Global Veterinaria 10 (3): 337-342, 2013
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2013.10.3.71221

The Study of the Effect of Multi-Enzyme Supplementation and Different Levels of Tomato Pomace on the Performance and Carcass Characteristics of Broiler Chicks

[1]*Behrouz Faryabidoust,* [2]*Leila Asadpour and* [1]*Shahram Nassabian*

[1]Department of animal science, Rasht Branch, Islamic Azad University, Rasht, Iran
[2]Department of Veterinary science, Rasht Branch, Islamic Azad University, Rasht, Iran

Abstract: Using factories by-products as supplementations in poultry industry, due to their better effects on production qualities and less durability in carcass have a significant position in poultry feeding. To study the effect of commercial tomato processing waste products on the Performance and carcass characteristics of broiler chicks an experiment was performed on Ross-308 broiler chicks. The study was designed to have ten treatments. First treatment was included Ross standard diet without multi-enzyme supplementation and tomato pomace; the second one Ross standard diet with 2 % tomato pomace and without multi-enzyme supplementation; the third, fourth and fifth ones with 3 %, 5 % and 10 % tomato pomace respectively and without multi-enzyme supplementation. From Sixth to tenth treatments %0.04 multi-enzyme was added. Each treatment was replicated four times. One day old chicks were randomly assigned to the treatments in a 2x5 factorial design. During experiment the chicks was fed adlibitum. At the end of the period (42 days) one chick from each treatment was slaughtered and the weight of different parts of carcass, feed intake and Conversion Ratio were measured. The results showed that there was significant difference in live weight, feed intake in starting, growing and final period and weight gain in starting period ($P<0.05$); however ; no significant difference was observed in weight gain in growing and final period ($P<0.05$). Furthermore, the study on the effect of multi-enzyme supplementation showed that there was significant difference in live weight, carcass, breast, thigh,wing, heart, liver and abdominal fat weight ($P<0.05$).

Key words: Multi-enzyme · Tomato Pomace · Broiler chicks · Performance · Carcass Characteristics

INTRODUCTION

In poultry industry main expenses are spent on feeding. At present the price of the main ingredients of diet including corn, soybean, fat and by-products has been increased at world market. Like any other industries poultry industry are searching for ways to minimize expenses on feeding. Any improvement at this sector reduces the expenses and finally results in higher economic benefit [1]. Regarding to the limitations of growing field, man and poultry competition on consumption of food resources and high cost of food preparation in poultry industry new foodstuffs no doubt can be a solution. Increase of materials and wastes from industries is one of the environmental concerns. Getting rid of them is a main environmental issue in many countries. However, attention has recently been focused on them and attempt has been made to use them in order to solve environmental issues [2]. Many of these wastes are used as valuable resources of energy and protein [3]. In addition to preventing their wasting and accumulation in environment and subsequent environmental problems, their use in livestock and poultry feeding play a vital role in reduction of expenses on feeding. Tomato pomace is a by –product of tomato processing and ketchup and juice production factories which contains skin, seed and pulp. Ammerman *et al.* [4] assessed dietary value of tomato pomace and found that dried tomato pomace can be used to feed poultry without any side effect on the performance of broiler chicks. Due to high amount of its protein, it has often been used in place of soybean and corn. Its protein, contains high amount of lysine [2]. Furthermore, high

Corresponding Author: Behrouz Faryabidoust, Department of Animal Science, Rasht Branch, Islamic Azad University, Rasht, Iran.

content of fiber and the existence of a compound called tomatin are cholesterol reducing factors [5, 6]. Tomato seed and pomace are good sources of alpha-tocopherol which is used as antioxidant to preserve carcass of broiler chicks [7]. The most important limiting factor in tomato pomace using, is its excessively high amount of fiber [8]. Cell wall which constitutes its main parts functions as a barrier for digestive enzyme to reach at nutrients or as a factor to reduce its speed. As viscosity of digestive materials goes up, decrease the spread of enzymes and slow down food and nutrients movement in digestive tract and consequently decrease digestion, nutrient absorption and food intake [9]. The present research aims to study the effect of using different levels of high fiber tomato pomace with and without multi-enzyme supplementation in the broiler chicks diet on the performance and carcass characteristics of broiler chicks.

MATERIALS AND METHODS

In this design 400 one day old male broiler chicks of Ross 308 were used. The mean weight of chicks in the first day was 350 g. The chicks were assigned in 2x5 factorial schedule to ten treatments and the experiment was replicated four times. The pens were completely separated by wood and metal mesh. Light was provided for 23 hours and one hour was blackout from day 7 up to day 42. The treatments have been as follows:

Treatment 1: Ross standard diet Treatments 2, 3, 4 and 5: Ross standard diet with 2 %, 3%,4%,5% tomato pomace Treatment 6: Ross standard diet with multi-enzyme supplementation Treatments 7, 8, 9 and 10: Ross standard diet with multi-enzyme supplementation and with 2%,3%,5%and10% tomato Pomace respectively.

Ingredient of the Diet: The compositions of the diets, the calculated feeding value of experimental diets, the result of tomato pomace analysis and multi-enzyme components are reported in the Tables 1-4.

Recorded Traits

Feed Intake: It was measured at the end of starter period, growing period and final period. At the beginning of each period the allotted diet to each experimental unit was weighed by digital scale. Feed intake was calculated by the total difference between allotted diet to each experimental unit and remained one.

Weight Gain: Chicks were weighed at the end of starter, growing and final periods. Weight gain value was computed from the weight difference of chicks at the beginning and end of each period.

Conversion Ratio: It was calculated by the following formula:

Conversion Ratio= Whole period Weight Gain / Whole Period Feed Intake

Carcass Separation: At the end of the experiment (at 42 days of age) one chick was randomly selected from each replicate, slaughtered, separated and the weight of carcass and its different organs like breast, wing, thigh, liver, heart and abdomen fat were measured by digital scale.

Data Analysis: The experiment was performed in factorial design. The collected Data was analyzed by SAS (1985) [10] software and averages were compared by Duncan test. Significance was accepted at P<0.05.

Table 1: The compositions of experimental diets

	Treatment 1			Treatment 2			Treatment 3			Treatment 4			Treatment 5		
Treatment	S	G	F	S	G	F	S	G	F	S	G	F	S	G	F
Corn	54.5	62.7	58.5	61.7	57.5	53.5	61.2	57	53	60.2	56	52	57.7	53.5	49.5
Soybean meal	37.5	29.5	33.5	28.5	32.5	36.5	28	32	36	27	31	35	24.5	28.5	32.5
Sun Flower	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
DTP	0	0	0	2	2	2	3	3	3	5	5	5	10	10	10
CaCO3	1.2	1.1	1.2	1.1	1.2	1.2	1.1	1.2	1.2	1.1	1.2	1.2	1.1	1.2	1.2
Dicalcium phosphate	1.6	1.5	1.5	1.5	1.5	1.6	1.5	1.5	1.6	1.5	1.5	1.6	1.5	1.5	1.6
Salt	0.23	0.25	0.26	0.25	0.26	0.23	0.25	0.26	0.23	0.25	0.26	0.23	0.25	0.26	0.23
Mineral permix	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin permix	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Baking soda	0.12	0.1	0.14	0.1	0.14	0.12	0.1	0.14	0.12	0.1	0.14	0.12	0.1	0.14	0.12
DL-Methionine	0.18	0.15	0.21	0.15	0.21	0.18	0.15	0.21	0.18	0.15	0.21	0.18	0.15	0.21	0.18
L-Lisine	0.07	0.1	0.09	0.1	0.09	0.07	0.1	0.09	0.07	0.1	0.09	0.07	0.1	0.09	0.07

Table 2: The calculated feeding value of experimental diets

Calculated content	Starter diets	Grower diets	Finisher diets
ME (Kcal.Kg)	3010	3050	3100
Crude protein %	21.04	19.60	18.18
Lisine %	1.27	1.10	0.97
Methionine+ Cystine %	0.94	0.84	0.76
Methionine%	0.47	0.42	0.36
Arg %	1.31	1.14	1.02
Trp %	0.20	0.18	0.16
Ca %	1.05	0.90	0.85
Available phosphor	0.50	0.45	0.42
Mg %	0.05	0.06	0.05
Na %	21.04	19.60	18.18
Cl %	0.17	0.17	0.16
K %	0.50	0.40	0.50
Cu (mg)	16	16	18
I (mg)	1.25	1.25	1.25
F (mg)	40	40	40
Mn (mg)	120	120	120
VitA)IU)	11000	9000	9000
VitE)IU)	75	50	50
VitK (mg)	3	3	2
VitB12 (mg)	0.016	0.016	0.010
B2 (mg)	8	6	5

Table 3: Chemical analysis of dried tomato pomace

Tomato Pomace	
ME (Kcal/Kg)	3560
Crude protein %	19.57
Dry matter	91
Ether extracts	6.2
Crude fiber	36
Nitrogen free extractives	22.54
Crude ash	4.24
Ca	0.7
P	0.55
Lysine%	1.08
Methionine+ Cystine%	0.80

Table 4: Components of supplemented multi-enzyme

Multi-enzyme Natuzyme	
Cellulase	6000000
Xylase	10000000
β-Glucanase	700000
Amylase	700000
Pektinase	70000
Fitase	1500000
Protease	3000000
Lipase	30000

RESULTS AND DISCUSSION

The study on the effect of different levels of tomato pomace on carcass quality showed that there was significant difference in breast, thigh,wing, heart, liver and abdominal fat weight ($P<0.05$). However, no significant difference was observed in abdomen filled carcass weight (Table 5).

Furthermore, the study of the cumulative effect of tomato pomace and multi-enzyme supplementation on carcass quality showed that there were significant differences in breast, thigh,wing, heart, liver and abdominal fat and carcass weights ($P<0.05$). The results are shown in (Table 6).

The results of different levels tomato pomace supplementation on performance parameters showed that there was significance difference in feed intake in starter period, growing period, final period and the entire of experimental period (Table 7); however ; no significance difference was observed in weight gain in growing period, final period and the entire of experimental period ($P<0.05$).

The study of the cumulative effect of tomato pomace and multi-enzyme supplementation on performance showed that there was significance difference in feed intake in starter period, growing period and final period, ($P<0.05$), in weight gain in starter period, growing period and final period and feed conversion ratio in the entire period (Table 8). Enzyme supplementation improved carcass most of quality and performance parameters due to improvement in tomato pomace digestibility. This results is in agreement with those of Mathlouthi *et al.* [11] who reported that supplementation of exogenous enzymes to the rye-based diet improved weight gain.

Fajri [12] in a study on the effect of dried tomato pomace at the levels of 0,5,10,15,20 % in replacement of soybean and corn on the intestine cytological traits of broiler chicks, found that there was significant effect on the weight gain in growing period and entire period($P<0.01$). Growth rate of chicks fed at the levels of 15, 20 % reduced compared to control group; however, feed intake and feed conversion ratio were not affected.

Tomecynski and Soska, [13] reported that tomato Pomace supplementation up to 5 % do not have negative but higher percent limit accessibility to energy from. [14] found that dried tomato pomace can be used in broiler chicken diets up to 20 %. AL-Betawi [3] studied the effect of dried tomato Pomace processed by heat and alkali under sunlight on broiler chicks performance in 5 weeks and no significant differences were observed in term of live weight, feed intake ratio and mortality rate between control and experimental groups. AL-Betawi reported that TP can be used at a level of 10% in broilers diet. King and Zeidler [7] studied tomato pomace supplementation at level of 30 % and found that there is no difference in terms of weight and feed intake ratio. Liadakis *et al.* [15] evaluated dietary value of tomato Pomace in pultry feeding and reported that dried tomato Pomace up to 3 % can be used instead of alfalfa powder without any

Table 5: The effect of different level of tomato pomace on carcass quality

Treatment	live weight	Breast weight	Thigh weight	Wing weight	Heart weight	Liver weight	Abdominal fat weight
0%DTP	2120.63^{ab} ±49.417	428.75^{a} ±128.111	466.25^{a} ±18.590	120.56^{a} ±1.683	10.936^{a} ±0.067	52.735^{a} ±0.067	35.506^{a} ±7.327
2%DTP	2060.00^{ab} ±47.767	425.25^{a} ±156.199	437.50^{a} ±19.612	111.25^{a} ±1.340	12.623^{c} ±0.100	53.213^{a} ±0.287	30.336^{b} ±7.312
3%DTP	2012.50^{ab} ±51.427	455.63^{a} ±183.249	462.50^{a} ±18.289	118.75^{a} ±1.055	9.622^{b} ±0.159	46.060^{b} ±0.645	26.666^{b} ±7.190
5%DTP	2138.13^{a} ±48.794	433.75^{a} ±142.657	423.13^{a} ±18.755	105.94^{b} ±1.000	11.002^{a} ±0.239	53.125^{a} ±0.600	30.633^{b} ±7.271
10%DTP	1975.63^{b} ±52.567	375.25^{b} ±155.567	360.63^{b} ±19.042	93.87^{c} ±1.568	9.875^{b} ±0.032	45.125^{b} ±0.212	29.760^{b} ±7.167

Table 6: The cumulative effect of tomato pomace and multi-enzyme supplementation on carcass quality

Treatment	live weight	Breast weight	Thigh weight	Wing weight	Heart weight	Liver weight	Abdominal fat weight
0%DTP+0%ME	0^{bc}.2075 131.275 ±	00^{abc}.405 49.833±	5^{bc}.367 29.861±	875^{dc}.109 6.957 ±	270^{ab}.11 0.687±	123^{cd}.50 3.541 ±	783^{a}.48 5.162 ±
2%DTP+0%ME	3^{c}.1971 86.646 ±	25^{bc}.371 59.213±	25^{bc}.376 64.080±	250de.96 10.307 ±	200^{e}.8 0.605 ±	698^{d}.43 3.808 ±	135^{a}.44 2.602 ±
3%DTP+0%ME	8^{bc}.2033 49.561 ±	50^{abc}.412 6.454±	50^{bc}.387 31.225±	107.503^{dc} 2.886 ±	617^{e}.9 0.263 ±	810^{c}.53 151.7 ±	543^{a}.46 6.841 ±
5%DTP+0%ME	5^{c}.1972 82.323 ±	25^{abc}.426 43.851±	50^{bc}.392 13.229±	^{de}114.390 10.054 ±	792^{e}.9 1.219 ±	393^{cd}.50 6.205 ±	510^{a}.45 5.516 ±
10%DTP+0%ME	0^{d}.1715 56.125 ±	00^{c}.348 857.26 ±	00^{c}.320 28.867±	250^{e}.80 20.742 ±	607^{bc}.10 0.772 ±	045^{d}.43 6.073 ±	945^{a}.46 1.539 ±
0%DTP+0/04%ME	3^{abc}.2166 94.813 ±	25^{ab}.452 178.36±	00^{a}.525 10.801±	250^{a}.131 8.539 ±	602^{bc}.10 0.778 ±	705^{a}.74 978.5 ±	230^{b}.22 2.859 ±
2%DTP+0/04%ME	8^{abc}.2148 129.381 ±	25^{a}.479 322.76 ±	75^{a}.498 12.500±	250^{abc}.126 4.787 ±	450^{e}.9 0.487 ±	972^{b}.62 6.895 ±	430^{cd}.14 1.455 ±
3%DTP+0/04%ME	3^{c}.1991 109.176 ±	75^{a}.498 115.569±	50^{a}.537 86.554±	000^{ab}.130 19.148 ±	627^{c}.9 0.975 ±	123^{b}.66 4.632 ±	790^{d}.9 1.164 ±
5%DTP+0/04%ME	8^{a}.2303 251.607 ±	25^{abc}.441 45.894±	75^{ab}.453 109.268±	500^{bcd}.112 9.574 ±	212^{a}.12 1.171 ±	725^{a}.80 8.759 ±	753^{c}.15 0.941 ±
10%DTP+0/04%ME	3^{ab}.2236 196.697 ±	50^{c}.402 55.937±	25^{bc}.401 48.196±	500^{dc}.107 11.902 ±	682^{c}.9 1.097 ±	545^{c}.54 1.905 ±	575^{cd}.12 1.714 ±

Table 7: The results of different level of tomato pomace on performance parameters

Treatment	Feed Intake in starting	Feed Intake in Growing	Feed Intake in Finishing	Weight Gain in starting	Weight Gain in Growing	Weight Gain in Finishing	Conversion Ratio
0%DTP	1142.52^{a} ±8.219	2002.50^{ab} ±23.00	1808.63^{a} ±25.30	729.19^{bc} ±9.00	1067.50^{a} ±22.83	460.31^{a} ±47.68	2.299^{a} 0.901±
2%DTP	1071.90^{c} ±8.188	2026.25^{ab} ±23.02	1818.31^{a} ±25.21	713.81^{c} ±9.29	1031.88^{a} ±23.60	463.69^{a} ±47.39	2.187^{a} 0.212±
3%DTP	1142.08^{a} ±8.369	1971.25^{b} ±23.00	1749.56^{a} ±25.62	723.63^{c} ±9.16	1053.88^{a} ±23.49	384.25^{a} ±47.54	2.208^{a} 0.170±
5%DTP	1126.13^{ab} ±8.341	1973.75^{b} ±23.00	1784.94^{a} ±25.50	753.50^{ab} ±9.01	1057.69^{a} ±23.16	451.13^{a} ±47.29	2.187^{a} 0.914±
10%DTP	1104.34^{b} ±8.232	2071.25^{a} ±23.59	1592.88^{b} ±25.59	762.38^{a} ±9.17	1045.81^{a} ±25.83	405.81^{a} ±47.19	2.206^{a} 0.507±

Table 8: The cumulative effect of tomato pomace and multi-enzyme supplementation on performance parameters

Treatment	Feed intake in starting	Feed intake in Growing	Feed intake in Finishing	Weight Gain in starting	Weight Gain in Growing	Weight Gain in Finishing	Conversion Ratio
0%DTP+0%ME	75^{b}.1130 782.120±	45^{b}.2030 117.886±	50^{cd}.1729 2.122±	63^{e}.693 838.22±	83^{e}.1093 30.991 ±	00^{bc}.2250 41.912 ±	043^{a}.2 0.093±
2%DTP+0%ME	75^{b}.1130 45.522±	45^{b}.2030 57.807±	86^{ab}.1721 3.123±	00de.704 740.20±	20de.1114 85.575 ±	25^{bc}.2171 56.091±	282^{c}.2 0.509±
3%DTP+0%ME	00^{b}.1130 12.193±	00^{b}.2030 38.622±	50^{ab}.1722 3.543±	75de.701 996.35±	95de.1101 23.616 ±	75^{bc}.2233 23.098 ±	222^{ab}.2 0.912±
5%DTP+0%ME	38^{a}.1169 16.710±	08^{a}.2069 101.324±	89^{ab}.1716 2.145±	25^{bcd}.740 193.33±	45^{bcd}.1140 23.708 ±	50^{bc}.2172 12.654±	991^{a}.1 0.562±
10%DTP+0%ME	25^{c}.1079 9.674±	05^{c}.2079 37.749±	13^{e}.1769 1.719±	25^{cde}.724 991.17±	45^{cde}.1124 26.497 ±	00^{c}.2065 98.980 ±	248^{ab}.2 0.076±
0%DTP+0/04%ME	88^{ab}.1154 10.562±	58^{ab}.2054 28.577±	56^{a}.1841 2.127±	75^{abc}.764 103.23±	95^{abc}.1164 123.743 ±	25^{ab}.2366 74.754 ±	113^{b}.2 0.390±
2%DTP+0/04%ME	75^{d}.1011 16.545±	45^{d}.2011 14.720±	18^{bc}.1712 2.908±	63^{cde}.723 134.45±	83^{cde}.1132 98.574 ±	75^{ab}.2348 67.812 ±	192^{ab}.2 0.703±
3%DTP+0/04%ME	63^{ab}.1155 10.980±	363^{ab}.2055 28.577±	60^{d}.1691 1.349±	75^{bc}.745 180.5±	85^{bc}.1145 101.106 ±	25^{bc}.2191 78.010 ±	205^{ab}.2 0.945±
5%DTP+0/04%ME	75^{c}.1083 11.087±	45^{c}.1983 38.622±	49^{bcd}.1807 1.819±	75^{a}.766 994.17±	85^{a}.1166 75.000 ±	75^{a}.2453 55.511 ±	985^{a}.1 0.955±
10%DTP+0/04%ME	38^{b}.1130 45.279±	08^{b}.2030 101.324±	250^{cd}.1700 0.834±	20^{a}.800 650.11±	35^{a}.1200 55.865 ±	25^{a}.2461 49.012 ±	164^{ab}.2 0.011±

DTP: Dried Tomato Pomace
ME: Multi Enzyme

negative effect. In another study, the effect of enzyme complex including protease, amylase, xylose, pektinase, cellulase, fitase and β-glucanase on performance and intestine viscosity of broiler chicks with basal diet of corn and soy bean was investigated and found that enzyme supplementation reduces intestine viscosity and improves performance which is consistent with the result of the present study [16]. It can be due to the fact that by the reduction of the viscosity of intestine contents multi enzyme in diet limits bacteria growth, helps eaten food to mix with excretions and improves lipid absorption. It is the main mechanism which improves the performance of broiler chicks [17, 18]. The results obtained in the present study indicate tomato pomace can be used in broilers rations at a level of 5% without multi-enzyme and up to 10% with multi-enzyme supplementation from the total diet.

AKNOWLEDGMENTS

The authors are grateful to the Islamic Azad University, Rasht Branch for supporting this research work.

REFERENCES

1. Sheppard, A., 2004. The structure and economics of broiler production in England. Special studies in agriculture economics. University of Exeter Publication. pp: 59.
2. Persia, M.E., C.M. Parsons, M. Schang and J. Azcona, 2003. Nutritional evaluation of dried tomato seeds. Poult. Sci., 82: 53-57.
3. AL-Betawi, N.A., 2005. Preliminary Study on tomato Pomace unusual Feed stuff in broiler diets.Pakistan Journal Nutrition, 4(1): 57- 63.
4. Ammerman, C.B., R.H. Harms R.A. Dennison, L.R. Arrington and P.E. Loggins, 1965. Dried tomato pulp, its preparation and nutritive value for livestock and poultry. Florida Agric. Exp. Sta. Bull., 691: 1-19.
5. Friedman, M., T.E. Fitch and W.H. Yokoyama, 2000. Lowering of plasma LDL cholesterol in hamsters by the tomato glycoalkaloid tomatine. Food Chem. Toxicol., 38: 549-553.
6. Kumar, P.G., S. Sudheesh, B. Ushakumari, V.A.K. Kumar, S.S. Vijaykumar and N.R. Vijayalakshmi, 1997. A comparative study on the hypolipidemic activity of eleven different pectins. Journal of food Science and Technology, 34(2): 103-107.
7. King, A. and G. Zeidler, 2004. Tomato Pomace may be a good Source of Vitamin E in Broiler Diets. California Agric., 58(1): 59-62.
8. Dotas, D., S. Zamanidis and J. Balios, 1999. Effect of dried tomato pulp on the performance and egg traits of laying hens. Br. Polut. Sci., 40: 695-697.
9. Bedford, M.R., 2000. Exogenous enzymes in monogastric nutrition-their current value and futurebenefits. Animal Feed Science and Technology, 86: 1-13.

10. Statistical Analysis System Institute, SAS Users Guide, Version 5. SAS Institute, Cary, NC (1985).
11. Mathlouthi, N., S. Mallet, L. Saulnier, B. Quemener and M. Larbier, 2002. Effects of xilanase and β-glucanase addition on performance, nutrient digestibility and physico-chemical conditions in the small intestine contents and caecal microflora of broiler chickens fed a wheat and barley-based diet, Animal Research, 51: 395-406.
12. Fajri, M., 2006. The survey of replacement of different levels of deried tomato pomace with soybean meal and corn on performance and gut morphology in broiler chicks. M. Sc. Thesis, Department of animal science, faculty of agriculture, University of Urmia. (In Farsi).
13. Tomecynski, R. and Z. Soska, 1976. Estimation of Biological Value and Chemical Composition of Seeds and Skins of Tomatoes. Zeszyty Naukowe Akademii Rolniczo - Technicznej Wolsztynie, 189: 153 - 164.
14. Ramesh, K.R. and G. Devegowda, 2005. Effect of enzyme complex on performance, in testinal viscosity and toe ash of broiler chickens fed corn - soybean meal based diet.
15. Liadakis, G.N., C. Tzia, V. Oreopoulo and C.D. Thomopoulos, 1998, Isolation of tomato seed meal protein with salt solutions, Food Science, 63: 450-453.
16. Squires, W., E.C. Naber and V.P. Toelle, 1992. The effect of heat, water, acid and alkali treatment of tomato canner wastes on growth, metabolizble energy value and nitrogen utilization of broiler chicks. Poult. Sci., 71(3): 522-529.
17. Smits, C.H.M. and G. Annison, 1996. Non-starch plant polysaccharides in broiler nutrition-towards a physiologically valid approach to their determination. Worlds Poultry Science Journal, 52: 203-221.
18. Choct, M., R. Hughes, J. Wang, M. Bedford, A. Morgan and G. Annison, 1996. Increased small intestinal fermentation is partly responsible for the anti-nutritive activity of non-starch polysaccharides in chickens. Brtish Poultry Science, 37: 609-621.