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Effect of Incremental Levels of Dried Tomato Pomace with and without Dietary Enzyme Supplementation on Growth Performance, Carcass Traits and Ileal Protein Digestibility of Broiler Chicks

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Abstract: This experiment was carried out in order to determine the nutritional value of Dried Tomato Pomace (DTP) and the impact of its incremental levels with and without enzyme supplementation on broilers growth performance and ileal protein digestibility. About 384 days old broiler chicks (Ross 308) were raised together until day 7. At 7 days of age chicks were randomly allocated to one of eight treatments with 4 replicates of 12 birds each according to factorial arrangement based on a completely randomized design. Treatments included 0, 3, 6 and 9% of DTP for starter period (7-21 days); 0, 6, 9 and 12% for grower period (21-42 days) and 0, 9, 12 and 15% for finisher period (42-49 days) with and without enzyme supplementation. Body weight gain and feed intake of chicks were recorded at the end of each period and calculated for entire experimental period. Food conversion ratio was also calculated for different periods. At 49 days of age, two male birds per replicate were slaughtered for determination of protein digestibility by chromium oxide marker. Increasing DTP in none-enzyme supplemented treatments resulted in a significant reduction of daily weight gain ($p<0.05$). Birds fed DTP added diets had a marked ($p<0.05$) higher daily feed intake at 21-42 days period but enzyme supplementation reduced feed intake. The overall FCR of the experiment was significantly influenced by increasing the inclusion rate of DTP, so that chicks in control group exhibited the most efficient ($p<0.05$) FCR. Enzyme supplementation improved FCR in different periods compared to none-supplemented groups. Treatments failed to have any statistical ($p>0.05$) impact on carcass characteristics. There was no deleterious impact of experimental diets observed on ileal protein digestibility. The obtained results suggest that DTP along with enzyme supplementation could be incorporated in broilers diet up to 3, 6 and 9% for starter, grower and finisher periods, respectively without any adverse effect on performance and carcass characteristics.

Key words: Dried tomato pomace, enzyme, growth performance, broiler, chromium oxide, Iran

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most popular vegetables used as salad in food preparations and also commercially in form of juice, soup, puree, ketchup or paste. Commercial processing of tomato produces a large amount of waste at various stages.

The wet tomato pomace which amounts to 81,000 tons annually in Iran is considered as waste and may cause serious environmental problems (Pirmohammadi *et al*., 2006). Dried Tomato Pomace (DTP) is a mixture of tomato skin, pulp and crushed seeds that remain after the processing of tomato for juice, paste and/or ketchup. The proximate analysis shows that DTP may contain considerable nutrients such as crude protein, crude fiber, ether extract and nitrogen free extract (King and Zeidler, 2004). Elloitt ***et al.*** (1981) demonstrated that DTP is a good source of protein and the chemical composition of tomato cannery wastes suggests that this by-product contains 20-25% protein with 13% lysine more than that of soybean meal protein (Sogi *et al*., 2002), therefore has the potential to be applied as a high protein ingredient in poultry diets (Persia *et al*., 2003). The results of research studies show that the anti-nutritive factors found in unheated tomato pomace do not induce any unfavorable impacts on productive traits of broiler chicks as a result it can be used in broilers diet to provide some parts of protein requirement (Persia *et al*., 2003). The only limiting factor for its application in the diet can be the presence of poisonous pesticides residue in the waxy skin layer (NRC, 1994).

Tomato pulps can be incorporated up to 15% to the diet without indicating any adverse effects on broilers performance and carcass yield (King and Zeidler, 2004).

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Dotas *et al.* (1999) showed that dried tomato pulp can be used at 8% for laying hens and if diets are supplemented by fat this amount can raise to 12% for broilers without any harmful influence on performance parameters. DTP should not be used >20% of the whole diet for broiler chickens because its high level of crude fiber limits the energy of the diet and also the excessive powder removes the taste of the diet (Al-Betawi, 2005). In spite of existing research (Persia *et al.*, 2003; King and Zeidler, 2004; Al-Betawi, 2005; Jafari *et al.*, 2006) that evaluated the impact of DTP on performance of broilers and laying hens none were found that have employed incremental levels of DTP in order to optimize the inclusion rate of DTP in broiler diets. Thus, this study was designed to evaluate the effect of incremental levels of DTP in combination with commercial enzymes on growth performance and dietary ileal protein digestibility in broiler chickens.

MATERIALS AND METHODS

Dried Tomato Pomace (DTP) was purchased from a tomato processing company. The nutrient analysis of DTP was carried out according to the standard methods of analysis (AOAC, 1996) in order to determine dry matter, crude protein, crude fat, crude fiber, ether extract, calcium and phosphorous concentration (Table 1).

Animals and diets: A total number of 384 days old broiler chicks (Ross 308) were raised in one group till the 7 days of age. At day 7, chicks were divided into 32 groups of 12 birds each and every 4 groups were randomly allocated to one of 8 experimental diets according to a factorial arrangement based on a completely randomized design. Treatments included 0, 3, 6 and 9% of dried tomato pomace from 7-21 ddys; 0, 6, 9 and 12% from 21-42 days and 0, 9, 12 and 15% from 42-49 days with (A-D groups) and without (a-d groups) enzyme supplementation.

A commercial multi enzyme containing 10% visco units, 2200 IU xylenase, 200 IU β-glucanase and also cellulase, pectinase, protease and β-mono cidaze per gram was added to the enzyme supplemented diets at the concentration of 500 g ton^{-1}. All the chicks were fed the same pre-starter diet from 1-7 days containing 20.6% crude protein and 2870 kcal metabolizable energy per kg of diet.

Experimental diets were formulated to be isocaloric and isonitrogenous in the starter (7-21 days), grower (22-42 days) and finisher periods (43-49 days) to meet the requirements according to NRC (1994) (Table 2). All diets were fed in mash form through out the 7 weeks experimental period. Birds had free access to water and feed and were maintained under 23 h light program. The environmental temperature in the house was initially set at 32°C and gradually reduced to 22°C by week 6.

Table 1: Chemical analysis of DTP

Ingredients	Values
Metabolizable energy (kcal kg^{-1})	2200.00
Dry matter (%)	95.79
Crude protein (%)	20.47
Ether extract (%)	16.80
Crude fiber (%)	41.75
Ash (%)	5.00
Calcium (%)	0.43
Phosphorus (%)	0.60
Met+Cys (%)*	0.80
Lys (%)*	1.08

*Based on the reports by Persia *et al.* (2003)

Data collection and sampling: Body weight and feed intake were monitored at 7, 21, 42 and 49 days of age using pens as the experimental units. Before weighting, the birds were fasted for 4 h. At day 49, two birds per pen with a body weight close to the mean were individually weighed and slaughtered.

Then proportion of the carcass, abdominal fat, heart, liver, gizzard and small intestine weight to live body weight were calculated. To determine ileal protein digestibility of the diets, 3 g kg^{-1} chromic oxide were added to the diets for 5 days at day 44 and at 49 days of age, two birds randomly selected from each replicate were killed by cervical dislocation. Then, contents of the ileum (from Meckel's diverticulum to 1 cm above the ileo-caecal junction) were collected. The ileal digesta samples were frozen, freeze dried, ground and analyzed for nitrogen and chromic oxide to determine ileal protein digestibility (Batal *et al.*, 2000).

Chemical analysis: Feed and ileal digesta samples were analyzed for chromic oxide using the procedure described by Fenton and Fenton (1979). Nitrogen was determined by the Kjeldahl method and the protein contents were calculated using the multiplication factor of 6.25. The following equation was used for the calculation of ileal proten digestibility:

$$\text{Ileal protein digestibility (\%)} = \{1- [(Cr_2O_3\text{\% diet}/Cr_2O_3\text{\% digesta}) \times (\text{CP\% digesta}/\text{CP\% diet})]\} \times 100$$

Litter moisture: At 49 days homogenous, 100 g L samples from each pen were taken and dried in 105°C for 48 h and litter humidity was calculated, accordingly.

Statistical analysis: The GLM procedure of SAS (SAS Inst. Inc., Cary, NC) was used to analyze the continuous

Table 2: Ingredients and compositions of the experimental diets in different periods

	Starter (7-21 days)				Grower (22-42 days)				Finisher (42-49 days)			
Diets composition	0	3	6	9	0	6	9	12	0	9	12	15
Dried tomato pomace (%)												
Corn (%)	54.08	52.95	50.33	47.85	61.80	57.05	54.66	52.27	65.77	58.74	56.37	54.00
Soybean meal (%)	28.67	37.45	36.50	35.55	32.11	30.16	92.20	28.20	28.21	25.25	24.25	23.27
Soybean oil (%)	2.30	2.30	2.77	3.20	2.20	3.00	3.40	3.80	2.83	4.00	4.40	4.80
$CaCo^3$ (%)	1.60	1.43	1.66	1.64	1.56	1.62	1.56	1.66	1.51	1.57	1.54	1.60
Di-cal phosphate (%)	2.00	1.50	1.41	1.34	1.12	0.96	0.94	0.82	0.94	0.70	0.70	0.59
Mineral premix (%)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25
Vitamin premix (%)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25
NaCl (%)	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.24	0.24	0.24	0.24
Met (%)	0.2	0.22	0.24	0.27	0.05	0.07	0.08	0.09	-	-	-	-
Vitamin-E (%)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	-	-	-	-
Vitamin-A (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-	-	-	-
Metabolizable energy (kcal kg^{-1})	2900.00	2900.00	2900.00	2900.00	3000.00	3000.00	3000.00	3000.00	3101.00	3101.00	3101.00	3101.00
Crude protein (%)	20.84	20.84	20.84	20.84	18.75	18.75	18.75	18.75	17.44	17.44	17.44	17.44

All enzyme supplemented diets had the same composition but contained 0.05% ravobio multi enzyme; 1: mineral premix per kg of diet: Fe ($FeSO_4.7H_2O$, 20.09% Fe), 50 mg; Mn ($MnSO_4.H_2O$, 32.49% Mn), 100 mg; Zn (ZnO, 80.35% Zn), 100 mg; Cu ($CuSO_4 5H_2O$), 10 mg; I (KI, 58% I), 1 mg; Se ($NaSeO_3$ 45.56% Se), 0.2 mg; 2: vitamin premix per kg of diet: vitamin A (retinol), 2.7 mg; vitamin D3 (cholecalciferol), 0.05 mg; vitamin E (tocopheryl acetate), 18 mg; vitamin k3, 2 mg; thiamine 1.8 mg; riboflavin, 6.6 mg; panthothenic acid, 10 mg; pyridoxine, 3 mg; cyanocobalamin, 0.015 mg; niacin, 30 mg; biotin, 0.1 mg; folic acid, 1 mg; choline chloride, 250 mg; antioxidant 100 mg

variables of the broiler chicken data. Duncan (1995)'s multiple range test was applied to separate means. Statements of statistical significance are based on a probability of ($p<0.05$).

RESULTS AND DISCUSSION

Performance: Data obtained on performance parameters are shown in Table 3. Considering BWG there was no significant effect of treatments at 7-21 days but in other periods increasing dried tomato pomace markedly ($p<0.05$) decreased BWG particularly in D treatment. This is while, no significant differences were observed among DTP added groups. Enzyme supplementation marginally improved BWG of broiler chicks, particularly over the 21-42 days period. The results are in accord to those reported by Almirall *et al.* (1995) who reported that B-glucanase enzyme improved body weight of broilers, this enzyme decomposes glucanes and none starch polysaccharides and enhances digestion and absorption of nutrients. But as dietary inclusion rate of DTP increased (c and d groups) even enzyme supplementation could not compensate for the weight reduction due to increasing DTP. Birds fed the control diet were significantly heavier at 42 and 49 days of age compared to other treatments. This could partially be due to the high fiber content of the diet and consequently reduced energy access of the chicks. Persia *et al.* (2003) also observed significant reduction in weight gain of broiler chickens in the 8-21 days phase as the tomato waste level increased. Additionally, high content of fiber allows exaggerated multiplication of intestinal bacteria which may reach superior portions of jejunum producing acids which degrade enzymes in charge of digestion. The chickens fed with enzyme-supplemented diets had higher body weights in comparison with none supplemented diets, probably because of the increasing digestibility of nutrients and more availability of energy as a result of enzyme activity. Similar to current findings, Liral *et al.* (2010) also reported a linear reduction of body weight in different weeks of age as the inclusion rate of tomato wastes increased in broiler diets.

The highest level of DTP inclusion resulted in a marked increase in feed intake at 21-42 days compared to control birds. But enzyme inclusion in the diet reduced feed intake compared to none-supplemented groups, although the differences observed did not reach statistical significance. Feed intake increasing can be justified with regards to diet high fiber which limits energy access also the NSPs in contact with water form a gel that reduces passage time and absorption of nutrients and thus, increases feed consumption to compensate and meet nutritional demands. In treatments with enzyme, though no significant differences were found, the feed intake reduced because of the effects of enzyme on non starch polysaccharides and subsequent improvement in digestibility and absorption (Table 3). There was no impact of experimental diets on cumulative feed consumption over the 42-49 days and entire period. This result may be related to ingestion and digestion capacity which, increases as the birds get older, adult birds seem to be able to fit to high fiber content diets as they have a better developed digestive tracts compared to younger birds so that they can reduce or neutralize negative effects of fibrous portion of the diet (Potter *et al.*, 1990; Philip *et al.*, 1995).

Table 3: Effect of incremental levels of tomato pulp powder on body weight, body weight gain, feed intake and Feed Conversion Ratio (FCR) of broilers chickens at different ages

		Dietary treatments[1]								
Variables	Age (days)	A	B	C	D	a	b	c	d	SEM
BW (g)	21	638.60^{a}	620.10^{ab}	617.60^{b}	612.90^{b}	627.20^{a}	595.80^{b}	616.20^{b}	615.00^{b}	7.458
	42	2112.00^{a}	1925.00^{bc}	1998.00^{b}	1916.00^{c}	2009.00^{b}	2006.00^{b}	1986.00^{bc}	1939.00^{bc}	45.603
	49	2603.00^{a}	2446.00^{b}	2439.00^{b}	2424.00^{b}	2458.00^{ab}	2512.00^{ab}	2453.00^{b}	2435.00^{b}	49.384
BWG (g/d/bird)	7-21	35.91	35.54	35.35	35.02	36.06	35.00	35.32	35.18	0.305
	21-42	70.17^{a}	63.98^{b}	64.88^{b}	60.58^{b}	67.03^{ab}	65.32^{b}	65.23^{b}	64.97^{b}	1.185
	42-49	75.83^{a}	74.32^{ab}	68.71^{b}	69.21^{b}	75.43^{a}	74.32^{ab}	69.86^{b}	70.93^{b}	1.769
	7-49	60.81^{a}	57.94^{ab}	56.31^{bc}	54.94^{c}	59.50^{ab}	58.21^{ab}	56.80^{bc}	57.03^{bc}	1.176
FI (g/d/bird)	7-21	51.85	50.95	50.58	49.13	50.93	50.43	50.86	49.84	0.452
	21-42	142.00^{b}	144.40^{ab}	150.80^{a}	151.03^{a}	142.80^{b}	145.27^{ab}	146.00^{ab}	146.60^{ab}	0.915
	42-49	184.73	186.25	194.46	192.38	180.23	183.55	191.41	191.78	7.899
	7-49	126.19	127.22	131.96	130.01	124.68	126.41	129.70	129.45	2.568
FCR (g:g)	7-21	1.44	1.43	1.43	1.40	1.41	1.44	1.44	1.42	0.016
	21-42	2.02^{c}	2.26^{ab}	2.33^{ab}	2.49^{a}	2.13^{bc}	2.23^{ab}	2.25^{ab}	2.26^{ab}	0.042
	42-49	2.42^{b}	2.51^{ab}	2.83^{a}	2.78^{a}	2.39^{b}	2.47^{ab}	2.74^{a}	2.71^{a}	0.271
	7-49	2.07^{b}	2.19^{ab}	2.34^{a}	2.36^{a}	2.09^{b}	2.17^{ab}	2.28^{a}	2.27^{a}	0.048

a-c Means in a row with no common superscripts differ significantly ($p<0.05$); [1]A: control (0% tomato pulp powder in starter, grower and finisher); B: 3, 6 and 9% tomato pulp powder in starter, grower and finisher, respectively; C: 6, 9 and 12% tomato pulp powder in starter, grower and finisher, respectively; D: 9, 12 and 15% tomato pulp powder in starter, grower and finisher, respectively; a, b, c and d are enzyme supplemented groups

Table 4: Effect of incremental levels of tomato pulp powder on carcass traits and lymphoid organ weights of broiler chickens (percentage of body weight) at 49 days of age

	Dietary treatments[1]								
Relative organ weights (%)	A	B	C	D	a	b	c	d	SEM
Carcass yield	73.25	73.98	72.84	72.10	74.60	74.49	72.42	72.57	0.696
Abdominal fat	1.95	1.92	1.97	1.74	1.84	1.63	1.68	1.72	0.160
Gizzard	2.43	2.49	2.44	2.43	2.52	2.47	2.43	2.57	0.120
Heart	0.43	0.43	0.47	0.46	0.43	0.43	0.45	0.44	0.027
Intestine	4.70	5.20	4.30	5.20	5.06	5.32	4.48	5.25	0.282
Liver	2.23	2.16	2.04	2.03	2.32	2.17	2.16	2.15	0.123

[1]A: control (0% tomato pulp powder in starter, grower and finisher); B: 3, 6 and 9% tomato pulp powder in starter, grower and finisher, respectively; C: 6, 9 and 12% tomato pulp powder in starter, grower and finisher, respectively; D: 9, 12 and 15% tomato pulp powder in starter, grower and finisher, respectively; a-d are enzyme supplemented groups

Feed efficiency deteriorated significantly as the inclusion level of DTP increased in different periods and birds receiving the control diets exhibited the lowest FCR ($p<0.05$). High fiber content of the diet and the limitation of diet energy or the presence of pesticides residue in the outer skin layer of tomato pulps may account in part for deterioration of FCR.

Enzyme supplementation also, none significantly improved feed efficiency and marginally decreased FCR in different phases, the reduction was more pronounced in b group. The current results are in line with those obtained by Alam *et al.* (2003) who reported that by addition of enzymes the anti nutrient effects of non starch polysaccharides are reduced and improvement of growth performance is achieved.

Jafari *et al.* (2006) also observed decrease of feed efficiency in laying hens at 27-38 weeks of age with the inclusion of up to 15% of tomato waste in their diets. These findings are in agreement with those reported by Buchanan *et al.* (2007) who indicated that inclusion of 24% of DTP in broiler diets resulted in the worst feed conversion ratio due to high fiber content. On the contrary in a study with laying hens, Nobakht and Safamehr (2007) reported that DTP did not have any adverse impact on final BW and FCR of hens when inclusion rate increased to 7.5%.

Carcass traits: As Table 4 displays carcass characteristics were not influenced by experimental diets. Broilers in enzyme supplemented groups tended to have higher carcass yield and lower abdominal fat but the impact of enzyme disappeared when the inclusion rate of DTP increased (c and d groups). The obtained results are similar to that reported by King and Zidler (2004) who showed that DTP up to 15% in diet does not affect carcass traits of broiler chicks. Enzyme supplementation could have had a positive effect on nutrient digestibility and energy availability resulting in higher carcass yield compared to none supplemented groups.

Ileal protein digestibility and litter moisture: According to Table 5, there was no deleterious effect of DTP inclusion in diet detected on protein digestibility at 49 days and the obtained values were quite similar among dietary treatments. These results confirm the previous reports stating that DTP is a high quality vegetable

Table 5: Effect of incremental levels of tomato pulp powder on ileal protein digestibility and litter moisture at 49 d of age

	Dietary treatments[1]								
Variables (%)	A	B	C	D	a	b	c	d	SEM
Protein digestibility	70.75	70.60	70.90	70.80	70.77	70.22	70.10	70.22	0.161
Litter moisture	22.13	21.93	22.67	22.11	21.11	20.32	20.63	21.86	1.665

[1]A: control (0% tomato pulp powder in starter, grower and finisher); B: 3, 6 and 9% tomato pulp powder in starter, grower and finisher, respectively; C: 6, 9 and 12% tomato pulp powder in starter, grower and finisher, respectively; D: 9, 12 and 15% tomato pulp powder in starter, grower and finisher, respectively. a-d are enzyme supplemented groups

protein source and there are no anti-nutritional factors in DTP which may influence protein digestibility (Liadakis *et al*., 1995; Sogi *et al*., 2005). DTP had no significant impact on litter moisture measured at 49 day of age. But the moisture content of the litter marginally decreased by enzyme supplementation. Similar to the findings, Adams (2003) showed that enzyme supplementation in broiler diets reduced litter moisture, probably because enzyme activities decreases water binding capacity of NSPs which reduces wet droppings and consequently litter moisture.

The ambivalent reports regarding the effectiveness and the optimum inclusion rate of DTP in broiler diets (Persia *et al*., 2003; King and Zeidler, 2004; Jafari *et al*., 2006) could be due to several factors including origin of the farm (area, state), soil conditions and use of fertilizers, means of irrigation, variety of tomato, ripeness, tomato processing conditions and cannery plants, relative percentage of seed, skin, pulp and leaves in wet pomace and many more factors related to drying process. These factors can influence the degree of nutrient digestibility of DTP and consequently its nutritional value and impact on productive traits of broiler chicks.

CONCLUSION

In this study, the results of the current study indicate that dried tomato pomace can be practically applied into broiler diets up to 3, 6 and 9% with a multi-enzyme supplementation in the starter, grower and finisher phases respectively, without experiencing any harmful effects on productive and carcass characteristics.

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