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IMPACT OF CITRIC ACID AND PHYTASE SUPPLEMENTATION ON PERFORMANCE OF BROILER

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SUMMARY: The experimental work of the present study was carried out at El-Azab Poultry Research Station, Fayoum, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Dokki, Egypt during the period from January to February 2012. Chemical analyses were performed in the laboratories of the Poultry Production Department, Faculty of Agriculture, Fayoum University. Chickens was initially fed a control diet for three days. A total number of 216 four-day old unsexed broiler (Cobb strain) were divided into nine treatments (24 birds each). Each treatment contained three replicates of eight birds.

The experimental treatments were as follows:

1. Chicks were fed the control diet (C). **2**.C+2% citric acid (CA). **3**.C +0.1% phytase.
4. C–25% available phosphorus (AP). **5**.C–25% AP +2% CA. **6**.C–25% AP +0.1% phytase.
7. C–50% AP. **8**.C–50% AP +2% CA. **9**.C–50% AP +0.1% phytase.

Results obtained could be summarized in the following:

١-Productive performance: A linear significant decreases in live body weight (LBW) at 38 days of age, live body weight gain (LBWG), feed intake (FI), crude protein conversion (CPC), performance index (PI), carcass weight after evisceration and dressing% at the end of experimental period with decreasing AP level. Neither type of addition (CA or phytase) nor interaction between level of AP with type of addition had any significant effect on LBW, LBWG, feed conversion, CPC, caloric conversion ratio, growth rate and PI. Chicks fed diet containing recommended level of AP supplemented with 2% CA had the highest FI during the period from 4 to 38 days.

2-Intestinal microflora count: Chicks fed diet containing –25% AP had higher total microflora count, while, those fed diet containing recommended level of AP had higher colibacillus (lower total microflora count). Chicks fed diet supplemented with 2% CA had lower value of total microflora count. Chicks fed diets containing -25% AP un-supplemented with CA or phytase had lower value of colibacillus.

3-Blood constituents: Chicks fed diet un-supplemented with CA or phytase had significantly higher value of hemoglobin and red blood cells count (lower value of mean corpuscular volume and mean corpuscular hemoglobin).

4-Chemical composition of broiler meat and tibia parameters: The highest moisture% of broiler meat (the lowest ash%) was observed for chicks fed diet un-supplemented with CA or phytase. Chicks fed diet containing recommended level of AP had higher density, strength, ash and calcium%. Chicks fed 2% CA or 0.1% phytase supplementation to broiler diets increase density, strength, ash, calcium and phosphorous%.

5-Economical efficiency (EEf): EEf values during the period from 4 to 38 days of age was improved of chicks fed diet containing -50% AP supplemented with 0.1% phytase, chicks fed diet containing recommended level of AP supplemented with 0.1% phytase and chicks fed diet containing -25% AP supplemented with 0.1% phytase as compared with those fed the control diet and other treatments.

It could be concluded that, Cobb broiler chicks fed low AP diets supplemented with CA or phytase maintain the same performance as that obtained from chicks fed diets containing recommended level of AP. On the other hand, it can be concluded that AP can be reduced from the recommended level by 50% and supplement these diets with either CA or phytase without affecting performance. Besides, using such diets reduces feed cost and phosphorus pollution.

Key words: Citric acid, available phosphorus, phytase and broiler performance.

INTRODUCTION

Poultry production increased from just over 118.8 million birds at the end of 2000 to over 137.2 million birds by the end of 2010 in Egypt (**FAO, 2012**), this increase in production resulted in an increase in poultry litter available for land application. Phosphorus (P) is an essential mineral for all living organisms needed for structural and metabolic growth and development **(Soares, 1995).** On the other hand, P plays a critical role in the formation of hydroxyapatite, nucleic acids, bioactive signaling proteins and phosphorylated enzymes **(Berndt *et al.*, 2005)**. Its is also the most expensive mineral added to diets due to decreased rock phosphate stores **(Moore *et al.*, 1999).**

Major ingredients used in poultry feeds are of plant origin. About two third of the P in these feedstuff is present as phytate P, which is poorly utilized by poultry due to low phytase activity found in the digestive tract **(Selle and Ravindran, 2007**). Researchers have estimated that only 25 to 50% of supplemental P is metabolized, leading to a net excretion of 50% or more into poultry litter **(Yi *et al.*, 1996).** As a result, it is necessary to supplement most mono gastric diets with P to meet the requirements of that animals especially in the early stages of development **(Viljoen, 2001)**. Previously, the major concern facing the poultry industry was how to ensure that the P requirements of the birds were met to ensure optimal growth and performance. These concerns have stimulated the re-evaluation of the broilers existing requirements **(Dhandu and Angel, 2003)** and the determination of the actual digestibility of P in all the commonly used feedstuffs incorporated in broiler diets **(Van der Klis and Versteegh, 1999)**.

Phytase is a part of enzymes called phosphatases, which are responsible for catalyzing the hydrolysis of phytate to inorganic monophosphate, free esters of myo-inositol, and free myo-inositol, making P available for absorption in both plants and animals **(Haefner *et al.*, 2005).** Phytates are associated with other cations such as Ca, Mn and Zn **(Maenz, 2000)**; Ca, Mg and Cu **(Sebastian *et al.*, 1998)**; Ca, Mg, Zn, Fe, K and Cu as well as amino acids **(Ravindran *et al.*, 1998)** and proteins, amino acids **(Selle *et al.*, 2000)** making them also less available to the animal. Phytic acid also reduces the activity of pepsin, trypsin, and α-amylase **(Sebastian *et al.*, 1998).** Consequently, apparent metabolizable energy value is also reduced. Thus any attempt to maximize the utilization of dietary P could reduce the feed cost and thus achieve the underlying objective of reducing the environmental pollution**.** Currently, many laboratories are experimenting with different feed additives that may be used to alleviate the problems associated with the withdrawal of antibiotics from feed. Acidifiers have been used by the poultry industry for several years, and there are many putative claims of the effects caused by acids.

On the other hand, the hydrolysis and absorption of phytate P by monogasteric animals are complex process that are influenced by many factors. Dietary ingredients and feed processing seem to be the most important factors related to the diet, while age and type of birds could also affect phytate utilization **(Attia *et al.*, 2003).** This possesses a problem to nonruminant animals because they do not produce sufficient amounts of intrinsic phytase necessary to hydrolyze the phytic acid complex. On the other hand, despite the limitations of the short gastrointestinal tract, it is possible to overcome the inherent shortcomings of broiler digestion to maximize the hydrolysis of the phytate molecule and reduce the amount of supplemental P in broiler diets using some feed additives such as phytase and organic acids (OA).

Physical methods such as soaking, drying, germination **(Jongbloed *et al.*, 1991)**. Also, several feed additives have been investigated to determine their efficiency for increasing P use and decreasing P excretion by poultry. One potential feed additive is phytase enzyme. Supplementation of diets with exogenous microbial phytase **(Kornegay, 2001)** was found to be effective in increasing phytate hydrolysis. Microbial phytase can chemically hydrolyze 97% of the P from phytate in soybean meal (**Nelson *et al.*, 1968).** Citric acid (CA) is another feed additive that has been shown to improve P use in chicks fed corn soybean meal (C-SBM) diets **(Boling *et al.*, 2001a).** Several authors **(Boling *et al.*, 2000, 2001a)** have found that CA alone or in combination with phytase increased the phytate hydrolysis in chicken. It is hypothesized that CA complex with Ca and reduces the formation of more stable Ca-phytate complexes. Alternatively, CA may change the intestinal pH for better phytase activity.

Abdel-Fattah *et al.* (2008) reported that the use of 1.5% commercial OA (acetic, CA and LA) improved broiler performances, no further improvements was observed when the dose of OA was increased to 3.0%. Similar results were found by other researchers **(Nezhad *et al.*, 2007)**. Also, **Boling *et al.* (2001a)** showed that supplementation of a P deficient C-SBM diet [0.10% available P (AP)] with 6% CA resulted in a 22% increase in LBWG in chicks compared to those consuming diets with no added CA, the same magnitude as that observed with addition of 1.450 units of phytase/kg to a P deficient diet **(Biehl *et al.*, 1995)**. Other studies have shown that CA additions up to 6% linearly improved LBWG of chicks when added to a P deficient C-SBM diet but not when added to in a phytate-free diet **(Snow *et al.*, 2004)**.

In poultry production, OA are mainly used to sanitize feed and water to inhibit pathogens, such as *Salmonella spp***. (Broek *et al.*, 2003).** Improved mineral utilization may be accomplished through the reduction of dietary pH, producing an environment conducive to phytase activity **(Boling *et al.*, 2001b).** Alternatively, improved mineral utilization may occur though the binding of Ca with CA, rendering it unavailable for chelation with phytate and thus increasing phytate solubility in the small intestine **(Afsharmanesh and Pourreza, 2005).**

Therefore, the purpose of the present work was to determine the influence of reducing dietary phosphate with or without single supplementation of citric acid and phytase on growth performance, mortality rate, carcass parameters, bone parameters, bacterial count, intestinal pH, blood serum parameters and economical efficiency of broiler chicks.

MATERIALS AND METHODS

The experimental work of the present study was carried out at El-Azab Poultry Research Station, Fayoum, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Dokki, Egypt during the period from January to February 2012. Chemical analyses were performed in the laboratories of the Poultry Production Department, Faculty of Agriculture, Fayoum University according to the procedures outlined by **A.O.A.C. (1990)**.

Chickens was initially fed a control diet for three days. A total number of 216 four day old unsexed broiler (Cobb strain) were divided into nine treatments (24 birds each). Each treatment contained three replicates of eight birds, so that all groups and replicates had equal average body weights (84.22±0.53g).

The experimental (3x3) factorial treatments were as follows:

1. Chicks were fed the control diet (C). **2**.C+2% CA. **3**.C +0.1% phytase.
4. C–25% AP. **5**.C–25% AP +2% CA. **6**.C–25% AP +0.1% phytase.
7. C–50% AP. **8**.C–50% AP +2% CA. **9**.C–50% AP +0.1% phytase.

The experimental diets were supplemented with minerals and vitamins mixture DL-methionine and L-Lysine HCl to cover the recommended requirements according to the strain catalog recommendations and were formulated to be iso-nitrogenous and iso-caloric (Table1). The vaccination program adopted by recommended requirements according to standard commercial guidelines.

Citric acid used in this study were purchased from Sigma Chemical Co. (St. Louis, MO). De Man, Rogosa, and Sharpe (MRS). Citric acid was supplied as monohydrate citric acid with 92% purity, and phytase (Natuphos 500 BASF Corp., Mt. Live, Nj) source also had 10.000 unit active phytase per gram.

Chicks were individually weighed to the nearest gram at the start of experiment, wing-banded and randomly allotted to the dietary treatments. Chicks were raised in electrically heated batteries with raised wire mesh floors and had a free access to the feed and fresh water from nipple drinkers (2 nipples/cage) throughout the experiment. Light was provided for 23 h/d. Room temperature on zero day was 33ºC and decreased approximately 3ºC per week until 20ºC was reached, according to standard poultry rearing practices. Batteries were placed into a room provided with continuous fans for ventilation. The chicks were fed with broiler starter diets between four and 14 days, broiler grower diets between 15 and 25 days and broiler finisher diets between 26 and 38 days.

At the same time, feed consumption was recorded and feed conversion (FC,g feed/g gain) and live body weight gain (LBWG) were calculated. Crude protein conversion (CPC), caloric conversion ratio (CCR) and growth rate (GR) were also calculate. Performance index (PI) was calculated according to the equation described by **North (1981)** as follows: PI = (LBW, Kg/FC) x100.

At the end of the growing period (38 days of age), slaughter tests were performed using three chicks around the average live body weight of each treatment. The birds were on feed withdrawal overnight (approximately 12h), then individually weighed to the nearest gram, and slaughtered by severing the jugular vein (Islamic method). After four minutes bleeding time, each bird was dipped in a water bath for two minutes, and feathers were removed. After the removal of head, carcasses were manually eviscerated to determine some carcass traits, dressing% (eviscerated carcass without head, neck and thighs) and total giblets% (gizzard empty, liver, heart and spleen). The eviscerated weight included the front part with wing and rear part. The bone of front and rear were separated and weighed to calculate meat percentage. The meat from each part was weighed and blended using a kitchen blender.

At the time of slaughter test, three samples of ileum content for each treatment were taken. Total microflora, colibacillus and lactobacillus of ileum content were enumerated. The pH of intestinal contents was directly determined by pH-meter. At the end of the experimental period (38 days), individual blood samples were taken from 3 birds of each treatment. The blood samples were collected into dry clean centrifuge tubes and centrifuged at 3000 rpm for 20 minutes. The clear serum samples were carefully drawn and transferred to dry, clean, small glass bottles, and stored at–20Ċ in a deep freezer until the time of chemical determinations. The biochemical characteristics of blood were determined colorimetrically, using commercial kits.

Table 1: Composition and analyses of the experimental diets.

Items%	Starter (4-14 days)			Grower (15-25 days)			Finisher (26-38 days)		
	Control (Con.)	Con. -25% AP	Con. -50% AP	Control (Con.)	Con. -25% AP	Con. -50% AP	Control (Con.)	Con. -25% AP	Con. -50% AP
Yellow corn, ground	**60.60**	**61.04**	**61.40**	**63.44**	**63.89**	**64.26**	**63.74**	**64.31**	**64.81**
Soybean meal	**30.10**	**30.30**	**30.40**	**28.45**	**28.35**	**28.35**	**28.01**	**27.90**	**27.78**
Corn gluten meal	**3.80**	**3.61**	**3.50**	**1.40**	**1.40**	**1.35**	**0.00**	**0.00**	**0.00**
Calcium carbonate	**1.07**	**1.44**	**1.90**	**0.97**	**1.43**	**1.87**	**0.93**	**1.35**	**1.75**
Sodium chloride	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**
Vit. and Min. premix[1]	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**
Monocalcium phosphate	**2.02**	**1.35**	**0.65**	**1.95**	**1.28**	**0.61**	**1.80**	**1.17**	**0.55**
Vegetable oil[2]	**1.50**	**1.36**	**1.25**	**2.90**	**2.76**	**2.67**	**4.55**	**4.30**	**4.13**
DL–Methionine	**0.11**	**0.11**	**0.11**	**0.13**	**0.13**	**0.13**	**0.24**	**0.24**	**0.24**
L-Lysine	**0.20**	**0.19**	**0.19**	**0.16**	**0.16**	**0.16**	**0.13**	**0.13**	**0.14**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Calculated analysis[3]**:**									
Crude protein (CP)	**21.00**	**21.00**	**21.01**	**19.00**	**19.00**	**19.00**	**18.00**	**18.00**	**18.00**
Ether extract	**4.14**	**4.01**	**3.91**	**5.57**	**5.45**	**5.37**	**7.20**	**6.97**	**6.82**
Crude fiber	**3.49**	**3.51**	**3.52**	**3.41**	**3.41**	**3.42**	**3.36**	**3.37**	**3.37**
Calcium (Ca)	**1.03**	**1.00**	**1.00**	**0.96**	**0.96**	**0.96**	**0.90**	**0.90**	**0.90**
Available phosphorus (AP)	**0.50**	**0.38**	**0.25**	**0.48**	**0.36**	**0.24**	**0.45**	**0.34**	**0.23**
Ca/AP ratio	**2.06**	**2.64**	**3.95**	**1.99**	**2.68**	**4.02**	**1.99**	**2.67**	**3.97**
Methionine	**0.46**	**0.46**	**0.46**	**0.44**	**0.44**	**0.44**	**0.52**	**0.52**	**0.52**
Methionine+Cystine	**0.81**	**0.81**	**0.81**	**0.75**	**0.76**	**0.76**	**0.82**	**0.82**	**0.82**
L-Lysine HCl	**1.20**	**1.20**	**1.20**	**1.10**	**1.10**	**1.10**	**1.05**	**1.05**	**1.05**
ME, Kcal./Kg	**2988.9**	**2988.2**	**2988.4**	**3083.3**	**3083.5**	**3085.9**	**3182.8**	**3177.0**	**3176.3**
Cost (£.E./ton)[4]	**2139.0**	**2090.6**	**2044.6**	**2112.2**	**2067.4**	**2025.0**	**2191.6**	**2142.7**	**2100.6**

[1] Each 3.0 Kg of the Vit. and Min. premix manufactured by Agri-Vet Company, Egypt and contains : Vit. A, 12000000 IU; Vit. D_3 2000000 IU; Vit. E, 10 g; Vit. K_3, 2.0 g; Vit. B1, 1.0 g; Vit. B2, 5 g; Vit. B6, 1.5 g; Vit. B12,10 mg; choline chloride, 250 g; biotin, 50 mg; folic acid, 1 g; nicotinic acid , 30 g; Ca pantothenate, 10 g; Zn, 50 g; Cu,10 g; Fe, 30 g; Co, 100 mg; Se, 100 mg; I, 1 g; Mn, 60 g and anti-oxidant, 10 g, and complete to 3.0 Kg by calcium carbonate.
[2] Mixture from 75% soybean oil and 25% sunflower oil.
[3] According to **NRC, 1994**.
[4] According to the local market price at the experimental time

Chemical analyses of representative samples of the carcass meat (without skin) were carried out to determine DM, CP (N x 6.25), EE and ash contents according to the methods of **A.O.A.C. (1990).** Nitrogen free extract was calculated by difference**.** The left tibia was removed (meat was removed from the bone and the cartilage was left intact) and frozen for subsequent determination of tibia density **(Halliday *et al.*, 2010),** tibia breaking strength and tibia ash percentage. Tibia breaking strength was determined by using a HD 250 Texture Machine (Texture Technologies Corporation, Scarsdale, NY) fitted with a 3-point bend rig with a load cell capacity of 50 kg and a crosshead speed of 100 mm/min. After determination of bone breaking strength, fat was removed from the tibias by a 36-h Soxhlet extraction in ethyl alcohol and then dried at 100^{o}C for 24h. Tibia ash percentage was determined by placing the bones in a muffle furnace and ashing for 36h at 550^{o}C. Ash weight was expressed as a percentage of dried tibia weight. Accumulative mortality rate was obtained by adding the number of dead birds during the experiment divided by the total number of chicks at the beginning of the experimental period (no mortality of birds were recorded during the study period).

To determine the economical efficiency for meat production, the amount of feed consumed during the entire experimental period was obtained and multiplied by the price of one Kg of each experimental diet which was estimated based upon local current prices at the experimental time.

Statistical analysis of results was performed using the General Linear Models (GLM) procedure of the SPSS software **(SPSS, 1999),** two way analyses of variance model was applied according to the follow general model:

$$Y_{ijk}= \mu+T_i+E_j+TE_{ij}+e_{ijk}$$

Where:

Y_{ijk}**:** observed value. **μ:** overall mean.

T_i**:** level of AP effect (**i**: recommended, -25% and -50% AP).

E_j: type of addition effect (**i**: non, 2% CA and 0.1% phytase).

TE_{ij}: interaction of level of AP effect by type of addition effect.

e_{ijk}: random error

Treatment means showing significant differences (P≤0.05 and P≤0.01) were tested using Duncan's multiple range test **(Duncan, 1955)**.

RESULTS AND DISCUSSION

1-Productive performance:

Impact of CA and phytase supplementation on productive performance of Cobb broiler chicks during the period from 4 to 38 days of age are presented in Table 2. Concerning level of AP, the results showed a linear significant (P≤0.05) decreases in live body weight (LBW) at 38 days of age, live body weight gain (LBWG), performance index (PI) and had the worst CPC during the period from 4 to 38 days of age with decreasing AP level.

Neither type of addition nor interaction between level of AP with type of addition had any significant effect on LBW, LBWG, feed conversion (FC), crude protein conversion (CPC), caloric conversion ratio (CCR), growth rate (GR) and PI. Numerically, chicks fed diet containing recommended level of AP supplemented with 0.1% phytase had higher LBW at 38 days of age, heavier LBWG, higher PI and the best FC values, while, those fed diet containing -50% AP un-supplemented with CA or phytase had lower LBW, LBWG and PI during the same period. While, those fed diets containing –25% or –50% AP un-supplemented with CA or phytase had the worst FC values, but differences were not significant (Table 2). On the other hand, CA or phytase supplementation to broiler diets improved LBW, LBWG, FC and PI compared with those fed un-supplemented diet, but differences were not significant (Table 2).

Similar results were reported by **Sohail and Roland (1999)** who studied the effects of three levels of phytase (0, 300, and 600 FTU/kg) in broilers fed two levels of AP (0.225 and 0.325%). They reported a decrease in LBW in broilers fed the 0.225%P diet, and the inclusion of phytase regardless of level negated the effects on growth and bone variables. Likewise, **Yan *et al.* (2004) and Angel *et al.* (2005)** reported that broilers fed very low level of dietary P had depressed LBWG, and even with an excess activity of supplemental phytase, LBWG was not equivalent to controls with NRC-recommended P levels **(NRC, 1994)** in their diets. This reduced LBWG, even with phytase, was related to the ratio of dietary Ca to total AP in the diet (Ca:P ratios greater than 1.5 were associated with reduced LBWG). Also, **Angel *et al.* (2006); Cowieson *et al.* (2006) and Ravindran *et al.* (2006)** reported that addition of phytase to P-inadequate diets enhances performance.

Table 2: Impact of citric acid and phytase supplementation on productive performance of Cobb broiler chicks during the period from 4-38 days of age.

Items		Live body weight, g	Live body weight gain, g	Feed intake, g	Feed conversion	Crude protein conversion	Caloric conversion ratio	Growth rate	Performance index
Level of AP[1] (L):									
Recommended (R)		2068.28^{a}	1983.68^{a}	3272.22^{A}	1.67	0.31^{b}	5.01	0.938	72.76^{a}
-25% AP		2002.43^{ab}	1918.32^{ab}	3261.89^{B}	1.73	0.32^{ab}	5.21	0.935	68.56^{ab}
-50% AP		1980.53^{b}	1896.57^{b}	3250.95^{C}	1.74	0.33^{a}	5.29	0.936	66.82^{b}
±SEM[2]		25.30	25.32	2.17	0.02	0.01	0.10	0.00	1.65
Type of addition (T):									
Un-supplemented		1991.59	1907.19	3266.06^{A}	1.73	0.32	5.15	0.936	67.08
2% citric acid		2028.54	1944.44	3271.33^{A}	1.71	0.32	5.17	0.935	70.42
0.1% phytase		2031.11	1946.93	3247.67^{B}	1.69	0.32	5.19	0.937	70.64
±SEM		25.30	25.32	2.17	0.02	0.01	0.08	0.00	1.65
L × T (treatments):									
R	Un-supplemented	2050.42	1965.79	3267.33^{BC}	1.68	0.30	4.91	0.941	70.97
	2% citric acid	2073.58	1988.96	3286.00^{A}	1.67	0.31	5.02	0.935	73.64
	0.1% phytase	2080.83	1996.29	3263.33^{BC}	1.66	0.32	5.10	0.939	73.68
-25% AP	Un-supplemented	1966.00	1881.79	3271.67^{B}	1.76	0.33	5.26	0.932	65.91
	2% citric acid	2018.38	1934.46	3267.00^{BC}	1.72	0.32	5.15	0.936	69.70
	0.1% phytase	2022.92	1938.71	3247.00^{D}	1.69	0.32	5.21	0.936	70.08
-50% AP	Un-supplemented	1958.35	1874.00	3259.17^{C}	1.76	0,33	5.30	0.936	64.37
	2% citric acid	1993.67	1909.92	3261.00^{BC}	1.73	0.33	5.33	0.935	67.93
	0.1% phytase	1989.58	1905.79	3232.67^{E}	1.72	0.33	5.26	0.935	68.17
±SEM		43.82	43.86	3.76	0.04	0.01	0.15	0.01	2.87

a, …b, and A,.. E, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to b; P≤0.01 for A to E). [1]Available phosphorus [2] Pooled SEM

Further more, **Boling *et al.* (2000) and Snow *et al.* (2004)** showed that CA additions up to 6% linearly improved LBWG of chicks when added to a P deficient C-SBM diet but not when added to a phytate-free diet**.** Moreover, **Ebrahimnezhad *et al.* (2008),** reported that a combination of CA and phytase resulted in better LBWG and improving FC in low P diets. **Boling *et al.* (2001b)** reported that CA could have positive effects on growth performance when diets are low in AP and high Ca:AP ratio. In another study, levels of 3 to 4% CA markedly increased growth in broiler chicks fed a P-deficient C-SBM diet **(Rafacz *et al.*, 2003)**.The present results disagree with the findings of **Kornegay (1996)** who did not find improving LBW in broilers fed a finisher diet with phytase from 3 to 7 wk of age. Also, CA did not improve LBWG in chicks fed a P adequate C-SBM diet **(Boling *et al.*, 2001a)**.

Results presented in Table 2 indicated that reducing dietary AP with or without single supplementation of CA and phytase significantly ($P \leq 0.01$) affected FI during the period from 4 to 38 days of age. The results indicated a linear significantly decrease in FI with reduction of AP contents of the diet as compared with those fed diet containing recommended level.

Concerning type of addition, chicks fed diet supplemented with 2% CA had significantly higher FI value during the period from 4 to 38 days of age, however, chicks fed diet supplemented with 0.1% phytase had significantly lower FI value during the same period (Table 2).

Concerning interaction between level of AP with type of addition, chicks fed diet containing recommended level of AP supplemented with 2% CA had the highest FI value during the period from 4 to 38 days of age, while, those fed diet containing –50% AP supplemented with 0.1% phytase had the lowest FI value during the same period (Table 2).

Similar results were reported by **Sohail and Roland (1999)** who reported a decrease in FI in broilers fed the 0.225% P diet, and the inclusion of phytase regardless of level negated the effects on growth and bone variables. Also, similar results were previously observed by several authors **(Johnston and Southern, 2000 and Singh and Khatta, 2003)** who reported that addition of microbial phytase to low P broiler diets significantly improved the LBWG, FI and FC and that improvement was dependent on the level of phytase added. Likewise, supplementation of broiler diets with microbial phytase enhance performance **(Abd-El Samee, 2002; Driver *et al.*, 2004 and El-Husseiny *et al.*, 2006).** The present results disagree with the findings of **Mulyantini *et al.* (2004)** who showed that phytase supplementation to broiler diets did not show any changes in performance. However, **Denbow *et al.* (1995)** reported that FC was unaffected by phytase addition. **Rafacz *et al.* (2003)** indicated that levels of 3 to 4% CA did not depress FI in broiler chicks fed a P-deficient C-SBM diet. **Broz *et al.* (1994)** found that inclusion of phytase (125, 250 or 500 FTU/kg) in broiler diets increased growth rate and FI, but had no effect on FC, there was also an increase in plasma P and tibia ash, accompanied by decreased P concentration in excreta.

The present results disagree with the findings of several studieds **(Peter and Baker, 2001 and Augspurger and Baker, 2004)** by using purified diets, finding that phytase was found to have no effect on protein utilization (phytase is probably less likely to generate responses in atypical diets with low phytate concentrations).

Slaughter parameters%: Impact of CA and phytase supplementation on slaughter parameters% of Cobb broiler chicks are presented in Table 3. Concerning level of AP, the results indicated that no significant differences due to level of AP on slaughter parameters%, except, carcass weight after evisceration and dressing which were significantly ($P \leq 0.05$) affected. It can be concluded that, a linear significant decrease in carcass weight after evisceration and dressing% was observed with decreasing AP level.

Neither type of addition nor interaction between level of AP with type of addition had any significant effect on slaughter parameters%, except, type of addition with LBW (Table 3). Similarly, **Ebrahimnezhad *et al.* (2008)** reported that supplementation of diet with CA and phytase had no effect on liver, spleen and abdominal fat relative weight. In this respect, **Shelton *et al*. (2004)** reported that including phytase at 500 FTU/kg to low Ca and P swine diets without trace minerals negated the decrease in carcass characteristics. However, **Pillai *et al.* (2006)** reported that broilers fed P deficient diets supplemented with phytase had increased breast and leg yield when compared to broilers fed the P adequate diet.

Intestinal microflora: Results presented in Table 3 show the impact of CA and phytase supplementation on total microflora count, colibacillus and lactobacillus of Cobb broiler chicks. Level of AP, type of addition and dietary treatments had significantly ($P \leq 0.01$) affected total microflora count and colibacillus, however, no significant effect on lactobacillus was found.

Regarding to level of AP, chicks fed diet containing –25% AP had higher total microflora count, while, those fed diet containing recommended level of AP had higher colibacillus (lower total microflora count). Concerning type of addition, chicks fed diet supplemented with 0.1% phytase had higher values of total microflora count and colibacillus, while, those fed diet supplemented with 2% CA had lower value of total microflora count and chicks fed diet un-supplemented with CA or phytase had lower value of colibacillus (Table 3).

Regarding to interaction effect of dietary treatments, chicks fed diet containing recommended level of AP supplemented with 0.1% phytase had higher values of total microflora count and colibacillus, while, those fed diet containing recommended level of AP supplemented with 2% CA had lower value of total microflora count. Chicks fed diet containing -25% AP un-supplemented with CA or phytase had lower value of colibacillus (Table 3). Similar results were observed by **Shelton *et al*. (2004)** who found that the P released by the inclusion of phytase at 500 FTU/kg to low Ca and P swine diets without trace minerals resulted in an increase in intestinal microflora, which was available for absorption in the cecum/colon region.

Blood constituents: Impact of CA and phytase supplementation on blood constituents of Cobb broiler chicks are presented in Table 4. The results indicated no significant differences due to level of AP on blood constituents, except, lymphocyte and P which was significantly ($P \leq 0.05$) affected. It can be concluded that, a linear significant increase in P was observed with decreasing AP level. Type of addition had insignificantly affected blood constituents except, hemoglobin, red blood cells count (RBCs) and mean corpuscular volume (MCV), mean corpuscular hemoglobin **(**MCH) and eosinophils which were significantly affected.

Table 3: Impact of citric acid and phytase supplementation on some slaughter parameters% and intestinal microflora count of Cobb broiler chicks during the period from 4-38 days of age.

Items		Slaughter parameters%									Intestinal microflora count		
		Live body weight (g)	Total giblets	Breast meat	Rear meat	Carcass weight after evisceration	Dressing	Bursa	Thymus	Intestinal pH	Total icroflora count	Coliba-cillus	Lacto-bacillus
Level of AP[1] (L):													
Recommended (R)		2270.00	4.47	65.39	58.47	69.20^{a}	73.67^{a}	0.15	0.15	6.29	10.57^{B}	5.15^{A}	5.84
-25% AP		2123.33	4.69	62.71	55.58	68.07^{a}	72.76^{ab}	0.17	0.17	6.22	10.87^{A}	4.79^{B}	5.79
-50% AP		2131.67	4.94	62.09	54.08	66.17^{b}	71.10^{b}	0.15	0.17	6.10	10.61^{B}	4.76^{B}	6.22
±SEM[2]		78.42	0.15	1.17	1.68	0.59	0.58	0.01	0.02	0.05	0.05	0.04	0.19
Type of addition (T):													
Un-supplemented		1970.00^{b}	4.81	62.67	58.38	66.83	71.64	0.16	0.15	6.21	10.59^{B}	4.46^{B}	6.15
2% citric acid		2195.00^{ab}	4.63	63.61	54.88	68.22	72.85	0.14	0.18	6.19	10.13^{C}	4.52^{B}	5.88
0.1% phytase		2360.00^{a}	4.64	63.92	54.87	68.39	73.04	0.16	0.16	6.20	11.33^{A}	5.73^{A}	5.81
±SEM		78.42	0.15	1.17	1.68	0.59	0.58	0.01	0.02	0.05	0.05	0.04	0.19
L × T (treatments):													
R	**Un-supplemented**	2265.00	4.34	64.60	60.17	69.30	73.64	0.13	0.11	6.31	10.29^{EF}	4.46^{C}	6.16
	2% citric acid	2180.00	4.51	64.62	60.35	68.54	73.06	0.16	0.18	6.32	9.74^{G}	4.59^{C}	6.16
	0.1% phytase	2365.00	4.55	66.94	54.88	69.76	74.31	0.16	0.15	6.24	11.69^{A}	6.42^{A}	5.19
-25% AP	**Un-supplemented**	1970.00	4.03	64.17	58.12	66.75	71.78	0.20	0.17	6.22	10.89^{C}	4.45^{C}	6.16
	2% citric acid	2115.00	4.41	62.26	52.76	68.31	72.71	0.14	0.17	6.16	10.49^{DE}	4.51^{C}	5.13
	0.1% phytase	2285.00	4.63	61.72	55.85	69.16	73.79	0.17	0.17	6.27	11.24^{B}	5.43^{B}	6.09
-50% AP	**Un-supplemented**	1675.00	5.07	59.24	56.83	64.45	69.52	0.16	0.17	6.09	10.60^{D}	4.47^{C}	6.15
	2% citric acid	2290.00	4.98	63.95	51.54	67.80	72.78	0.13	0.18	6.10	10.17^{F}	4.46^{C}	6.35
	0.1% phytase	2430.00	4.75	63.08	53.88	66.26	71.01	0.16	0.15	6.10	11.07^{BC}	5.34^{B}	6.15
±SEM		135.82	0.26	2.03	2.91	1.02	1.01	0.02	0.04	0.09	0.08	0.06	0.33

a, …b, and A,.. G, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to b; P≤0.01 for A to G). [1]Available phosphorus [2] Pooled SEM.

Table 4: Impact of citric acid and phytase supplementation on some blood parameters of Cobb broiler chicks during the period from 4-38 days of age.

Items		Hemoglobin (g/dL)	RBC[1] ($10^6/mm^3$)	Blood index				WBC[5] $10^3/mm^3$	Plate count	Differential count%				Phosphorus %
				Hematocrit %	MCV[2], μ^2	MCH[3], μμg	MCHC[4] %			Neutro-phils	Lympho-cyte	Mono-cytes	Eosino-phils	
Level of AP[1] (L):														
Recommended (R)		10.68	3.09	41.17	135.05	35.18	26.52	14.81	43.50	30.83	65.83^{a}	4.17	2.50	3.87^{b}
-25% AP		10.77	3.14	38.17	130.38	35.65	27.17	15.53	41.17	32.17	59.50^{b}	4.00	2.67	4.43^{a}
-50% AP		10.37	2.94	38.33	134.58	34.87	26.38	12.65	37.67	27.50	66.33^{a}	3.83	2.50	4.45^{a}
±SEM[2]		0.19	0.08	1.26	2.20	1.23	0.31	0.75	3.43	2.78	1.82	0.24	0.24	0.13
Type of addition (T):														
Un-supplemented		10.93^{A}	3.27^{A}	39.67	123.97^{B}	32.67^{b}	26.92	16.03	38.83	31.00	62.50	4.33	2.33^{b}	4.10
2% citric acid		10.92^{A}	3.19^{A}	40.50	130.43^{B}	35.20^{ab}	26.55	13.73	37.67	31.00	63.67	4.17	3.17^{a}	4.12
0.1% phytase		9.97^{B}	2.71^{B}	37.50	145.62^{A}	37.83^{a}	26.60	13.23	45.83	28.50	65.50	3.50	2.17^{b}	4.53
±SEM		0.19	0.08	1.26	2.20	1.23	0.31	0.75	3.43	2.78	1.82	0.24	0.24	0.13
L × T (treatments):														
R	Un-supplemented	11.10	3.28	41.50	126.25	33.75	26.75^{AB}	16.55	44.50	29.00	63.50	5.00	2.50	3.30
	2% citric acid	10.70	3.16	41.00	140.00	36.85	25.00^{B}	13.98	40.50	29.50	70.00	4.00	2.50	3.65
	0.1% phytase	10.25	2.85	41.00	138.90	34.95	27.80^{A}	13.91	45.50	34.00	64.00	3.50	2.50	4.65
-25% AP	Un-supplemented	11.40	3.40	40.50	119.25	33.55	28.10^{A}	16.85	36.50	32.50	61.00	4.00	2.50	4.50
	2% citric acid	11.20	3.24	40.00	123.40	34.50	27.90^{A}	14.65	35.50	35.50	56.00	5.00	3.50	4.30
	0.1% phytase	9.70	2.78	34.00	148.50	38.90	25.50^{B}	15.10	51.50	28.50	61.50	3.00	2.00	4.50
-50% AP	Un-supplemented	10.30	3.13	37.00	126.40	30.70	25.90^{B}	14.70	35.50	31.50	63.00	4.00	2.00	4.50
	2% citric acid	10.85	3.17	40.50	127.90	34.25	26.75^{AB}	12.55	37.00	28.00	65.00	3.50	3.50	4.40
	0.1% phytase	9.95	2.52	37.50	149.45	39.65	26.50^{AB}	10.69	40.50	23.00	71.00	4.00	2.00	4.45
±SEM		0.32	0.14	2.19	3.82	2.13	0.54	1.30	5.94	4.81	3.15	0.41	0.41	0.23

[1] Red blood cells [2] Mean corpuscular volume [3] Mean corpuscular hemoglobin [4] Mean corpuscular hemoglobin concentration [5] White blood cells

a, …b, and A,.. B, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to b; P≤0.01 for A to B). [1]Available phosphorus [2] Pooled SEM

Chicks fed diet un-supplemented with CA or phytase had higher values of hemoglobin and RBCs, (lower values of MCV and MCH), while, those fed diet supplemented with 0.1% phytase had lower values of hemoglobin and RBCs (higher values of MCV and MCH), as shown in Table 4. The results indicated no significant differences due to interaction effect of dietary treatments on blood constituents, except, mean corpuscular volume concentration (MCHC) which was significantly (P≤0.01) affected. Chicks fed diet containing –25% AP un-supplemented with CA or phytase had higher value of MCHC while, those fed diet containing recommended level of AP supplemented with 2% CA had lower value (Table 4).

Similar results were previously observed by **Ebrahimnezhad *et al.* (2008)** who found that supplementation of low P diet with CA significantly increased plasma P concentration, but had no significant effect on plasma Ca concentration. Likewise, **Viveros *et al.* (2002) and Brenes *et al.* (2003)** reported that decreasing AP level of diet increased ALP activity. Phytase and CA through the mechanism mentioned above facilitate liberation of phytate P and so increase plasma P concentration. **Boling *et al.* (2001b)** showed that CA did not improve Ca availability; plasma Ca concentration was not also affected by either phytase or CA. Also, **Broz *et al.* (1994)** utilized graded levels of fungal phytase (125, 250, or 500 FTU/kg), he reported that phytase supplementation increased P plasma.

Chemical composition of broiler meat: Level of AP had insignificantly affected chemical composition of broiler meat, except, ash% which was significantly affected. It can be concluded that chicks fed diet containing recommended level of AP had higher (P≤0.01) ash%, however, those fed diet containing -50% AP had lower ash%. Type of addition had insignificantly affected protein, fat and NFE% of chicks meat, however, significantly affected moisture and ash. The highest moisture% (the lowest ash%) was observed for chicks fed diet un-supplemented with CA or phytase (Table 5). Carcass part significantly influenced (P≤0.01) chemical composition of broiler meat. Rear part had higher fat% than the breast part (31.50 vs 24.18%). However, breast part had higher moisture, protein, ash and NFE% (consequently lower fat%) than rear part (Table 5). Data presented in Table 5 showed in general that feeding different treatments insignificantly affected the chemical composition of broiler meat.

Tibia parameters: Data presented in Table 5 showed that level of AP had significantly affected all tibia parameters, except, P% which was insignificantly affected. It can be concluded that chicks fed diet containing recommended level of AP had higher density, strength, ash and calcium%, however, those fed diet containing -50% AP had lower density, strength, ash and calcium% of chicks tibia. Type of addition had significantly affected tibia parameters, it can be concluded that chicks fed diet un-supplemented with CA or phytase to broiler diets had lower tibia parameters, while, those fed single supplementation of 2% CA had higher ash, calcium and phosphorous%. Chicks fed diet supplemented with 0.1% phytase had higher density and strength of chicks tibia (Table 5). It can be concluded that 2% CA or 0.1% phytase supplementation to broiler diets increase density, strength, ash, calcium and phosphorous% compared with those fed un-supplemented diet. On the other hand supplementation of P deficient C-SBM diets with 2% CA or 0.1% phytase improve the utilization of phytate P in the diet.

The results indicated that interaction effect of dietary treatments significantly (P≤0.05) affected strength, ash and calcium% of chicks tibia, however, insignificantly affected density and phosphorous% (Table 5).

Table 5: Impact of citric acid and phytase supplementation on chemical composition of broiler meat% (on dry matter basis) and tibia parameters of Cobb broiler chicks during the period from 4-38 days of age.

Items		Chemical composition of broiler meat%					Tibia parameters				
		Moisture	Protein	Fat	Ash	NFE	Density (g/cm^3)	Strength (kg)	Ash%	Calcium%	Phosphorous %
Level of AP[1] (L):											
Recommended (R)		6.64	63.04	26.29	3.64^{A}	0.39	1.08^{A}	31.86^{A}	44.14^{A}	25.43^{a}	12.55
-25% AP		5.69	62.56	28.09	3.31^{A}	0.35	0.98^{B}	28.81^{B}	41.06^{B}	24.92^{ab}	12.54
-50% AP		5.97	61.80	29.13	2.81^{B}	0.30	0.93^{B}	28.43^{B}	40.22^{C}	24.43^{b}	12.27
±SEM[2]		0.50	0.80	1.26	0.13	0.03	0.02	0.31	0.24	0.24	0.25
Type of addition (T):											
Un-supplemented		7.22^{a}	61.17	28.47	2.79^{B}	0.34	0.92^{B}	27.96^{C}	41.14^{b}	23.44^{C}	11.86^{b}
2% citric acid		5.36^{b}	62.83	28.07	3.37^{A}	0.37	1.01^{A}	29.19^{B}	42.22^{a}	26.17^{A}	13.11^{a}
0.1% phytase		5.72^{b}	63.39	26.97	3.60^{A}	0.32	1.05^{A}	31.96^{A}	42.05^{a}	25.17^{B}	12.39^{ab}
±SEM		0.50	0.80	1.26	0.13	0.03	0.02	0.31	0.24	0.24	0.25
Carcass part:											
Breast		7.08^{A}	64.76^{A}	24.18^{B}	3.56^{A}	0.42^{A}	------	------	------	------	------
Rear		5.12^{B}	60.17^{B}	31.50^{A}	2.95^{B}	0.27^{B}	------	------	------	------	------
±SEM		0.37	0.32	0.41	0.14	0.02	------	------	------	------	------
L × T (treatments):											
R	Un-supplemented	7.25	62.15	26.68	3.54	0.39	1.08	31.20^{a}	44.30^{ab}	24.77^{bc}	11.55
	2% citric acid	6.08	63.48	26.44	3.60	0.40	1.10	31.78^{a}	44.92^{a}	26.89^{a}	13.87
	0.1% phytase	6.59	63.50	25.76	3.79	0.37	1.06	32.61^{a}	43.20^{bc}	24.64^{bc}	12.23
-25% AP	Un-supplemented	7.35	61.00	28.52	2.74	0.39	0.89	26.90^{bc}	39.98^{ef}	23.73^{c}	12.41
	2% citric acid	5.04	63.00	27.97	3.63	0.37	1.02	27.74^{b}	41.29^{de}	25.64^{ab}	12.53
	0.1% phytase	4.68	63.67	27.79	3.58	0.29	1.04	31.81^{a}	41.90^{cd}	25.38^{b}	12.69
-50% AP	Un-supplemented	7.05	60.36	30.23	2.11	0.26	0.81	25.78^{c}	39.14^{f}	21.82^{d}	11.64
	2% citric acid	4.97	62.02	29.79	2.88	0.34	0.91	28.06^{b}	40.46^{ef}	25.99^{ab}	12.93
	0.1% phytase	5.90	63.01	27.36	3.45	0.29	1.06	31.46^{a}	41.05^{de}	25.49^{ab}	12.25
±SEM		0.87	1.39	2.18	0.22	0.06	0.04	0.53	0.41	0.42	0.43

a, …f, and A,.. C, values in the same column within the same item followed by different superscripts are significantly different (at P≤0.05 for a to f; P≤0.01 for A to C). [1]Available phosphorus [2] Pooled SEM

Similar to the present results, **Sohail and Roland (1999)** reported a decrease in bone strength in broilers fed the 0.225% P diet, and the inclusion of phytase regardless of level negated the effects on growth and bone variables. Also, **Driver *et al.* (2006)** reported that although there was an increase in the incidence of broken tibias in broilers fed diets with lower levels of Ca and P from day zero to 35 days, the inclusions of phytase reversed the associated negative effects. **Shelton *et al*. (2004)** reported that including phytase at 500 FTU/kg to low Ca and P swine diets without trace minerals negated the decrease in bone strength and bone ash percentage. However, **Pillai *et al.* (2006)** reported that no differences in bone breakage during processing was found between broilers fed P adequate diets and those fed the negative control supplemented with phytase.

Our results agreed with other researchers who reported that addition of phytase to P inadequate diets enhances tibia ash **(Angel *et al.*, 2006; Cowieson *et al.*, 2006; Pillai *et al.*, 2006 and Ravindran *et al.*, 2006).** Supplementation of broiler diets with microbial phytase increase P availability **(Abd-El Samee, 2002 and Driver *et al.*, 2004).** Regarding minerals utilization, significant increases were observed in tibia P and Zn content with phytase supplementation to low NPP corn/sunflower diet as compared to those un-supplemented **(Salem *et al.*, 2003 and El-Husseiny *et al.*, 2006). Connor (2008)** reported that reducing dietary AP levels decreased tibia ash and tibia Ca and P levels and the inclusion of phytase and CA increased tibia ash and tibia Ca and P levels**. Boling *et al*. (2000) and Rafacz *et al.* (2005)** found that tibia ash was significantly increased by the addition of CA in chick diets. Since low level of AP will decreased tibia ash **(Viveros *et al*., 2002),** it seems that phytase and CA exert their effects on tibia ash by increasing availability of phytate P. Similarly, several studies have previously shown higher tibia ash in CA supplemented low P diets **(Leeson *et al.* 2000 and Snow *et al.* 2004)**. While, supplementation of low P diet with CA had no significant effect on tibia ash **(Ebrahimnezhad *et al.*, 2008)**.

Economical efficiency (EEf): Results in Table 6 show that EEf values during the period from 4 to 38 days of age was improved of chicks fed diet containing -50% AP supplemented with 0.1% phytase (2.652 and 101.39%, respectively), chicks fed diet containing recommended level of AP supplemented with 0.1% phytase (2.633 and 100.65%, respectively) and chicks fed diet containing -25% AP supplemented with 0.1% phytase (2.625 and 100.34%, respectively) as compared with those fed the control diet and other treatments. Whereas, chicks fed diet containing -25% AP un-supplemented with CA or phytase had the lowest corresponding values, being 2.535 and 96.91%, respectively. The relative efficiency varied between 96.91% to 101.39%, which is of minor importance relative to other factors of production.

Chicks fed diet containing recommended level of AP supplemented with 0.1% phytase had higher tibia strength and those fed diet containing recommended level of AP supplemented with 2% CA had higher values of ash and calcium% (the increase in tibia ash resulting from CA supplementation indicate that the CA markedly improved phytate P utilization in broiler chicks). While, chicks fed diet containing -50% AP un-supplemented with CA or phytase had lower values of tibia strength, ash and calcium% (Table 5).

Table 6: Impact of citric acid and phytase supplementation on economical efficiency (EEf) of Cobb broiler chicks during the period from 4-38 days of age.

Level of available phosphorus (AP)	Recommended			-25% AP			-50% AP		
Type of addition	Un-supplemented	2% citric acid	0.1% phytase	Un-supplemented	2% citric acid	0.1% phytase	Un-supplemented	2% citric acid	0.1% phytase
a_1	0.4340	0.4517	0.4447	0.4370	0.4413	0.4363	0.4244	0.4450	0.4463
b_1	213.90	217.70	216.50	209.06	212.86	211.66	204.46	208.26	207.06
a_1 x b_1=c_1	92.833	98.329	96.271	91.359	93.942	92.354	86.771	92.676	92.417
a_2	0.8773	0.8810	0.8723	0.8810	0.8727	0.8707	0.8764	0.8747	0.8630
b_2	211.22	215.02	213.82	206.74	210.54	209.34	202.50	206.30	205.10
a_2 x b_2=c_2	185.31	189.43	186.52	182.14	183.73	182.27	177.48	180.44	177.00
a_3	1.9560	1.9533	1.9463	1.9537	1.9530	1.9400	1.9584	1.9413	1.9233
b_3	219.16	222.96	221.76	214.27	218.07	216.87	210.06	213.86	212.66
a_3 x b_3=c_3	428.68	435.51	431.62	418.61	425.89	420.73	411.37	415.17	409.02
($c_1+c_2+c_3$)=c_{total}	706.82	723.28	714.41	692.11	703.56	695.35	675.62	688.29	678.43
d	1.9658	1.9890	1.9963	1.8818	1.9345	1.9387	1.8740	1.9099	1.9058
e	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0	1300.0
d x e=f	2555.5	2585.6	2595.2	2446.3	2514.8	2520.3	2436.2	2482.9	2477.5
f- c_{total} =g	1848.7	1862.4	1880.8	1754.2	1811.2	1825.0	1760.6	1794.6	1799.1
Economical efficiency(g/ c_{total})	2.6155	2.5749	2.6326	2.5346	2.5744	2.6246	2.6059	2.6073	2.6518
Relative efficiency(r)	100.00	98.45	100.65	96.91	98.43	100.34	99.63	99.69	101.39

a_1, a_2 and a_3 ……………………….average feed intake (Kg/bird) during the periods of starter, grower and finisher, respectively.
b_1, b_2 and b_3 ……………………… price / Kg feed (P.T.) during the periods of starter, grower and finisher, respectively (based on average local market price of diets during the experimental time).
c_1, c_2 and c_3 ………………………. feed cost (P.T.) during the periods of starter, grower and finisher, respectively.
Total feed cost (P.T.) = c_{total} = ($c_1+c_2+c_3$)
Average LBWG (Kg/ bird) d
Price / Kg live weight (P.T.) e…………………..…….…(according to the local market price at the experimental time).
Total revenue (P.T.) = d x e = f
Net revenue (P.T.) = f - c_{total} =g
Economical efficiency = (g / c_{total}) ……….………………...(net revenue per unit feed cost).
Relative efficiency r………………..……….(assuming that economical efficiency of the control group (1) equals 100).

Bosch *et al.* (1998) utilized a Virginia farm as a model for investigating the economic benefits of incorporating phytase in poultry diets. They reported $1,435 in economic gains associated with the inclusion of phytase to turkey diets, due to increased sale of lower P litter that could be applied to farmland and to the reduction in dietary P supplementation. However, the optimal level of phytase is unknown because P equivalency of phytase can be affected by many factors such as dietary concentrations of phytate P, Ca and NPP, phytase inclusion levels, the source of exterior phytase and the level of endogenous phytase in the ingredients **(Selle and Ravindran, 2007).**

The results of the present study indicated that Cobb broiler chicks fed low AP diets supplemented with CA or phytase maintain the same performance as that obtained from chicks fed diets containing recommended level of AP. On the other hand, it can be concluded that AP can be reduced from the recommended level by 50% and supplement these diets with either CA or phytase without affecting performance. Besides, using such diets reduces feed cost and phosphorus pollution.

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الملخـــص العـــربي

تأثير إضافة حمض الستريك والفيتيز علي إداء بداري التسمين

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تم إجراء التجربة في محطة بحوث الدواجن بالعزب بالفيوم – معهد بحوث الإنتاج الحيواني – مركز البحوث الزراعية – وزارة الزراعة بالدقي – مصر . وذلك خلال الفترة من شهر يناير إلى فبراير لسنة ٢٠١٢. التحاليل الكيماوية أجريت في معامل قسم إنتاج الدواجن – كلية الزراعة – جامعة الفيوم. غذيت الكتاكيت عمر يوم ولمدة ٣ أيام علي عليقة المقارنة وتم توزيع ٢١٦ كتكوت غير مجنس (سلالة كب) بصورة عشوائية إلى تسع معاملات (٢٤ طائر/معاملة) كل معاملة مقسمة إلي ثلاثة مكررات (٨ طائر/مكرر). وكانت المعاملات التجريبية كما يلي:

١-غذيت الكتاكيت علي عليقة المقارنة.
٢-عليقة المقارنة +٢% حمض ستريك.
٣-عليقة المقارنة +٠,١% فيتيز.
٤-عليقة المقارنة-٢٥% فوسفور متاح.
٥-عليقة المقارنة-٢٥% فوسفور متاح +٢% ىستريك.
٦-عليقة المقارنة-٢٥% فوسفور متاح+٠,١% فيتيز.
٧-عليقة المقارنة-٥٠% فوسفور متاح .
٨-عليقة المقارنة-٥٠% فوسفور متاح +٢% ستريك.
٩-عليقة المقارنة-٥٠% فوسفور متاح+٠,١% فيتيز.

وتم تلخيص النتائج المتحصل عليها كما يلي :

١-**الأداء الإنتاجي و صفات الذبيحة:** تبين ان هناك انخفاض خطي معنوي في وزن الجسم الحي عند عمر ٣٨ يوم والزيادة في وزن الجسم ،كمية الغذاء المأكول، كفاءة تحويل البروتين، معامل الأداء الإنتاجي، وزن الذبيحة بعد التجويف والتصافي في نهاية الفترة التجريبية مع خفض نسبة الفوسفور المتاح. لم يكن هناك أي تأثير معنوي لأي من نوع الإضافة (حمض ستريك أو الفيتيز) ولا للتداخل بين نوع الإضافة مع مستوي البروتين علي وزن الجسم الحي والزيادة في وزن الجسم ومعامل التحويل الغذائي وكفاءة تحويل البروتين وكفاءة تحويل الطاقة ومعدل النمو ومعامل الأداء الإنتاجي. ارتفعت معنويا كمية الغذاء المأكول للكتاكيت المغذاة علي علائق تحوي المستوي الموصي به من الفوسفور المتاح مضافاً إليها ٢% حمض ستريك خلال الفترة من ٤-٣٨ يوم.

2-**ميكروفلورا الأمعاء:** الكتاكيت المغذاة علي العلائق المنخفضة في محتواها من الفوسفور المتاح بنسبة ٢٥% كانت الأعلى معنويا في العدد الكلي للميكروفلورا، بينما المغذاه علي المستوي المثالي به من الفوسفور المتاح كانت الأعلى معنويا في colibacillus (اقل عدد كلي للميكروفلورا). الكتاكيت المغذاة علي العلائق المنخفضة في محتواها من الفوسفور المتاح بنسبة ٢٥% بدون إضافة الستريك او الفيتيز كانت الأقل في colibacillus.

٣-**مكونات الدم:** الكتاكيت المغذاة علي العلائق غير المحتوية علي أي إضافات أعلي معنويا في نسبة الهيموجلوبين و عدد خلايا الدم الحمراء (اقل قيمة لمتوسط حجم الخلايا، ومتوسط وزن الهيموجلوبين).

٤-**التركيب الكيماوي للحم بداري التسمين و قياسات عظمة التيبيا:** الكتاكيت المغذاة علي علائق غير المضاف إليها الستريك او الفيتيز أعلي معنويا في نسبة الرطوبة (اقل نسبة رماد). كان للكتاكيت المغذاة على نسبة الفوسفور الموص به أعلى معنوية لكثافة وقوة العظم ونسبة الرماد و الكالسيوم في عظمة التيبيا. كانت هناك زيادة معنوية لكثافة وقوة العظم، نسبة الرماد، الكالسيوم والفوسفور في عظمة التيبيا للكتاكيت المغذاة علي علائق مضافاً إليها ٢% حمض ستريك أو ٠,١% فيتيز.

٥-**الكفاءة الاقتصادية:** تحسنت الكفاءة الاقتصادية والنسبية للكتاكيت المغذاة علي -٥٠% من الفوسفور المتاح مع إضافة ٠,١% فيتيز،الكتاكيت المغذاة على المستوي المثالي من الفوسفور المتاح مع إضافة ٠,١% فيتيز و الكتاكيت المغذاة علي -٢٥% من الفوسفور المتاح مع إضافة ٠,١% فيتيز مقارنة بتلك التي غذيت على علائق الكنترول وباقي المعاملات.

يمكن التوصية بأن تغذية الكتاكيت (كب) على العلائق المنخفضة في الفوسفور المتاح مع إضافة حمض الستريك أو الفيتيز يماثل في أداءه تلك المغذاة على العلائق المثالية في الفوسفور المتاح. وبمعني أخر يمكن استنتاج انه يمكن خفض نسبة الفوسفور المتاح حتي ٥٠% عن المستوي الموصي به مع إضافة حمض الستريك أو الفيتيز بدون التأثير علي الأداء. بالإضافة إلى أن استخدام هذه العلائق يقلل من تكلفة الغذاء والتلوث بالفوسفور.