**Sig.**
Calcium (mg/dl)	9.32±0.51	9.50±0.60	9.17±0.57	9.43±0.42	9.32±0.61	9.47±0.37	9.41±0.28	NS
Phosphorus (mg/dl)	3.59±0.24	3.74±0.08	3.93±0.09	3.73±0.15	4.01±0.18	3.42±0.16	3.78±0.26	NS
ALP activity (U/dl)	236.33^{a}±4.70	193.33^{ab}±19.12	212.01^{ab}±11.37	174.01^{b}±7.93	176.33^{b}±25.91	180.66^{b}±12.13	206.33^{ab}±17.32	*

a, b Means within the same row with different superscripts are significantly different. Sig. = Significance, * (P≤0.05). NS = Non Significant.

Table (6): Effect of different dietary treatments on some bone composition and measurements at 35 days of age.

Items	Dietary Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**Sig.**
Bone Composition								
Wet tibia weight %	1.39±0.07	1.22±0.01	1.33±0.18	1.30±0.10	1.37±0.09	1.20±0.10	1.31±0.04	NS
Dry tibia weight %	0.84±0.02	0.72±0.05	0.78±0.12	0.78±0.11	0.74±0.02	0.61±0.04	0.63±0.01	NS
Tibia ash %	39.01±2.78	44.42±2.13	45.44±1.47	43.12±2.46	41.61±1.33	40.61±0.91	42.65±2.01	NS
Tibia Ca %	20.41±0.95	20.56±1.48	20.16±1.01	18.67±1.20	19.87±1.10	18.92±1.39	20.18±0.83	NS
Tibia P %	10.64±0.10	9.62±0.66	10.66±0.03	9.96±0.04	10.05±0.03	9.37±0.02	10.47±0.59	NS
Bone Measurements								
Tibia length (mm)	7.48±0.42	7.15±0.23	7.63±0.16	7.39±0.33	7.43±0.18	7.75±0.33	8.98±0.40	NS
Tibia width (mm)	0.80±0.01	0.83±0.01	0.80±0.02	0.75±0.01	0.83±0.01	0.82±0.01	0.81±0.02	NS
Tibia Seedor index[1]	1.25±0.16	1.33±0.13	1.03±0.11	1.24±0.03	1.19±0.06	1.19±0.12	0.99±0.09	NS
Tibia Robusticity index[2]	3.58±0.26	3.39±0.19	3.85±0.09	3.52±0.07	3.59±0.11	3.70±0.21	4.35±0.26	NS
Tibia breaking force[3] (N)	34.21^{a}±0.31	29.17^{d}±0.28	31.05^{bcd}±0.10	29.94^{cd}±0.10	33.37^{ab}±0.04	30.93^{bcd}±0.24	31.94^{abc}±0.51	**

a, b, c, d Means within the same row with different superscripts are significantly different. Sig. = Significance ** (P≤0.01), NS = Non Significant.

1: Seedor et al. (1991), 2: Reisenfeld (1972), 3: Crenshaw et al. (1981).

Table (7): Effect of different dietary treatments on calcium and phosphorus intake and retention at 35 days of age.

Items	Dietary Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**Sig.**
Calcium								
Intake (g)	$4.88^{a}\pm0.08$	$2.75^{d}\pm0.02$	$3.96^{c}\pm0.02$	$2.08^{e}\pm0.05$	$4.33^{b}\pm0.13$	$3.89^{c}\pm0.05$	$2.87^{d}\pm0.05$	**
Excretion (g)	$3.17^{a}\pm0.08$	$1.85^{d}\pm0.05$	$2.34^{c}\pm0.04$	$1.31^{f}\pm0.01$	$2.62^{b}\pm0.04$	$2.39^{c}\pm0.03$	$1.67^{e}\pm0.03$	**
Retention (g)	$1.71^{a}\pm0.13$	$0.90^{c}\pm0.04$	$1.63^{a}\pm0.04$	$0.77^{c}\pm0.06$	$1.71^{a}\pm0.08$	$1.50^{a}\pm0.09$	$1.25^{b}\pm0.04$	**
Retention %	$34.99^{bc}\pm2.36$	$32.71^{c}\pm1.81$	$41.05^{a}\pm1.18$	$37.18^{abc}\pm2.01$	$39.45^{ab}\pm0.85$	$38.45^{ab}\pm1.80$	$42.72^{a}\pm1.36$	**
Relative retention	100.00 %	93.47 %	117.32 %	106.26 %	112.75 %	109.91 %	122.10 %	-
Phosphorus								
Intake (g)	$2.54^{a}\pm0.05$	$1.51^{d}\pm0.02$	$2.01^{c}\pm0.04$	$1.17^{e}\pm0.02$	$2.25^{b}\pm0.04$	$2.02^{c}\pm0.05$	$1.44^{d}\pm0.01$	**
Excretion (g)	$1.10^{a}\pm0.02$	$0.63^{c}\pm0.01$	$0.83^{b}\pm0.01$	$0.43^{e}\pm0.01$	$0.83^{b}\pm0.01$	$0.79^{b}\pm0.01$	$0.54^{d}\pm0.01$	**
Retention (g)	$1.45^{a}\pm0.07$	$0.88^{c}\pm0.03$	$1.16^{b}\pm0.05$	$0.74^{d}\pm0.01$	$1.41^{a}\pm0.03$	$1.23^{b}\pm0.05$	$0.89^{c}\pm0.01$	**
Retention %	$56.74^{c}\pm1.86$	$58.14^{bc}\pm1.10$	$58.09^{bc}\pm1.46$	$62.85^{a}\pm0.37$	$62.86^{a}\pm0.54$	$60.57^{ab}\pm1.15$	$61.98^{a}\pm0.88$	*
Relative retention	100.00 %	102.47 %	102.37 %	110.76 %	110.79 %	106.75 %	109.24 %	-

a, b, c, d, e Means within the same row with different superscripts are significantly different. Sig. = Significance ** (P≤0.01), * (P≤0.05).

Table (8). Effect of dietary treatments on economic traits.

Items	Dietary Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**Sig.**
Average feed consumption (Kg)	$2.69^{ab}\pm0.01$	$2.72^{a}\pm0.01$	$2.68^{ab}\pm0.01$	$2.51^{c}\pm0.01$	$2.48^{c}\pm0.06$	$2.57^{bc}\pm0.09$	$2.48^{c}\pm0.01$	**
Total cost (LE)	13.88±0.02	13.86±0.04	13.70±0.02	13.08±0.03	13.08±0.23	13.38±0.34	13.05±0.02	-
Feed cost (LE)	9.88±0.02	9.86±0.04	9.70±0.02	9.08±0.03	9.08±0.23	9.38±0.34	9.05±0.02	-
Live body weight (Kg)	1.61±0.02	1.60±0.02	1.62±0.05	1.51±0.04	1.58±0.10	1.52±0.07	1.58±0.02	NS
Total return# (LE)	23.41±0.37	23.23±0.30	23.51±0.79	21.83±0.61	22.93±1.46	22.11±1.09	22.95±0.27	-
Net return (LE)	9.53±0.38	9.36±0.33	9.81±0.80	8.75±0.60	9.85±1.23	8.72±1.03	9.90±0.26	-
Economic efficiency¤	68.65±2.74	67.58±2.59	71.56±5.94	66.87±4.64	74.94±8.28	65.34±8.09	75.84±1.95	NS
Relative economic efficiency*	100.00±0.00	98.44±3.77	104.23±8.66	97.40±6.76	109.15±2.06	95.16±1.78	110.47±2.85	NS

a, b, c Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P≤0.01), NS = Non Significant.
According to local price of Kg LBW which was 13.00 L.E. *Assuming that the relative economic efficiency of control group equals 100. ¤: North (1981).

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الملخص العربى

تأثير التحديد الغذائى للفوسفور فى وجود ملح حمض عضوى على جودة العظام ومعامل هضم المعادن لدجاج التسمين

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دراسة غذائية إستمرت فترة خمس أسابيع باستخدام ٢٥٢ كتكوت تسمين غير مجنس عمر يوم من سلالة Hubbard قد صممت لدراسة تأثير إستخدام مستويات مختلفة من الكالسيوم و الفوسفور المحدد غذائياً مع مستويات مختلفة من ملح حمض الفورميك على الأداء الانتاجي، مقاييس الدم، مقاييس العظام، إحتجاز العناصر والتقييم الإقتصادى لدجاج التسمين. سبع معاملات غذائية تم توزيعهم بتصميم عشوائى كامل على سبع مجموعات من الطيور، إحتوت كل مجموعة على ٣٦ كتكوت فى ستة مكررات بكل منها ستة كتاكيت. العلائق التحريبية كانت: مجموعة المقارنة (T1) إحتوت على ١٠٠% من إحتياجات الكالسيوم والفوسفور المتاح و بدون إضافة ثنائى فورمات الصوديوم (NDF)؛ (T2) إحتوت ٥٠% من إحتياجات الكالسيوم والفوسفور المتاح مع إضافة ١,٥ كجم/ طن (NDF)؛ (T3) إحتوت ٤٠% من إحتياجات الكالسيوم والفوسفور المتاح مع إضافة ١,٥ كجم/ طن (NDF)؛ (T4) إحتوت ٣٠% من إحتياجات الكالسيوم والفوسفور المتاح مع إضافة ١,٥ كجم/ طن (NDF)؛ (T5) إحتوت ٥٠% من إحتياجات الكالسيوم والفوسفور المتاح مع إضافة ٣,٠ كجم/ طن (NDF)؛ (T6) إحتوت ٤٠% من إحتياجات الكالسيوم والفوسفور المتاح مع إضافة ٣,٠ كجم/ طن (NDF) و (T7) إحتوت ٣٠% من إحتياجات الكالسيوم والفوسفور المتاح مع إضافة ٣,٠ كجم/ طن (NDF). أوضحت النتائج أن وزن الجسم الحى و وزن الجسم المكتسب و معامل التحويل الغذائي لم يتأثر معنويا بالتغذية على العلائق التجريبية المختلفة، بينما تأثر الاستهلاك الغذائي معنويا. أوضحت قيم تركيزات سيرم الدم من الكالسيوم والفوسفور عدم وجود تأثير معنوى للمعاملات المختلفة، بينما أظهرت معاملة المقارنة (T1) مستويات مرتفعة معنويا من نشاط إنزيم الألكالاين فوسفاتيز عند مقارنتها بمعاملات (T4)، (T5) أو (T6)، بينما ظهرت المعاملات (T2)، (T3) و (T7) متشابهة معنويا. لم تتأثر قيم الوزن النسبى لعظمة الساق الرطبة والجافة ونسبة الرماد، الكالسيوم والفوسفور بعظم الساق، معنويا بالمعاملات الغذائية المختلفة. بنفس الإتجاه، لم تتأثر قيم طول وسمك عظمة الساق، دليل Seedor و دليل متانة العظام، معنويا بالمعاملات الغذائية. بينما إنخفضت قيمة قوة كسر عظم الساق معنويا مع الطيور المغذاة على عليقة (T2) ، (T3) أو (T6). سجلت كل المعاملات الغذائية (T2: T7) قيم أفضل لمعامل إحتجاز الكالسيوم والفوسفور عند مقارنتها بمجموعة المقارنة (T1) بإستثناء الطيور المغذاة (T2) فيما يخص معامل إحتجاز الكالسيوم. أوضحت نتائج التقييم الإقتصادي أن NDF يمكن إضافته مستويات مختلفة (T2: T7) فى علائق طيور التسمين بدون أى تاثير سلبى على الأداء الإنتاجى.

يستنتج من هذه الدراسة أنه يمكن التوصية بأن يُستَخدَم NDF كمادة مُحَمِّضَة للغذاء وبمستويات مختلفة وذلك لتحسين الإستفادة من عنصرى الكالسيوم والفوسفور لحفظ الآداء الانتاجي، المحتجز من العناصر وجودة العظام بالاضافة الى تحسين إقتصاديات الغذاء.