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Adding Phytogenic Material and/or Organic Acids to Broiler Diets: Effect on Performance, Nutrient Digestibility and Net Profit

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ABSTRACT

A growth experiment was conducted to study performance, nutrients digestibility and economic efficiency of broiler chicks fed corn-soybean meal diets supplemented with a commercial phytogenic product (Bedgen 40®) contained artichoke extract (*Cynara scolymus*), a commercial mixture of organic acids (Galliacid®) and a combination of both. Starter, grower and finisher diets were supplemented with two levels of both being 0 and 150 g t^{-1} artichoke extract and 0 and 600 g t^{-1} organic acids in 2×2 factorial arrangement. Dietary treatments were examined on 200 one day-old Cobb broiler chicks. The experiment lasted from 1-39 days of age. The results showed that supplementation of artichoke extract or organic acids mixture significantly ($p<0.05$) increased body weight gain by about 6% and improved feed conversion ratio by about 7%, compared with the control diet of no feed additives. Addition of artichoke extract improved the digestibility coefficients ($p<0.01$) of CP and CF, while, addition of organic acids mixture improved the digestibility coefficients ($p<0.01$) of DM, OM, CP, CF and NFE compared to the un-supplemented diet. Supplementation of artichoke extract and organic acids decreased total feed cost/kg body weight and improved net profit and economic efficiency. It could be concluded that using artichoke extract or organic acids mixture improved broiler performance and economic efficiency of broilers fed corn-soybean meal diets. No associative effect was detected on performance, digestibility or economic efficiency when a combination of both products was used.

Key words: Bedgen 40®, artichoke extract, Galliacid®, broilers performance, nutrient digestibility, net profit

INTRODUCTION

The non-prescription use of antibiotics in poultry feeds has been eliminated or limited to more extend. The European Union banned sub-therapeutic levels of some antibiotics used to promote growth in 1997 and a ban on other antibiotics in 1999 and most of antibiotics were banned by January 2006. So, there is need to find more efficient alternatives or combinations of different alternatives for maintaining health and improving performance of poultry and other livestock species (Waldroup *et al*., 2003; Qamar *et al*., 2015). These alternatives include direct-fed microbials (probiotics), prebiotics, organic acids, enzymes or phytogenics.

Windisch *et al*. (2009) defined phytogenic feed additives (often also called phytobiotics or botanicals) as plant derived feed additives included into livestock diets to improve productivity,

properties of feed and food quality, as well as promotion of zootechnical performance. As phytogenics are natural substances or derived thereof, there is common sense that safety concerns do not apply *per se*. Hence application of phytogenics to agricultural livestock has to be safe to the animal, the user, the consumer of the animal product and the environment.

Herbal used in broilers revealed positive effect on performance, immunity and hematological parameters and could act as natural growth promoters (Hashemi and Davoodi, 2011; Qamar *et al*., 2015). One of the suggested herbal feed additives is Artichoke (*Cynara scolymus*) or its extract. Artichoke is widely grown in Mediterranean countries and is rich in natural antioxidants. It contains high levels of phenolic compounds that have the major effect on bile flow and liver protection (Speroni *et al*., 2003).

However, literature does not draw a consistent picture on using phytogenic feed additives. There are reports that show increased, unchanged as well as reduced villi length and crypt depth in jejunum and colon for broiler and piglet treated with phytogenics (Namkung *et al*., 2004; Demir *et al*., 2005; Jamroz *et al*., 2006; Nofrarias *et al*., 2006; Oetting *et al*., 2006).

Also, organic acids are among the alternative growth promoters that are being used to stimulate growth performance in poultry (Hassan *et al*., 2010; Mohamed *et al*., 2014). Many studies demonstrated that supplementation of organic acids to broiler diets increase growth performance, improve gut morphology, reduce diseases and overcome some management problems (Gunal *et al*., 2006; Islam *et al*., 2008; Ao *et al*., 2009; Hassan *et al*., 2010; Sayrafi *et al*., 2011; Mohamed *et al*., 2014).

Most of the previous studies involved the effect of using phytogenic or organic acids on broiler performance while there was no report on using a combination of both. Therefore, the objective of this study was to evaluate the use of a commercial product of phytogenic (Bedgen 40®, composed of artichoke extract *Cynara scolymus*) and choline chloride and a commercial mixture of organic acids (Galliacid®) on performance, nutrients digestibility and economic efficiency of broiler chicks and if there is an associative effect of using a combination of both in broiler diets.

MATERIALS AND METHODS

A growth experiment was conducted to study the effect of supplementing broiler diet with a commercial phytogenic product (Bedgen 40®) and/or a commercial mixture of organic acids (Galliacid®) were used. Bedgen 40® is a phytogenic feed additive that contains artichoke extract (*Cynara scolymus*) and choline chloride produced by Bedson, Spain. Galliacid® is a mixture of fumaric acid, calcium formate, calcium propionate, potassium sorbate and hydrogenated vegetable oil produced by Jefo, Company, Saint-Hyacinthe Canada. These organic acids are coated and protected (microencapsulated) by a matrix of fatty acids. The experiment lasted from 1-39 days of age. At starting period (1-12 days), growing period (12-26 days) and finishing period (26-39 days) four diets were formulated: Diet 1: Without additives and serve as a control, diet 2: Control+150 g artichoke extract/ton feed, diet 3: Control+600 g mixture of organic acids/ton feed and diet 4: Control+a combination of 150 g artichoke extract and 600 g organic acids/ton feed.

All diets were formulated to meet the nutrient requirements of the chicks according to the strain guide. Table 1 shows the formulation and nutrient composition of the basal diets. These diets were fed to four groups of 50 one-day old Cobb broiler chicks (5 replicates of 10 chicks each/group). Replicates were randomly allocated in batteries and gas heaters were used to keep the required temperature for the brooding period. Light was provided 23 h a day throughout the experimental period. Feed and water were allowed for *ad libitum* consumption.

Table 1: Formulation and nutrient composition of the basal diets

Ingredients (%)	Starter diet	Grower diet	Finisher diet
Yellow corn	56.99	61.22	63.94
Soybean meal (48%)	34.00	29.00	27.00
Corn gluten meal (60%)	4.00	4.00	2.00
Soybean oil	1.00	1.80	3.20
Dicalcium phosphate	1.45	1.45	1.40
Limestone	1.30	1.30	1.30
Vitamin and Mineral mix[(1)]	0.30	0.30	0.30
NaCl	0.25	0.25	0.25
L-lysine HCl	0.30	0.30	0.30
DL-methionine	0.25	0.25	0.20
Choline chloride	0.15	0.12	0.10
Xylam*	0.01	0.01	0.01
Total	100.00	100.00	100.00
Calculated composition [(2)] (%)			
Crude protein (%)	23.95	21.98	19.98
ME (kcal kg^{-1})	3085.00	3180.00	3260.00
Lysine (%)	1.50	1.36	1.28
Methionine (%)	0.66	0.62	0.53
Methionine+Cystine (%)	1.05	1.00	0.88
Calcium (%)	0.93	0.92	0.90
Nonphytate P (%)	0.40	0.40	0.38

[(1)]Vitamin-mineral mixture supplied per kg of diet: Vit A: 12000 IU, Vit D_3: 2200 IU, Vit E: 10 mg, Vit K_3: 2 mg, Vit B_1: 1 mg, Vit B_2: 4 mg, Vit B_6: 1.5 mg, Vit B_{12}: 10 μg, Niacin: 20 mg, Pantothenic acid: 10 mg, Folic acid: 1 mg, Biotin, 50 μg, Copper: 10 mg, Iodine: 1 mg, Iron: 30 mg, Manganese: 55 mg, Zinc: 50 mg and Selenium: 0.1 mg, [(2)]According to NRC. (1994). *Xylam: A commercial enzyme preparation contains β-glucanase

At 12, 26 and 39 days of age, after fasting overnight birds were individually weighed and feed intake was recorded per replicate. Body weight gain and feed conversion ratio were calculated. Throughout the experiment, birds were vaccinated against AI, ND, IB and IBD. After such medical treatments a dose of vitamins (AD_3E) was offered in the drinking water for the successive 3 days. At 39 days of age, 6 birds of each treatment were randomly taken and housed in individual cages to determine the nutrients digestibility. The finishing period was considered as adaptation period and the collection period lasted 3 days. Fecal nitrogen was determined according to the method outlined by Terpstra and de Hart (1974). The proximate analyses of feed and dried excreta samples were carried out according to the Association of Official Analytical Chemists (AOAC., 1990).

Economic efficiency were calculated from money output-input analysis and represented as feed cost, fixed cost (chick price, management, labor, vaccine and medicated cost), the net profit and profitability under local conditions.

Data were statistically analyzed for analysis of variance using the General Liner Model of SAS (1990). Factorial (2×2) analysis of variance was used. Significant differences among treatment means were separated by Duncan's new multiple rang test (Duncan, 1955).

RESULTS

Growth performance: The results of broiler performance Body Weight Gain (BWG) and Feed Conversion Ratio (FCR) as affected by dietary treatments during the different interval and the overall experimental period are shown in Table 2.

The main effect of artichoke extract on BWG showed significant positive result for the starting, finishing ($p<0.05$) and overall ($p<0.01$) experimental period. Organic acid mixture showed the same

Table 2: Body Weight Gain (BWG) and Feed Conversion Ratio (FCR) of broiler chicks as affected by dietary treatments during the different intervals and the overall experimental period

Items		BWG (g)				FCR (g g^{-1})			
Artichoke extract	Organic acids	Starter	Grower	Finisher	Overall	Starter	Grower	Finisher	Overall
0	0	279	700	911	1890[b]	1.50[a]	1.63[a]	1.90[a]	1.74[a]
+	0	304	733	974	2011[a]	1.39[b]	1.53[b]	1.77[b]	1.62[b]
0	+	302	727	951	1979[a]	1.39[b]	1.54[b]	1.77[b]	1.63[b]
+	+	308	742	959	2009[a]	1.37[b]	1.52[b]	1.76[b]	1.62[b]
SE of means		±4	±7	±9	±14	±0.01	±0.01	±0.02	±0.01
Main effects									
Artichoke extract	0	290[b]	713	931[b]	1935[b]	1.44[a]	1.58[a]	1.84[a]	1.68[a]
	+	306[a]	737	966[a]	2010[a]	1.38[b]	1.53[b]	1.77[b]	1.62[b]
Organic acids	0	292[b]	716	955	1950[b]	1.45[a]	1.57[a]	1.84[a]	1.68[a]
	+	305[a]	734	955	1994[a]	1.38[b]	1.53[b]	1.77[b]	1.62[b]
Significances									
Artichoke extract (A)		*	NS	*	**	*	**	**	***
Organic acids (O)		*	NS	NS	**	*	**	**	***
A×O		NS	NS	NS	**	*	*	**	***

[a,b]Means within each column for each effect with no common superscript are significantly different ($p<0.05$). *$p<0.05$, **$p<0.01$, ***$p<0.001$, NS: Not significant ($p>0.05$)

effect for the starting and overall experimental period. The interaction between both feed additives showed no significant effect on BWG among the different dietary treatments during the different intervals but significant ($p<0.01$) effect was detected for the overall experimental period. Birds fed diet of no feed additives showed significant ($p<0.01$) less BWG compared with the other groups. At the end of the experiment, the results showed that using artichoke extract and/or organic acid mixture increased BWG by about 6%.

Consistent results of FCR were obtained during the different intervals (starter, grower and finisher) and the overall experimental period. Birds fed on diet of no additives recorded the worst FCR ($p<0.01$) compared to the other dietary treatments that contained artichoke extract and/or organic acids. Artichoke extract and organic acid mixture gave the same results of FCR when supplemented either individually or together.

Such additions improved the resulted values of FCR at the end of the experiment by about 7% compared to the diet of no feed additives (from 1.74 to 1.62).

Nutrients digestibility: The effects of dietary treatments on the nutrient digestion coefficients are summarized in Table 3. Nutrient digestion coefficients were significantly affected by dietary treatments. Artichoke extract supplementation improved ($p<0.01$) the digestion coefficients of Dry Matter (DM), Crude Protein (CP) and Crude Fiber (CF). Addition of organic acids mixture significantly ($p<0.01$) improved the digestibility of DM, OM, CP, CF and NFE. Digestibility values of EE did not affect by such feed additives.

Economic efficiency: Results of Economic Efficiency (EE) and relative EE of using artichoke extract and organic acids in broiler feeding, calculated at the end of the experiment, are presented in Table 4. Supplementation of artichoke extract and organic acids to broiler diet gave better relative REE than the control diet of no additives. Economic efficiency values were improved by 17,

Table 3: Effect of dietary treatments on nutrients digestion coefficient at 39 days of age

Items		Percentage					
Artichoke extract	Organic acids	Dry matter	Organic matter	Crude protein	Ether extract	Crude fiber	Nitrogen free extract
0	0	77.15^{c}	79.58^{c}	88.36^{c}	84.31	26.60^{c}	76.48^{c}
+	0	76.40^{c}	79.18^{c}	89.67^{b}	84.27	36.88^{a}	76.29^{c}
0	+	79.33^{a}	81.94^{a}	90.59^{a}	84.83	34.93^{ab}	79.33^{a}
+	+	78.23^{b}	80.79^{b}	90.83^{a}	84.21	32.92^{b}	78.20^{b}
SE of means		±0.31	±0.31	±0.26	±0.43	±1.05	±0.42
Main effects							
Artichoke extract	0	78.23^{a}	80.76	89.47^{b}	84.57	30.76^{b}	77.91
	+	77.32^{b}	79.99	90.25^{a}	84.24	34.90^{a}	77.25
Organic acids	0	76.78^{b}	79.38^{b}	89.02^{b}	84.29	31.74^{b}	76.39^{b}
	+	78.78^{a}	81.36^{a}	90.71^{a}	84.52	33.92^{a}	78.77^{a}
Significances							
Artichoke extract (A)		**	NS	**	NS	**	NS
Organic acids (O)		**	**	**	NS	**	**
A×O		**	**	**	NS	**	*

^{a,b}Means within each column for each effect with no common superscript are significantly different ($p<0.05$). NS: Not significant

Table 4: Effect of dietary treatments on Net Profit (NP) Economic Efficiency (EE) and relative EE at the end of experimental period

Item	Control	Artichoke extract	Organic acids	Artichoke extract+Organic acids
Body weight (g)	1930	2051	2019	2049
Feed intake/chick (g)	3284	3266	3220	3243
Feed cost/chick (LE)	12.32	13	12.74	13.01
Fixed cost/chick (LE)*	6.5	6.5	6.5	6.5
Total cost/chick (LE)	18.82	19.5	19.24	19.51
Sale price/bird (LE)**	22.2	23.59	23.22	23.56
Net profit (LE)	3.38	4.09	3.98	4.05
Economic efficiency (EE)***	0.18	0.21	0.207	0.208
Relative EE (%)	100	117	115	116

Total price for feeds was calculated according to the price of different ingredients available in A.R.E. at experimental time, *Included chick price, cost of management, vaccines and medicated cost, ..., **Live body weight X 11.50 LE/kg. ***EE: Net profit/Total cost/chick (LE)

15 and 16% for the chicks fed diets supplemented with artichoke extract, organic acids and both together, respectively, compared to the control diet of no additives.

These results indicated that artichoke extract and/or organic acids supplementation decrease the relative cost per unit of body weight and thus increase profitability from broiler production.

DISCUSSION

The results of the present study confirmed those obtained by Bonomi (2001) who found that adding dehydrated artichoke leaves to feed improved the growth rate of broilers and the egg production of laying hen. Similarly, Wheeler (2006) fed herbal medicines to broiler chicken and observed better FCR values at the end of the trial. Buchanan *et al*. (2008) stated that broiler chicken fed diets having plant extract blends had minimum feed conversion ratio, increase weight gain and maximum breast yield.

Also, Nidaullah *et al*. (2010) and Portugaliza and Fernandez Jr. (2012) reported improved FCR in broilers offered drinking water supplemented with different herbal plant extracts.

Recently, Qamar *et al*. (2015) found that supplementation of herbal medicine exhibited significant ($p<0.05$) positive effects on weight gain and feed conversion ratio of broilers. The authors demonstrated that phytogenic feed additives are supposed to help regular digestion while improving performance along with various other way of action including reducing bacterial colony counts and fermentation products, decreasing the activity of gut associated lymphatic system, boosting pre-cecal nutrient digestibility and keeping anti-oxidative properties. Limited research found which structured to growth promoting effects of phytogenic feed additives in poultry.

However, Effati *et al*. (2014) studied the effects of different levels of artichoke (*Cynara scolymus*) on growth performance and immune responses of broilers under heat stress. They found that body weight and feed conversion ratio were not influenced by dietary artichoke ($p>0.05$). However, supplementing artichoke in diet could improve antibody responses when birds were under reared heat stress condition.

On contrary, Tajodini *et al*. (2014) examined using artichoke (*Cynara scolymus* L.) powder on growth performance and immune responses of broilers and found that artichoke powder negatively affected growth performance (gain in body weight and feed conversion ratio). But it significantly increased antibody levels on blood, resulting in increased activity of immune system. Takahashi *et al*. (2000) and Tajodini *et al*. (2014) proposed that immune-stimulation may have adverse effects on growth performance, because more nutrients are repartitioned to synthesize and develop immune organs, thereby decreasing the amount of nutrients available for growth.

The better FCR may probably be due to improved digestibility of nutrients, because herbs and herbal products can control and bound the growth and colonization of several pathogenic and nonpathogenic species of bacteria in chicken gut. This may lead to a better efficiency in the consumption of feed, resulting in improved growth and feed efficiency.

On contrary, Abdo *et al*. (2007) found that feeding broilers on diets contained levels of artichoke leaves meal decreased performance. But it did significantly ($p<0.05$) improve utilization of all nutrients except NFE.

Regarding the effect of organic acids, the obtained results agreed with previous studies demonstrated that supplementation of organic acids to broiler diets could be used to increased growth performance, reduced diseases and overcome some management problems (Gunal *et al*., 2006; Islam *et al*., 2008; Ao *et al*., 2009; Hassan *et al*., 2010; Sayrafi *et al*., 2011; Mohamed *et al*., 2014).

Gunal *et al*. (2006), Islam *et al*. (2008) and Ao *et al*. (2009) concluded that organic acids could be used in poultry as a growth promoter and as a meaningful tool of controlling intrinsic pathogenic bacteria. Abd El-Hakim *et al*. (2009) found that addition of organic acids of broiler diets improved feed conversion ratio, growth performance, enhanced mineral absorption and speeding recovery from fatigue. Abdel-Fattah *et al*. (2008) found that broiler chicks fed dietary organic acids had superior improvement in live body weight, body weight gain and feed conversion ratio compared to those of un-supplemented diet. Owens *et al*. (2008) reported that total live weight gain and gain: feed of broiler chicks were significantly improved by 12 and 9%, respectively for diets containing organic acids additives, compared to the control diets. Ao *et al*. (2009) found that the basal diet supplemented with 2% citric acid of broilers significantly ($p<0.05$) increased feed intake, weight gain, AMEn of the diets and retention of CP and Neutral Detergent Fiber (NDF). Islam *et al*. (2008) concluded that Fumaric Acid (FA) may promote growth of broilers. Using 1.25% FA showed significantly ($p<0.05$) better weight gain and better feed efficiency than the groups with 5.0 and 7.5% FA. Higher gain was associated with higher feed intake.

Cengiz *et al*. (2012) reported that supplementation of organic acids to poultry diets was shown to increases beneficial microbial activity in the small intestine. It also suppresses the growth of certain species of bacteria such as *Salmonella, E. coli*, *Clostridium perfringes*, *Listeria monocytogenes* and *Campylobacter* (Van Immerseel *et al*., 2002; Hassan *et al*., 2010; Mohamed *et al*., 2014).

Mohamed *et al*. (2014) found that dietary inclusion of organic acids in broiler diets increased growth performance and improved intestinal morphology. It could be used as alternative to antibiotic growth promoters or as a tool of controlling intestinal pathogenic bacteria in broilers.

The net profit per kilogram live weight basis was higher in birds of experimental supplemented diets whereas, the lowest profit was gained from birds fed the control un-supplemented diet. This is in agreement with the results of using different phytogenics in broiler feeding. Durrani *et al*. (2008) reported that supplementation of herbal infusion increased profit margin in broiler when compared to non-supplemented group. Similarly, Zanu *et al*. (2011) found that dietary inclusion of *Moringa oleifera* leaf meal in the rations was more beneficial in terms of profit margin in broiler production than those fed ration without supplementation. Behboud *et al*. (2011) also observed a reduction in the cost of feed consumed at higher inclusion level of chicory leaf pulp which ultimately reduced cost of production of broiler.

It could be concluded that addition of artichoke extract and/or organic acids to broiler diets significantly improved growth performance and efficiency of feed utilization that resulted in decrease feed cost and increase total profit. No significant differences between birds fed artichoke extract and those fed organic acids supplemented diets. When both supplements were added together no associative effect was detected.

As the feed industry is currently looking for efficacious, safe and cost-efficient additives with a clearly defined mode of action and proven benefits, Bedgen 40® and Galliacid® have a considerable potential to fulfill this demand when used either individually or in combination.

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