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Full Length Research Paper

The effects of dried tomato pomace and a multiple-enzyme mixture supplementation (Rovabio Excel™) on performance and carcass quality of broiler chickens

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An experiment was conducted to study the effect of dried tomato pomace (DTP) and a multienzyme preparation supplementation (Rovabio Excel™) on the performance and carcass quality of broiler chickens. A 4 × 2 factorial arrangement of treatments comprising 4 dietary DTP levels (0, 8, 16 and 24%) with and without enzyme supplementation was used. Each diet was fed to 4 replicates pens of 8 broiler chicks from 1 to 42 days posthatch as a coarse mash. The addition of DTP up to 16% to broiler diets did not significantly affect feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) during starter (1 to 21 days), growing (22 to 42 days) and entire experimental (1 to 42 days) periods. Inclusion of 24% DTP into the diet significantly decreased FI at starter and entire experimental periods. Also, inclusion of 24% DTP into the diets significantly decreased BWG and increased FCR at all periods. Birds fed the diets supplemented with Rovabio Excel™ had significantly higher BWG during the starter and entire experimental periods. No significant effect of enzyme addition was observed on FI and FCR. The dietary treatments with or without enzyme did not significantly affect mortality. The 8% DTP-fed group had comparable carcass weight, carcass yield, yield of breast, thigh, abdominal fat, heart, liver and gizzard with those of control group. The higher levels of DTP significantly decreased carcass weight and yield, yield of breast and thigh when compared to the control group. Enzyme supplementation significantly increased carcass weight and yield of abdominal fat. No significant interactions between the DTP and enzyme were observed for performance parameters and carcass characteristics. These results demonstrate that supplementation of DTP up to 8% to broiler diets had no significant adverse effects on performance parameters and carcass characteristics. The enzyme had a significant effect on BWG, carcass weight and yield of abdominal fat.

Key words: Dried tomato pomace, enzyme, performance, carcass quality, broiler.

INTRODUCTION

Dried tomato pomace (DTP) as a by-product of tomato processing consists of peels, cores, seeds, trimmings, liquor and unprocessed green tomatoes picked by harvest machinery. It is an effective and economical way to recycle wastes of tomato cannery factories which prevents additional environmental pollution and other associated problems. DTP has been considered as a good source of protein for providing amino acids, especially lysine and natural pigments such as β-carotene and lycopene as well as a valuable source of α-tocopherol which is used as an antioxidant in broiler diet (King and Zeidler, 2004; Karadas et al., 2006). Several studies have investigated the use of tomato pulp and its

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Abbreviations: DTP, Dried tomato pomace; **FI,** feed intake; **BWG,** body weight gain; **FCR,** feed conversion ratio.

various by-products as a poultry feedstuff and concluded that DTP can be included in the diet at 50 g/kg without any adverse effects on broiler and laying hens performance (Ammerman et al., 1965; Petrenko and Banina, 1984). Yannakopoulos et al. (1992) reported that the inclusion of tomato meal up to 150 g/kg in layer diets had no negative effect on laying performance, but an improvement in yolk color was observed. Squires et al. (1992) reported no significant differences in performance of broiler chicks fed diets containing up to 20% treated or untreated tomato pomace. Persia et al. (2003) substituted tomato seeds (TS) for corn and soybean meal on an equal true digestible amino acid and TME_n basis at 5, 10, 15 and 20% in broiler diets. They observed that inclusion of TS at 20% had significant negative effects on weight gain and feed efficiency of broilers.

The major disadvantage of this feed ingredient is that it is limited in energy due to high fiber content (Mansoori et al., 2008). There is an enormous amount of literature concerning the supplementation of enzymes to feedstuffs for improving nutrient availability, but only limited research is available on the effect of enzymes on tomato pomace utilization in poultry. Rovabio Excel™ preparation was from a non-genetically modified fungus *Penicillium funiculosum* which contains xylanases, β-glucanases, mannanases, pectinases and proteases activities. There are only a few studies that have evaluated the use of Rovabio Excel™ in broiler nutrition (Sims et al., 2001; Mushtaq et al., 2006, 2007; West et al., 2007; Aftab, 2009). Supplementation of Rovabio Excel™ has been shown to improve final live weight and caloric efficiency of broilers fed normal or low energy corn-soybean based diet, respectively (Sims et al., 2001). Production parameters were not affected when Rovabio Excel™ was added to broiler diets containing high levels (20%) of sunflower meal, canola meal, rapeseed meal and cottonseed meal (Aftab, 2009).

The objective of the current experiment was to investigate the effects of various levels of DTP on performance and carcass quality of broiler chickens. The possible influence of Rovabio Excel™ supplementation on utilization of DTP was also studied.

MATERIALS AND METHODS

All experimental procedures were approved by the Animal Research Ethics Committee of the University of Ramin Agricultural and Natural Resources, Ahvaz, Iran.

Dried tomato pomace

Dried tomato pomace was obtained from Caspian Company, Tehran, Iran. It was analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), calcium (Ca) and phosphorous (P) using methods of the AOAC (AOAC, 1980). The DTP used in this study contained 90.7% DM, 22% CP, 11.6% EE, 27% CF, 0.43% Ca, and 0.6% P.

Bird management and diets

Two hundred and fifty six day-old male broiler chicks (Ross 308) were randomly assigned to 8 treatments with 4 replicates and 8 chicks per each replicate pen in a 42-days study. Birds were raised on floor pens. They received feed and water *ad libitum*. Light was provided continuously (24 h) throughout the experimental period and the initial room temperature was set at approximately 32°C and then gradually reduced based on normal management practices until reaching 22°C. Throughout the study, mortality and the weight of dead birds were recorded. A completely randomized design with a factorial arrangement was used with four levels of DTP (0, 8, 16 and 24 %) and two levels of Rovabio Excel™ enzyme (0 and 500 g/metric ton of feed). Compositions of diets are shown in Tables 1 and 2. The nutrient specifications were lower than those recommended by NRC (NRC, 1994) for broiler starter (0 to 21 days) and growing (22 to 42 days) diets. All diets were provided as a coarse mash to avoid uncertainty regarding the loss of enzyme activity associated with pelleting processes. The enzyme was added directly to the feed, without changing its composition. Feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) were measured weekly during experimental period. At the end of the experiment, 8 birds (two chicks per replicate) from each treatment were randomly selected, weighed, and killed by cervical dislocation. The liver, heart, gizzard, abdominal fat and the thigh and breast muscles were harvested and weighed individually. The organ weights were expressed as a percentage of live body weight.

Statistical analysis

Data were subjected to analysis of variance in a completely randomized design with factorial arrangement using the General Linear Models (GLM) procedure of SAS® (SAS Institute, 1996), and when treatment means were significant ($P < 0.05$), Duncan's multiple range test (Duncan, 1955) was used. Percentage data were transformed to arcsine percentages prior to analysis.

RESULTS AND DISSCUSION

The effect of DTP and Rovabio Excel™ on live performance and mortality are shown in Table 3. The supplementation of DTP to broiler diets up to 16% had no significant effects on FI, BWG and FCR during the starter, growing and entire experimental periods. Inclusion of 24% DTP into the diet significantly decreased FI at starter and entire experimental periods. Also, inclusion of 24% DTP into the diets significantly decreased BWG and increased FCR at all periods. The results of the present study are in good accordance with those of Dotas et al. (1999) who reported that the inclusion of DTP up to 12% in laying hen diets had no significant adverse effect on egg production, feed consumption and efficiency, egg weight, and egg shell thickness. Our results also agree with those obtained by Persia et al. (2003) who reported that the 20% DTP-fed group had a lower body weight gain as compared to control group. In contrast, several studies have shown that supplementation of DTP to broiler (Squires et al., 1992) and laying hen (Nobakht and Safamehr, 2007) diets leads to better performance. The growth depression of broilers fed diets containing 24% DTP may be explained by the reduction in feed

Table 1. Ingredients and calculated composition of broiler starter diets.

Ingredient	Enzyme added to diet							
	No				Yes			
DTP[1]	0.00	8.00	16.00	24.00	0.00	8.00	16.00	24.00
Corn	57.29	56.48	50.56	49.19	57.29	56.48	50.56	49.19
Soybean meal	29.94	28.44	25.39	14.30	29.94	28.44	25.39	14.30
Wheat bran	5.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Fish meal	3.00	2.60	2.79	8.02	3.00	2.60	2.79	8.02
Dicalcium phosphate	1.30	1.10	0.93	0.73	1.30	1.10	0.93	0.73
Oyster shell	1.06	1.20	1.10	1.10	1.06	1.20	1.10	1.10
Salt	0.13	0.18	0.20	0.20	0.13	0.18	0.20	0.20
Sodium bicarbonate	0.08	0.17	0.19	0.05	0.08	0.17	0.19	0.05
Vegetable oil	1.25	1.00	2.00	1.70	1.25	1.00	2.00	1.70
DL-methionine	0.16	0.16	0.20	0.19	0.16	0.16	0.20	0.19
L-lysine	0.29	0.17	0.14	0.02	0.29	0.17	0.14	0.02
Vitamin and Mineral premix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Calculated composition								
ME[3] (kcal/kg)	2850.00	2850.00	2850.00	2850.00	2850.00	2850.00	2850.00	2850.00
CP[4] (%)	20.48	20.48	20.48	20.48	20.48	20.48	20.48	20.48
CF[5] (%)	3.88	5.40	7.30	8.60	3.88	5.40	7.30	8.60
Ca[6] (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Lys[7] (%)	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29
Met[8] + Cys[9] (%)	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82

[1]Dried tomato pomace; [2]Provided per kilogram: vitamin A, 360,000 IU; vitamin D_3, 800,000 ICU; vitamin E, 7,200 IU; vitamin K_3, 800 mg; vitamin B_1, 720 mg; vitamin B_9, 400 mg; vitamin H_2, 40 mg; vitamin B_2, 2,640 mg; vitamin B_3, 4,000 mg; vitamin B_5, 12,000 mg; vitamin B_6, 1,200 mg; vitamin B_{12}, 6 mg; choline chloride, 200,000 mg; manganese, 40,000 mg; iron, 20,000 mg; zinc, 40,000 mg, copper, 4,000mg; iodine, 400 mg; selenium, 80 mg; [3]metabolizable Energy; [4]crude protein; [5]crude fiber; [6]calcium; [7]lysine; [8]methionine; [9]cysteine

consumption. This effect could be because of the greater crude fiber in these diets as compared to the control diet. The supplementation of enzyme significantly improved BWG during the starter and entire experimental periods. Our results agreed with the findings of Mathlouthi et al. (2002) who reported that supplementation of exogenous enzymes to the rye-based diet improved weight gain but our results disagreed with the findings of West et al. (2007), who reported that supplementation of Rovabio® Excel had no positive effects on BWG in three experiments. Mushtaq et al. (2006) reported that the supplementation of Rovabio® Excel to sunflower meal-based diets (contained up to 7% fiber) during 2 week posthatching had no significant effects on FI, BWG and FCR of broiler chickens. As noticed previously, Rovabio™ Excel is a multiple-enzyme mixture containing various enzymes, including fiber degrading enzymes. The observed enhancement in BWG during starter and entire experimental periods in the enzyme supplemented-broilers might be due to improvement in nutrients digestibility, especially AME_n and CP (Mansoori et al., 2008; Mathlouthi et al., 2002; Kocher et al., 2003). Feed intake and FCR were not significantly different between control and enzyme-supplemented diets during all experimental periods. Our results agreed with the findings of Buchanan et al. (2007), who reported that the supplementation of an exogenous multiple-enzyme mixture containing β-glucanase, pentosanase and hemicellulase hydrolyzing activities to normal or low energy broiler diets did not improve FI and FCR during 21 to 38, 38 to 56 and 21 to 56 days. The dietary treatments with or without Rovabio Excel™ did not significantly affect mortality. This is in agreement with researches done by West et al. (2007) and Mushtaq et al. (2006) demonstrating that the addition of Rovabio Excel® to broiler diets did not affect mortality. Our results are in disagreement with Mohammed (1995), who reported that supplementation of a multienzyme mixture to barley-based diets decreased mortality. Recent disagreement could be due to the different types of diet. The performance parameters and mortality were not significantly affected by interaction between DTP and enzyme.

The effects of treatments on carcass quality are shown

Table 2. Ingredients and calculated composition of broiler grower diets.

Ingredient	Enzyme added to diet							
	No				Yes			
DTP[1]	0.00	8.00	16.00	24.00	0.00	8.00	16.00	24.00
Corn	60.00	60.00	58.20	51.90	60.00	60.00	58.20	51.90
Soybean meal	27.71	26.57	15.98	13.61	27.71	26.57	15.98	13.61
Wheat bran	5.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Fish meal	1.20	1.00	5.40	5.20	1.20	1.00	5.40	5.20
Dicalcium phosphate	1.00	0.39	0.17	0.00	1.00	0.39	0.17	0.00
Oyster shell	1.30	0.86	1.40	1.40	1.30	0.86	1.40	1.40
Salt	0.18	0.20	0.20	0.19	0.18	0.20	0.20	0.19
Sodium bicarbonate	0.26	0.15	0.12	0.01	0.26	0.15	0.12	0.01
Vegetable oil	2.50	2.00	1.80	2.90	2.50	2.00	1.80	2.90
DL-methionine	0.10	0.12	0.12	0.16	0.10	0.12	0.12	0.16
L-lysine	0.20	0.16	0.06	0.09	0.20	0.16	0.06	0.09
Coccidioacetate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin and Mineral premix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Calculated composition								
ME[3] (kcal/kg)	2950.00	2950.00	2950.00	2950.00	2950.00	2950.00	2950.00	2950.00
CP[4] (%)	18.44	18.44	18.44	18.44	18.44	18.44	18.44	18.44
CF[5] (%)	3.70	5.20	6.70	8.60	3.70	5.20	6.70	8.60
Ca[6] (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Lys[7], (%)	1.10	1.10	1.10	1.20	1.10	1.10	1.10	1.20
Met[8] + Cys[9] (%)	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

[1]Dried tomato pomace; [2]Provided per kilogram: vitamin A, 360,000 IU; vitamin D_3, 800,000 ICU; vitamin E, 7,200 IU; vitamin K_3, 800 mg; vitamin B_1, 720 mg; vitamin B_9, 400 mg; vitamin H_2, 40 mg; vitamin B_2, 2,640 mg; vitamin B_3, 4,000 mg; vitamin B_5, 12,000 mg; vitamin B_6, 1,200 mg; vitamin B_{12}, 6 mg; choline chloride, 200,000 mg, manganese, 40,000 mg; iron, 20,000 mg; zinc, 40,000 mg; copper, 4,000 mg; iodine, 400 mg; selenium, 80 mg; [3]metabolizable energy; [4]crude protein; [5]crude fiber; [6]calcium; [7]lysine; [8]methionine; [9]cysteine.

Table 3. Effect of dried tomato pomace and Rovabio Excel™ enzyme on live performance and mortality of broilers.

Diet	FI[3] (g)			BWG[4] (g)			FCR[5] (g/g)			Mortality (%)
	0 to 21 days	22 to 42 days	0 to 42 days	0 to 21 days	22 to 42 days	0 to 42 days	0 to 21 days	22 to 42 days	0 to 42 days	0 to 42 days
DTP[1] (%)										
0	1109[a]	3578[a]	4687[a]	572[a]	1867[a]	2439[a]	1.94[b]	1.91[b]	1.92[b]	0.16[a]
8	1103[a]	3545[a]	4648[a]	566[a]	1788[a]	2355[a]	1.95[b]	1.98[b]	1.97[b]	0.16[a]
16	1068[ab]	3398[a]	4566[a]	547[a]	1765[a]	2312[a]	1.95[b]	1.98[b]	1.97[b]	0.16[a]
24	1020[b]	3240[a]	4260[b]	467[b]	1481[b]	1948[b]	2.18[a]	2.18[a]	2.18[a]	0.33[a]
SEM	12	48	55	10	38	46	0.03	0.02	0.02	0.10
Enzyme[2]										
–	1056[a]	3400[a]	4456[a]	523[b]	1680[a]	2203[b]	2.02[a]	2.03[a]	2.03[a]	0.33[a]
+	1094[a]	3530[a]	4624[a]	553[a]	1770[a]	2323[a]	1.98[a]	2.00[a]	2.00[a]	0.08[a]
SEM	12	48	55	10	38	46	0.03	0.02	0.02	0.10
Source of variation							Significance			
DTP	*	NS	*	**	**	**	**	*	**	NS
Enzyme	NS	NS	NS	*	NS	*	NS	NS	NS	NS
DTP × Enzyme	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]DTP = Dried tomato pomace; [2]Enzyme: Rovabio Excel™ was added at a rate of 500 ppm; [3]FI = feed intake; [4] BWG = body weight gain; [5]FCR = feed conversion ratio. NS = Non significant ($P > 0.05$); *$P \leq 0.05$; **$p \leq 0.01$. [a,b]Means in each column with different superscripts are significantly different ($p < 0.05$).

Table 4. The effects of dried tomato pomace and Rovabio Excel™ enzyme on broiler carcass weight and its components.

Diet	Carcass weight (g)	Carcass Efficiency[3]	Breast[4]	Thigh[4]	Abdominal fat[4]	Heart[4]	Liver[4]	Gizzard[4]
DTP[1] (%)								
0	1669[a]	75[a]	23.5[a]	23[a]	1.49[a]	0.71[a]	2.19[a]	2.36[a]
8	1598[ab]	74[a]	22.4[ab]	22[ab]	1.47[a]	0.72[a]	2.28[a]	2.38[a]
16	1475[bc]	73[b]	21.2[bc]	21[bc]	1.47[a]	0.77[a]	2.20[a]	2.40[a]
24	1322[c]	72[b]	20.3[c]	21[c]	1.34[a]	0.78[a]	2.29[a]	2.42[a]
SEM	38	0.3	0.4	0.2	0.02	0.01	0.06	0.05
Enzyme[2]								
–	1447[b]	74[a]	22[a]	22[a]	1.39[b]	0.74[a]	2.23[a]	2.30[a]
+	2141[a]	74[a]	22[a]	22[a]	1.49[a]	0.75[a]	2.25[a]	2.40[a]
SEM	38	0.3	0.4	0.2	0.02	0.01	0.06	0.05
Source of variation				Significance				
DTP	**	**	**	**	NS	NS	NS	NS
Enzyme	*	NS	NS	NS	*	NS	NS	NS
DTP × Enzyme	NS	NS	NS	NS	NS	NS	NS	NS

[1]DTP = Dried tomato pomace; [2]Enzyme: Rovabio Excel™ was added at a rate of 500 ppm; [3]percentage of live weight; [4]percentage of carcass weight; NS = non significant (P > 0.05); *P ≤ 0.05; **P ≤ 0.01. [a,b]Means in each column with different superscripts are significantly different (p < 0.05).

in Table 4. The 8% DTP-fed broilers had comparable carcass weight and yield, yield of breast, thigh, abdominal fat, and visceral organs (heart, liver and gizzard) with those of control broilers. Carcass weight, carcass yield and yield of breast and thigh were lower for 16 and 24% DTP-supplemented broilers when compared to control broilers. These levels of DTP did not significantly affect abdominal fat and visceral organs percentage. The supplementation of Rovabio Excel™ significantly increased carcass weight and percentage of abdominal fat but did not affect carcass yield and breast, thigh, and visceral organs percentage. Café et al. (2002) reported that addition of a commercial multienzyme to corn-soybean meal-based diets did not improve dressing percentage, yield of breast, thigh and wing component, but resulted in a significant increase in abdominal fat. The observed enhancement in carcass weight can be due to the same reason as previously discussed about BWG. The observed increase in abdominal fat may be due to increase in calorie to protein or calorie to amino acid ratios (Café et al., 2002). The addition of Rovabio® Excel to broiler diets based on canola meal had no pronounced effect on carcass, breast and abdominal fat percentages but the percentage of leg significantly decreased (Mushtaq et al., 2007). The interaction between DTP and enzyme was not significant for carcass characteristics.

Conclusions

The results of this study revealed that DTP can be included in diets for broiler chickens up to 8% without any adverse effect on the performance and carcass quality of broiler chickens. Supplementation of Rovabio Excel™ improved BWG during starter and entire experimental periods and increased carcass weight and yield of abdominal fat.

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