

Research Article



Effect of Hot Red Pepper Oil on the Productivity, Carcass Characteristics and Economic Efficiency of Broiler Chickens

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Abstract | Due to the ban on synthetic growth promoters, poultry nutritionists are trying to explore novel alternatives to replace the in-feed antibiotics. The purpose of this research was to determine the effects of dietary hot red pepper oil (HRPO) on the productive output, carcass characteristics and economic efficiency of Arbor Acres broiler chickens as natural additive in broilers' diet. One hundred, 7days-old Arbor Acres broiler chicks were randomly distributed into four treatment groups in a fully randomized design of three replicates per treatment and eight or nine chicks per replication. As a control (T1), chicks were fed a basal diet, while HRPO was added for four weeks as 0.25ml/kg (T2), 0.50 ml/kg (T3) and 1ml/kg (T4) to the basal diet. The findings showed that, body weight gain (BWG), feed conversion ratio (FCR) and dressing percentage were significantly ($p<0.05$) increased by the inclusion of HRPO in broiler diets. Abdominal fat was substantially ($p<0.05$) decreased while carcass weight and weight of visceral organs was increased ($p<0.05$) in HRPO supplemented groups. The highest BWG, best FCR and highest net profit (Egyptian pound (LE)/bird) were exhibited by the broilers supplemented with 0.50ml/kg level of HRPO in diet. Economically, supplementing the daily diet of broiler chickens' with HRPO substantially ($p<0.05$) lowered feed intake costs per kg BWG and improved net profit from each Egyptian pound invested in the broilers. These results demonstrated that HRPO could be used in broilers' diet as a replacement of antibiotic growth promoters as it has improving effect on broilers' performance and economic efficiency.

Keywords | Broiler, Hot red pepper oil, Economic productivity, Growth results.

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INTRODUCTION

In order to increase feed efficiency and body weight gain, growth promoters are usually used as in-feed supplements in broiler feed. They can be categorized as Antibiotic growth promoters (AGP) and Non-Antibiotic growth promoters (NAGP). Antibiotic growth promoters in broiler industry have been used to boost growth efficiency and feed conversion ratios (Dibner and Buttin, 2002; Miles et al., 2006). However, continuous treatment with broiler AGP can result in residues of antibiotics in broiler meat and bacterial resistance against treatments in human body.

In several countries the use of AGP in broiler fattening is therefore prohibited (Botsoglou and Fletouris, 2001; Alicek et al., 2004; Owens et al., 2008). NAGP use on the other hand is typically considered to be acceptable alternatives to AGP, as they normally do not carry any risk of bacterial resistance or unwanted contaminants in broiler meat. Organic acids, probiotics, prebiotics, synbiotics, phytonics, feed enzymes and immune stimulants are included in NAGP (Valera et al., 2021; Ikele et al., 2020; Deraz, 2018). Phytonics are drawing much attention nowadays. Phytonics include antioxidant, antimicrobial, antifungal and antiviral effects and are derived from herbs, spices or

aromatic plants (Taylor, 2001). One of the most essential herbs or spices, which is much common, is Red Pepper (*Capsicum annuum*). Red pepper is rich in vitamins C and E and capsaicin (Lee et al., 2010; Shahverdi et al., 2013). Hot red peppers, also known as chili peppers, owe their “heat” to capsaicin (Shahverdi et al., 2013; Al-Kassie et al., 2011).

Approximately 48 percent of the active substances of red pepper are capsaicin (CAP), the most active compound responsible for the pungent effects of hot red peppers (Jancso et al., 1997). Capsaicin is an essential alkaloid and have neurotonic and antimicrobial activity (Fadile and Elife, 2005), as well as may suppress lipid peroxidation effectively (Obloh et al., 2006; Conforti et al., 2007). CAP has many biochemical and pharmacological properties, including antioxidant, anti-inflammatory, anti-allergenic and anti-cancer activities (Lee et al., 2005). CAP was more effective in inhibiting lipid peroxidation than vitamin E (Luqman and Razvi, 2006). It is known to increase pancreatic and intestinal enzymes (Platel and Srinivasan, 2004), bile acids (Abdel et al., 2005) and BWG in broiler chicks (Puvača et al., 2015). Hot red pepper is rich in vitamin C, which lead to the reduction of heat stress (Yoshioka et al., 2001; Al-Kassie et al., 2012).

Through managing pathogens, these biotic additives such as *Capsicum annuum* contribute to the balance of gastrointestinal microbiota. Essential oil extracted from *Capsicum annuum* has antimicrobial activities against pathogenic bacteria, including *Escherichia coli*, *Clostridium perfringens*, and *Salmonella enteritidis* (Kozukue et al., 2005), and acts as a strong antioxidant, digestive stimulant, anti-inflammatory, and antidiarrheal agent. It increased return energy consumption and suppressed production in the organs (Frankič et al., 2009; Barbero et al., 2010; Traesel et al., 2010). Herbs and herbal extracts and their oils enhance feed consumption, boost digestive enzyme secretion, and trigger immune function, as well as encourage the anthelmintic, antibacterial, antioxidant, and antiviral activities (Abdelnour et al., 2018). Also, increase the production of beneficial bacteria and restrict various pathogenic bacterial activities in the broiler intestine (Langhout, 2000; Wenk, 2000). So, the goals of this study were to evaluate the impact of hot red pepper oil (HRPO) as natural feed additives (FA) on growth performance, carcass traits and economic efficiency of broilers.

MATERIALS AND METHODS

BIRDS AND MANAGEMENT

This work was carried out during the period from November to December 2019 at El-Bostan Farm, Faculty of Agriculture, Damanhur University. Arbor Acres broiler chicks

(n=100), 7 days old, were divided among four treatment groups in a completely randomized design with three replicates per treatment and eight or nine chicks per replicate distributed. They were fed iso-caloric and iso-nitrogenous basal diets containing three levels of HRPO i.e., 0.25, 0.5 and 1 ml/ kg diet (T2, T3 and T4 respectively) during the experiment time (7 to 35 days). The Control group (T1) was fed only basal diet without any supplementation. HRPO was observed as having 50 mg capsaicin /ml of HRPO.

During 7-21 and 22-35 days of age, broilers given a commercial mash diet (Table 1). During the preliminary phase (1-6 days of age), chickens were the same starter feed that provided during 7-21 days. The mean indoor temperatures during the 1st, 2nd, 3rd and 4 weeks of age were 34, 32, 30 and 28°C, respectively. Feed and water were given *ad libitum*. A 23:1h light-dark cycle was given for chicks. During the experimental process chicks were housed under similar management and hygienic conditions. The trials protocol was approved by the Science and Ethics committee of the Faculty of Agriculture, Department of Animal and Poultry production, Damanhur University.

Table 1: Composition of basal diets for studies.

Ingredients	Starter diet (1-21 d of age)	Grower diet (22-35 d of age)
Yellow corn, kg	490	550
Soybean meal 48% CP, kg	420	358
Di-calcium phosphate, kg	20	15
Limestone, kg	10	12.5
NaCl, kg	3	3
Vitamin+ premix mineral, kg	3	3
Dl-Methionine, kg	2.5	2.5
L- Lysine, kg	1.5	2.0
Vegetable oil, kg	50	54
Total	1000	1000
ME	3035	3135
CP	229	208
Ca	9.5	9.1
Available P	5.2	4.2
Methionine	6.0	5.6
TSAA	9.6	9.1
Lysine	13.7	12.6
Ether extra	47	48
Crude fiber	33	38
Ash	55	52
Dry matter	901	912

The Vit+Min blend contains: 24 mg vitamin A (retinyl acetate), 20 mg vitamin E (dl- α -tocopheryl acetate), 2.3 mg menadione, 0.05 mg Vitamin D3 (cholecalciferol), 5.5 mg riboflavin, 12 mg calcium pantothenate, 50 mg nicotinic acid, 600 mg choline chloride, 10 μ g vitamin B12, 3 mg vitamin B6, 3 mg thiamine, 1 mg folic acid, 0.50 mg d-biotin. Mineral traces (mg per kg of diet): Mn 80 Zn 60, Fe 35, Cu 8, Se 0.60.

A 33.33 percent mixture of soybean oil, cotton seed oil and sunflower.

VARIABLES AND DATA

The broilers were weighed (g), and body weight gain (BWG), feed intake, and feed conversion rate (FCR) was calculated at 7, 14, 21, 28 and 35 days of age. Daily recorded mortality. At the end of the experiment (35 days of age), three chicks were randomly selected and weighed to acquire live body weight (LBW) from each replicate. Chicks were slaughtered and feathered. The dressing percentage was measured and the inner organs were individually weighted as a percentage of carcass weight.

Economical evaluation were done through calculation of, chick cost (5 LE), Total feed intake /chick (kg), Total feed cost/chick (LE), Price/kg feed (6.7 LE), Fixed cost/chick (1.8 LE), FA cost (LE), Total cost/chick (LE), Price of kg broiler meat at end of the trial (24 LE), Total revenue / chick (LE), and Net margin profit (LE). The economic efficiency evaluation of the HRPO was performed by measuring, FA cost /Total cost%, FA cost /Total return%, Feed intake cost per Kg BWG, Total return/ Total cost% and Net profit/ Total cost%.

STATISTICAL ANALYSIS

ANOVA of SPSS/PC+ «version 25» used to conduct the statistical analysis of data. A substantial difference among the means was measured at 5 percent probability levels using Duncan’s multiple range technique.

RESULTS AND DISCUSSION

EFFECT OF DIETARY HRPO SUPPLEMENTATION ON GROWTH PERFORMANCE OF BROILERS

The finding in Table 2 showed that, the addition of different levels of HRPO into broiler diet significantly ($p < 0.05$) enhanced all productive performance parameters in treated groups relative to control group. The supplemented diet with level of 0.5ml HRPO/kg showed significantly ($p < 0.05$) the highest BWG (2302g/bird) and feed intake (3427g/bird) with best FCR (1.49) among all treatments. Our results can be illustrated by the work of Herati and Marjuki, (2011) where they reported that, the pungent compound of hot red pepper increases the production of

saliva and gastric secretion. Such digestive enzymes activate liver to secrete bile, which further digests food substance. In addition hot red pepper has been reported to encourage digestion and absorption of feed in the digestive tract (Afolabi et al., 2017). Both capscacinoids and capsaicin from pepper were reported to increase body temperature, consumption of oxygen and promote energy metabolism. The capsaicin in hot red pepper was involved in a stimulant, antiseptic and digestive effect that improved metabolism of carbohydrates by stimulating the sympathetic nervous system. The rise in energy or carbohydrate metabolism would improve the development of more tissues and weight gain or growth (Afolabi et al., 2017).

Table 2: Impact of HRPO dietary supplementation on growth performance (at 7-35 days) of broiler chickens.

Variables	Control (T1)	Hot red pepper oil (HRPO)		
		0.25ml/kg (T2)	0.5ml/kg (T3)	1ml/kg (T4)
Initial live weight (g/bird)	141.4 \pm 3.39	141.6 \pm 3.86	142.2 \pm 2.64	141.3 \pm 3.30
Final body weight (g/bird)	2279 \pm 26.73 ^d	2316 \pm 24.58 ^c	2444 \pm 30.76 ^a	2385 \pm 29.57 ^b
Body weight gain (g/bird)	2138 \pm 29.37 ^d	2174 \pm 66.78 ^c	2302 \pm 40.03 ^a	2244 \pm 30.85 ^b
Total feed intake (g/bird)	3407 \pm 60.06 ^b	3361 \pm 97.80 ^c	3427 \pm 31.19 ^a	3325 \pm 78.84 ^d
Feed conversion ratio	1.59 \pm 0.02 ^a	1.55 \pm 0.02 ^b	1.49 \pm 0.03 ^c	1.48 \pm 0.03 ^c

^{a-d} Means with different superscripts within the same row are substantially different at ($p < 0.05$).

EFFECT OF DIETARY HRPO ON CARCASS YIELD, DRESSING PERCENTAGE AND RELATIVE WEIGHT OF INTERNAL ORGANS

The carcass characteristics and internal organs (expressed as percentage of live weight) of broilers fed diets with different HRPO levels were presented in Table 3. In all experimental groups, the addition of various amounts of HRPO to broiler diets significantly ($p < 0.05$) improved dressing percentage. Birds fed on a diet containing a dietary level of 0.5ml HRPO /kg diet showed the highest ($p < 0.05$) dressing percentages (76.3%), as compared to the control group that had the lowest dressing percentages (75.29%). Our dressing percentage findings are similar to previous reports (Shahverdi et al., 2013; Al-Kassie et al., 2011), where they recorded a dressing percentage ranging from (70.11– 74.30%) by supplementing the broilers with 0.02 – 1.00 percent hot red pepper and black pepper enriched diet for six weeks. Our finding also agreed with those of

Table 3: Effect of HRPO dietary supplementation on carcass yield, dressing percentage and certain internal organs as a proportion of broiler final live weight.

Traits	Control (T1)	Hot red pepper oil (HRPO)		
		0.25ml/kg (T2)	0.5ml/kg (T3)	1ml/kg (T4)
Live body weight, g	2792±51.34 ^c	2778±56.00 ^d	2940±76.54 ^a	2813±180.84 ^b
Carcass weight, g	2102±26.19 ^b	2100±32.79 ^c	2243±63.53 ^a	2123±145.90 ^b
Dressing, %	75.29±0.59 ^c	75.6±0.44 ^b	76.3±0.21 ^a	75.5±0.38 ^b
Proventriculus, %	0.29±0.02	0.33±0.01	0.28±0.03	0.28±0.02
Gizzard, %	1.28±0.04 ^a	1.13±0.10 ^b	1.02±0.16 ^c	1.17±0.10 ^b
Liver, %	1.84±0.06 ^c	2.07±0.19 ^b	2.24±0.04 ^a	1.89±0.09 ^c
Heart, %	0.44±0.01	0.45±0.01	0.42±0.03	0.41±0.02
Spleen, %	0.07±0.01 ^c	0.13±0.35 ^a	0.07±0.001 ^c	0.09±0.006 ^b
Intestine, %	3.5±0.09	3.89±0.11	3.97±0.20	3.7±0.15
Pancreas, %	0.19±0.006 ^c	0.22±0.009 ^a	0.20±0.005 ^b	0.20±0.002 ^b
Abdominal fat, %	1.34±0.08 ^b	1.54±0.30 ^a	0.93±0.18 ^c	1.26±0.17 ^b
Bursa, %	0.17±0.01 ^c	0.25±0.05 ^a	0.20±0.01 ^b	0.22±0.03 ^b
Thymus, %	0.39±0.04 ^c	0.49±0.04 ^a	0.41±0.04 ^b	0.40±0.03 ^b

^{a-d} Means with different superscripts within the same row are substantially different at (p<0.05).

Table 4: Effect of HRPO dietary supplementation on overall expenses, total return and net benefit for the study groups (Egyptian pound (LE)/Bird).

Traits	Control (T1)	Hot red pepper oil (HRPO)		
		0.25ml/kg (T2)	0.5ml/kg (T3)	1ml/kg (T4)
Feed intake costs	22.8±0.42 ^b	22.5±0.97 ^c	23.0±0.22 ^a	22.3±0.73 ^d
Additive costs (HRPO)	0	0.49±0.02 ^c	1.03±0.01 ^b	1.99±0.07 ^a
Chick costs	5.00	5.00	5.00	5.00
Management costs	1.80	1.80	1.80	1.80
Total costs/bird	29.6±0.42 ^c	29.79±0.98 ^d	30.83±0.22 ^b	31.1±0.80 ^a
Broiler weight gain/bird	2138±29.37 ^d	2174±66.78 ^c	2302±40.03 ^a	2244±30.85 ^b
Broiler sale/bird	51.3±0.72 ^d	52.2±0.63 ^c	55.3±0.92 ^a	53.8±0.75 ^b
Total return/bird	51.3±0.72 ^d	52.2±0.63 ^c	55.3±0.92 ^a	53.8±0.75 ^b
Net profit/bird	21.7±0.57 ^d	23.1±0.70 ^b	24.5±0.97 ^a	22.8±0.57 ^c

^{a-d} Means with different superscripts within the same row are substantially different at (p<0.05).

Abd EL-Haliem, (2019) who stated that, the inclusion of hot red pepper (HRP) in diet resulted in substantial variations (p<0.05) observed in relative weights of dressing, carcass and offal.

All the measured variables for internal organs (expressed as percentages of live body weight) were statistically improved (p<0.05) with the exception of the heart and intestine (Table 3). Compared to the control diet, the addition of HRPO to broiler diets noticeably (p<0.05) increased percentages of liver, spleen, pancreas, bursa and thymus. The group fed 0.5ml HRPO/kg diet recorded significantly (p<0.05) the highest liver percentage (2.24%) and the lowest abdominal fat percentage (0.93%), as compared to those

of liver percentage (1.84%) and abdominal fat percentage (1.34%) recorded for control group. Our results for internal organs may be due to capsaicin in HRPO meal which is pungent or pepperish; it could have challenged the body which in turn stimulated the production of more leucocytes or antibodies that can fight foreign bodies and diseases when the need arises. This would improve the bird's ability to combat pathogens and thus their anti-pathogenic or antibacterial properties (Al-Kassie et al., 2012) and this may be the explanation for the increase in percentages of relative weight of liver, spleen, pancreas, bursa and thymus. The addition of HRPO to broiler diets also, reduce the abdominal fat percentage substantially (p<0.05) as exhibited in Table 3. Our findings align with those of Puvaca et al.,

Table 5: Economic efficiency evaluation of HRPO in broiler diet as a natural feed additive (FA).

Traits	Control (T1)	Hot red pepper oil (HRPO)		
		0.25ml/kg (T2)	0.5ml/kg (T3)	1ml/kg (T4)
FA cost/Total cost, %	0	0.02±0.00 ^c	0.03±0.00 ^b	0.06±0.00 ^a
FA cost/Total return, %	0	0.01±0.00 ^c	0.02±0.00 ^b	0.04±0.00 ^a
Feed intake cost per Kg BWG	10.65 ^a ± 0.04	10.32 ^b ±0.46	9.98 ^c ±0.78	9.92 ^d ±0.56
Total return/Total cost, %	1.73±0.02 ^b	1.79±0.02 ^a	1.80±0.03 ^a	1.73±0.02 ^b
Net profit/ Total cost, %	0.73±0.02 ^b	0.79±0.02 ^a	0.80±0.03 ^a	0.73±0.02 ^b

^{a-d} Means with different superscripts within the same row are substantially different at (p<0.05).

(2015) where they documented that, hot red pepper (*Cap-sicum annuum* L.) plays an important role in mitigating the cholesterol and fat deposition in the body, contributes to decreased triglycerides levels and manage lipid metabolism in a detrimental way to prevent atherosclerosis or coronary heart diseases in people who use chicken products in their regular diet.

EFFECT OF HRPO SUPPLEMENTATION ON OVERALL EXPENSES, TOTAL RETURN AND NET BENEFIT

The findings obtained from the assessment of the economic component of the experiment were presented in Table 4. It showed a substantial increase in feed costs and total costs (p < 0.05) with an increase in dietary HRPO levels. Total costs of feed (feed intake costs + FA cost) ranged from 22.8 – 24.29 Egyptian pound (LE) /bird for control group and those fed diets with 1ml HRPO/Kg diet, respectively. While, total costs (LE/bird) ranged from 29.6–31.1 for control group and those fed diets with 1ml HRPO/Kg diet, respectively. All treated groups with HRPO showed the highest return and net profit compared to the control group. Total return (LE/bird) ranged from 51.3–55.3 for control group and those fed diets with 0.5ml HRPO/Kg diet, respectively. Net profit (LE/bird) ranged from 21.7–24.5 for control group and those fed diets with 0.5ml HRPO/Kg diet, respectively. Our results agreed with those of Abd EL-Haliem, (2019) where he reported the highest return and net profit achieved by treated groups with HRP than those of control group in growing Japanese quails. Diet containing 0.2% HRP recorded the highest net profit.

ECONOMIC EFFICIENCY EVALUATION OF HRPO IN BROILER DIET AS A NATURAL FEED ADDITIVE (FA)

Evaluation of economic efficiency of dietary supplementation of extracted hot red pepper oil is shown in Table (5). The cost of feed additive (HRPO) used in experiment in comparison with total costs and total return were very little. The increase in production costs with the addition of HRPO to the chickens' diet compared to chickens without natural additive supplementation is negligible, These can be explained as by very little additional costs to broiler diet we can get a significant increase into return and net profit

of broiler fattening project (economically efficient). Also, costs of feed intake per kg BWG differed significantly at (p<0.05). For birds fed control diets, the highest cost of feed intake per Kg BWG (10.65 LE) was obtained, whereas for birds fed with 1 ml HRPO/kg diet, the lowest feed intake cost per Kg BWG was obtained.

The return and net profit from each Egyptian pound invested in broiler fattening in the three experimental groups is higher than that of control group. The highest return from each invested pound (1.80%) and highest net profit from each invested pound (0.80%) recorded in birds fed diet contain 0.5ml HRPO /kg. Diet contain 0.5ml HRPO /kg considered the most economically efficient diet as it recorded the highest final live body weight and the highest return and net profit for each Egyptian pound invested into broiler chicks fattening.

Our findings are consistent with those of Afolabi et al., (2017) where the cost of feed intake per kg BWG also increased significantly (p<0.05). For birds fed control diet, the highest cost of feed intake/kg BWG (₦292.80) was obtained, whereas for those fed diets with 0.2% hot red pepper meal, the lowest cost of feed intake/kg BWG (₦273.6) was obtained.

CONCLUSIONS

Inclusion of 0.5ml to 1ml/kg hot red pepper oil in broilers' diet increased their production efficiency at a lower cost and had no adverse effect on broiler carcass and their internal organs. Thus, HRPO could be used in broilers' diet as a replacement of antibiotic growth promoters as it has improving effect on broilers' performance and economic efficiency. Due to a natural source, it could be hypothesized that inclusion of HRPO will not have any deleterious effects on meat quality of broilers. However, further research on its' effects on meat quality (like technological and sensory) should be investigated.

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