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*Full Length Research Paper*

# Effects of different levels of dried tomato pomace on performance, egg quality and serum metabolites of laying hens

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**A study was conducted to investigate the effects of dietary inclusion of dried tomato pomace (DTP) on performance, egg quality and serum metabolites in laying hens. A total of one hundred and forty four LOHMANN LSL-LITE hens were randomly allocated into 4 groups consisting of 6 replicates, each replicate has 6 birds. Birds were fed either a basal diet or the basal diet supplemented with 150, 170 or 190 g/kg of DTP. As a result of this study, there were no significant differences in body weight (BW), feed intake (FI), egg production (EP), feed conversion ratio (FCR) egg weight (EW), egg mass (EM), eggshell weight (ESW), eggshell thickness (EST) and Haugh unit (HU) among treatments. Dietary inclusion of DTP significantly increased yolk color score (YCS, P < 0.01). As dietary DTP increased from 0 to 19%, YCS significantly increased from 7.25 to 9.67 and 7.25 to 9.83 in first and second periods, respectively. Total serum protein, cholesterol, LDL, HDL, albumin, glucose and triglyceride levels were not significantly affected by DTP addition. In summary, DTP can be used as an alternative feedstuff in laying hen diets at inclusion levels up to 190 g/kg without any negative impact on performance and egg quality traits.**

**Key words:** Dried tomato pomace, egg quality, laying hen, serum metabolites.

## INTRODUCTION

The major problems facing worldwide animal industry are the availability and high cost of feed ingredients. This necessitates the search for inexpensive alternative sources of feedstuffs. Agro-industrial by-products represent one of the most important and promising energy and protein sources. Researchers are constantly searching for ways to improve the use of agricultural byproducts by including them in animal feed. Examples of crop residues and agricultural by-products in Iran are cereal bran, citrus pulp, poultry litter and tomato pulp. Industrial processing of tomato produces a large amount of waste at various stages. Iran produces up to 4,800,000 tones of fresh tomatoes annually (FAO, 2009), most of which are used for processing in tomato cannery factories, producing a large amount of wet tomato pomace.

The wet tomato pomace contains 33% seed, 27% skin and 40% pulp, while the dried pomace contains 44% seed and 56% pulp plus skin (Sogi and Bawa, 1998). Dried tomato pomace (DTP) contains 10% moisture, 20.77% crude protein, 1760 Kcal/kg ME, 39.8% crude fiber (CF), 7.3% ether extract (EE), 4.24% ash, 0.5% calcium and 0.45% phosphorus (Jafari et al., 2006). The limiting factors of DTP in poultry diets are low energy

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**Abbreviations: DTP,** Dried tomato pomace; **DM,** dry matter; **CP,** crude protein; **CF,** crude fiber; **EE,** ether extract; **YI,** yolk index; **YCS,** yolk color score; **ME,** metabolizable energy; **LDL,** low-density lipoproteins; **HDL,** high-density lipoproteins; **BW,** body weight; **FI,** feed intake; **EP,** egg production; **FCR,** feed conversion ratio; **EW,** egg weight; **EM,** egg mass; **ESW,** eggshell weight; **EST,** eggshell thickness; **HU,** haugh unit; **SI,** shape index.

and high fiber contents (Squires et al., 1992). DTP contain remarkable amounts of α-tocopherol (242 ppm) (Bordowski and Geisman, 1980), lutein, β-carotene, and lycopene, which in combination with commercially available pigments, could contribute to a darker yolk color that is desirable for the consumers (Mlodowski and Kuchta, 1998). Also, the tomato seed protein is rich in lysine (approximately 13% more lysine than soya protein) and can supplement feed that is deficient in lysine (Tsatsaronis and Boskou, 1975; Bordowski and Geisman, 1980; Carlson et al., 1981; Latlief and Knorr, 1983).

A number of studies have determined the feasibility of feeding tomato waste in poultry. Literature review demonstrated that DTP inclusion in laying hens diet resulted in similar performance with hens fed with corn-soybean meal diet (Dotas et al., 1999) or increased egg production (EP) and egg mass (EM) at levels up to 100 g/kg in diets of laying hens (Jafari et al., 2006). However, inclusion of DTP at higher level (150 g/kg of diet) decreased EP and EM, and increased feed conversion ratio (FCR) (Jafari et al., 2006). Studies by Nobakht and Safamehr (2007) indicated that the feeding of DTP increased feed intake (FI), EP, egg weight (EW), EM and eggshell weight (EST) whereas serum and egg yolk cholesterol content were not significantly affected. Some authors have found that supplementing laying hen diet with DTP did not influence performance parameters but increased the YCS (Mansoori et al., 2008). However, the effects of adding DTP in diet on laying diet performance and egg quality have been well described (Yannakopoulos et al., 1992; Mlodowski and Kuchta, 1998; Dotas et al., 1999; Jafari et al., 2006; Nobakht and Safamehr, 2007; Mansoori et al., 2008), but the studies available on the effects of DTP on serum metabolites in laying hen is limited and inconsistent. Feeding DTP to laying hens had no effect on plasma cholesterol and low-density lipoproteins (LDL) (Nobakht and Safamehr, 2007), serum albumin, globulin, glucose and triglycerides contents (Rahmatnejad et al., 2009). Also, feeding DTP at an inclusion rate of 24% to broiler chickens increased total serum protein, and levels of 16 and 24% cause significant increase in the mean values of high-density lipoproteins (HDL) and a decrease in serum cholesterol and LDL (Rahmatnejad et al., 2009). Lucopene, folate, vitamin C, vitamin A, phenolics and flavonoids are beneficial compounds found in the tomatoes (Sahin et al., 2008). Lycopene is a major red carotenoid present in tomatoes and exhibits cholesterol lowering effect in human beings (Gerster, 1997). Also, tomato's pectin increases the activity of plasma lecithin cholesterol acyl transferase and significantly decreases the concentration of serum cholesterol in rats (Presanna et al., 1997).

In light of the above, laying hen diets supplemented with DTP may have the potential to modulate the blood variables. Therefore, the objective of the present study was to assess the efficacy of using DTP as feedstuff in laying hen diets concerning serum metabolites performance parameters and egg shell quality.

## MATERIALS AND METHODS

### Birds, feeding and management

Wet tomato pulp (obtained from a commercial processor) was air-dried in order to obtain DTP. A total number of 144 LOHMANN LSL-LITE hens, with an initial age of 65 weeks were distributed in a completely randomized experimental design into four treatments with six replicates of 6 hens each. During the experimental period, hens had free access to water and one of 4 experimental diets. The hen house was provided with 16 h light per day. The experiment was carried out from 65 to 75 weeks of age. Similar management conditions were maintained for all groups. Experimental diets were formulated according to recommendations for LOHMANN LSL-LITE. Treatment groups were fed the basal diet (control group, T1) or the basal diet supplemented with 150 (T2), 170 (T3) and 190 g/kg DTP (T4). Ingredients and calculated chemical composition of experimental diets are shown in Table 1. The protein and energy content of all the experimental diets were 14.6% and 2720 Kcal/kg, respectively.

### Collection of samples, measurements and chemical analysis

Individual body weight was recorded at the start and termination of the trial in order to determine body weight variations. The hens' performance including EP, EW and FI was measured for 10 weeks, and EM as well as FCR was calculated. Specific gravity (SG) was determined on one hundred and forty four eggs produced during 3 days at the end of every 5 week period. Egg specific gravity was determined using 5 gradient saline solutions varying in specific gravity from 1.060 to 1.100 with 0.01 unit increments (Holder and Bradford, 1979). After measuring SG, all these eggs were used to measure ESW, eggshell thickness (EST), haugh unit (HU), shape index (SI), yolk index (YI), and YCS. The eggshell samples were washed and dried at room temperature and weighed. Eggshell (that dried at room temperature) thickness was a mean value of measurements at three places on the egg (air cell, equator, and sharp end) measured by using dial pipe gauge. HU and YI were calculated according to Wesley and Stadelman (1959), SI was calculated as the ratio of width and length of the egg multiplied by 100 (Parmar et al., 2006). Egg yolks collected from each treatment were scored using the Roche egg yolk color fan. Blood samples were taken from the wing vein of four randomly selected hens in each replicate at the middle and the end of the experiment. Blood samples were transferred into tubes and then centrifuged (15 min, 2500 rpm). The serum was separated and stored at -20°C for further analysis. The concentrations of glucose, cholesterol, total protein, albumin, triglycerides, HDL and LDL were measured with a spectrophotometer by using commercial kits (Pars Azmon, Iran). The DTP were analyzed for DM by drying it at 102°C for 16 h in a forced air oven, and for CP, EE, CF and ash by following methods 976.06, 920.39, 978.10 and 942.05 of AOAC (1990), respectively. Previous studies in our laboratory demonstrated that the ME of DTP was 1750 (kcal/kg) (Ghazi et al., 2010 (unpublished data).

### Statistical analysis

Data were analyzed by the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) software (2002). Probability values < 0.05 were taken to indicate statistical significance. The treatment means were compared using Duncan's multiple range test.

**Table 1.** Composition of the experimental basal diets for laying hens.

| Ingredient | Dietary treatment[1] | | | |
|---|---|---|---|---|
| | T1 | T2 | T3 | T4 |
| Maize | 61.71 | 59.06 | 58.71 | 58 |
| Soybean meal | 11.27 | 7.52 | 7.08 | 6.23 |
| Fish meal | 4.38 | 5 | 5 | 5 |
| Wheat barn | 11 | 1.89 | 0.67 | 0 |
| Sunflower oil | 1.6 | 1.6 | 1.6 | 1.7 |
| Oyster shell | 8.99 | 8.75 | 8.74 | 8.71 |
| Dicalcium phosphate | 0.32 | 0.31 | 0.32 | 0.33 |
| salt | 0.19 | 0.2 | 0.2 | 0.2 |
| Vitamin premix[2] | 0.25 | 0.25 | 0.25 | 0.25 |
| Mineral premix[3] | 0.25 | 0.25 | 0.25 | 0.25 |
| HCL-Lysine | 0 | 0.04 | 0.07 | 0.19 |
| DL-Methionine | 0.03 | 0.12 | 0.13 | 0.14 |
| DTP | 0 | 15.00 | 17.00 | 19.00 |
| **Calculated analyses** | | | | |
| ME (Kcal/kg) | 2720 | 2720 | 2720 | 2720 |
| Crude protein (%) | 14.6 | 14.6 | 14.6 | 14.6 |
| Crude fiber (%) | 3.40 | 6.95 | 7.43 | 7.93 |
| Calcium (%) | 3.75 | 3.75 | 3.75 | 3.75 |
| Available P (%) | 0.29 | 0.29 | 0.29 | 0.29 |
| Methionine (%) | 0.30 | 0.30 | 0.30 | 0.32 |
| Lysine (%) | 0.65 | 0.65 | 0.65 | 0.65 |
| Methionine + Cysteine (%) | 0.56 | 0.56 | 0.56 | 0.58 |

[1]T1 = Control group, T2 = diet with 150 g/kg of DTP, T3 = diet with 170 g/kg of DTP, T4 = diet with 190 g/kg of DTP. [2] Vitamin premix supplied the following per kilogram of diet: Vitamin A, 12,500 IU; Vitamin D3, 3125 ICU; Vitamin E, 37.5 IU; Vitamin K3, 6.25 mg; Vitamin B1, 3.75 mg; Vitamin B2, 12.5 mg; Vitamin B6, 10.0 mg; Pantothenate, 18.8 mg; Niacin, 50 mg; Biotin, 0.06 mg; Folic acid, 1.25 mg; Vitamin B12, 0.05 mg. [3]Mineral premix supplied the following per kilogram of diet: Cu ($CuSO_4 \cdot 5H_2O$, 25.45% Cu) 6 mg; Fe ($FeSO_4 \cdot 7H_2O$, 20.29% Fe) 50 mg; Mn ($MnSO_4 \cdot H2O$, 32.49% Mn) 40 mg; Zn (ZnO, 80.35% Zn) 60 mg; Se ($NaSeO_3$, 45.56% Se) 0.075 mg.

## RESULTS AND DISCUSSION

### DTP analysis

The proximate analysis of DTP used in this study is shown in Table 2. The dry matter (DM) content of DTP was 88.49%, which is similar to values reported by Jafari et al. (2006) and Mansoori et al. (2008) but lower than the values reported by King and Zeidler (2004), Maghsoud and Akbar (2008) and Paryad and Rashidi (2009). This variation at DM content of DTP can be described by differences among methods and pressure applied during the processing stage of pomace production. The tomato pomace used in this study contained 18.92% crude protein (CP), which is comparable to the CP level found by Jafari et al. (2006), but lower than values reported by King and Zeidler (2004), Maghsoud and Akbar (2008), Mansoori et al. (2008) and Paryad and Rashidi (2009). The level of EE content of DTP was 6.84% which is similar to values reported by Jafari et al. (2006), Mansoori et al. (2008), Maghsoud and Akbar (2008) but lower than values reported by King and Zeidler (2004), Paryad and Rashidi (2009). The crude fiber (CF) level was 32.47%, which is comparable with the findings of Jafari et al. (2006), but higher than in Mansoori et al. (2008) and Paryad and Rashidi (2009) who reported CF levels as 28.6 and 25.92%, respectively. The ash value of DTP used in this study was similar to value reported by Jafari et al. (2006) but lower than values reported by Mansoori et al. (2008) and Paryad and Rashidi (2009). The variations reported in chemical composition of DTP could be due to various factors, including varieties of tomato, soil conditions, use of fertilizers, ripeness, tomato processing conditions, relative percentage of seed, skin, pulp and leaves in wet pomace and many more factors related to the drying process (Persia et al., 2003; King and Zeidler, 2004; Jafari et al., 2006).

### Effect of DTP on performance parameters

Performance data of laying hens fed experimental diets

**Table 2.** Chemical composition (%) of DTP used in this study.

| Nutrient | DTP |
|---|---|
| Dry matter (%) | 88.49 |
| Metabolizable energy[a] (kcal/kg) | 1750 |
| Crude protein (%) | 18.92 |
| Ether extract (%) | 6.84 |
| Crude fiber (%) | 32.47 |
| Ash (%) | 4.67 |

[a]Ghazi et al. 2010 (Unpublished data).

**Table 3.** Effect of DTP supplementation on feed intake, egg production, feed conversion ratio, egg weight and egg mass.

| Treatment[a] | Feed intake (g/hen/day) | Egg production (%) | Feed conversion ratio | Egg weight (g) | Egg mass (g/hen/ day) | Body weight change (g) |
|---|---|---|---|---|---|---|
| T1 | 115.74 | 85.32 | 2.25 | 60.84 | 51.90 | -103.33 |
| T2 | 117.73 | 83.80 | 2.27 | 62.64 | 52.37 | -478.33 |
| T3 | 117.88 | 82.63 | 2.27 | 63.22 | 52.22 | 75.00 |
| T4 | 113.88 | 78.86 | 2.42 | 63.01 | 49.64 | 249.17 |
| P-value | 0.36 | 0.55 | 0.61 | 0.088 | 0.742 | 0.053 |
| SEM | 0.466 | 1.591 | 0.047 | 0.372 | 0.951 | 100.58 |

[a]T1 = Control group, T2 = diet with 150 g/kg of DTP, T3 = diet with 170 g/kg of DTP, T4 = diet with 190 g/kg of DTP.

are described in Table 3. There was no significant difference between different levels of DTP inclusion in respect of body weight (BW), FI, EP, FCR, EW and EM. Obtained result for BW is in accordance with result obtained by Jafari et al. (2006), Nobakht and Safamehr (2007), Mansoori et al. (2008), and contrary to conclusion made by Calislar and Uygu (2010). Data displayed a trend of increased BW as the level of DTP increased, and this could be a consequence of its high fiber content of diet that may increase FI. Yannakopoulos et al. (1992), Dotas et al. (1999), Jafari et al. (2006) and Mansoori et al. (2008) reported that the dietary addition of DTP did not have any significant effect on FI. In contrast, Nobakht and Safamehr (2007) and Calislar and Uygu (2010) found that the inclusion of DTP increased the FI in laying hen. In the same manner, DTP inclusion could not affect FCR. This result is similar to those reported by Yannakopoulos et al. (1992), Dotas et al. (1999), Nobakht and Safamehr (2007) and Mansoori et al. (2008). However, Jafari et al. (2006) and Calislar and Uygu (2010) found that DTP resulted in greater FCR. In agreement with our results, Yannakopoulos et al. (1992), Dotas et al. (1999), Nobakht and Safamehr (2007) and Mansoori et al. (2008) found that DTP had no significant difference on FCR. In contrast, Jafari et al. (2006) and Calislar and Uygu (2010), who used younger hens, found better FCR compared to that found in our study with 65 to 74 week old hens. After the 40th week until the end of the laying period, EP decreased in hens and concomitantly, FCR increased (Lesson and Summers, 2005), and thus the poorer FCR in our study, compared to that of Jafari et al. (2006) and Calislar and Uygu (2010), may be related to the higher age of our hens. EP was not statistically affected by the different levels of DTP addition. Gregoriades et al. (1984), Yannakopoulos et al. (1992), Dotas et al. (1999), Mansoori et al. (2008) and Calislar and Uygu (2010) reported that the use of DTP did not have any significant effect on EP.

It has been shown that feeding hen diets containing DTP at inclusion rates up to 10% increased EP (Nobakht and Safamehr, 2007). Nobakht and Safamehr (2007) reported that EP may be influenced by supplying high levels of nutrients especially some amino acids like lysine and higher FI with inclusion of DTP in laying hen diets. Jafari et al. (2006) observed that EP increased by inclusion of DTP at levels up to 100 g/kg in diets of laying hens, and decreased at an inclusion level of 150 g/kg, and suggested that this could be a consequence of the high fiber content of diet which may decrease nutrient availability in poultry. EW was not affected by dietary treatments, a finding which is in agreement with the previously reported data (Dotas et al., 1999; Jafari et al., 2006; Mansoori et al., 2008). This result can be attributed to the similar linoleic acid and CP contents in the diets of all treatments. In contrast, Yannakopoulos et al. (1992) and Nobakht and Safamehr (2007) reported that EW increased by both tomato meal and DTP supplementation and that this could be due to DTP's high lysine content.

**Table 4.** Effect of DTP supplementation on shape index, yolk index, haugh unit, eggshell weight, eggshell thickness, YCS and specific gravity at first and second experimental periods.

| Parameter | Treatment[a] | | | | P-value | SEM |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | | |
| **1-5 Weeks** | | | | | | |
| Shape index (%) | 74.26 | 74.25 | 75.72 | 74.2 | 0.092 | 0.255 |
| Yolk index (%) | 45.85 | 45.13 | 45.98 | 45.4 | 0.781 | 0.313 |
| Haugh unit | 88.7 | 88.4 | 89.11 | 88.12 | 0.684 | 0.317 |
| Eggshell weight (g) | 6.61 | 6.77 | 6.62 | 6.54 | 0.866 | 0.094 |
| Eggshell thickness ($mm \times 10^{-2}$) | 44.83 | 42.08 | 40.58 | 42.42 | 0.142 | 0.658 |
| YCS | 7.25a | 8.17b | 8.92c | 9.67d | 0 | 0.202 |
| Specific gravity ($mg/cm^{-2}$) | 1.08 | 1.08 | 1.08 | 1.08 | 0.773 | 0.001 |
| **5-10 Weeks** | | | | | | |
| Shape index (%) | 75.09 | 73.42 | 76.6 | 75.42 | 0.061 | 0.43 |
| Yolk index (%) | 47.36 | 47.73 | 46.91 | 48.33 | 0.484 | 0.323 |
| Haugh unit | 87.5 | 89.15 | 88.8 | 90.1 | 0.181 | 0.383 |
| Eggshell weight (g) | 6.72 | 6.77 | 6.92 | 6.92 | 0.89 | 0.105 |
| Eggshell thickness ($mm \times 10^{-2}$) | 41.92 | 40.5 | 41.42 | 40.17 | 0.645 | 0.522 |
| YCS | 7.25a | 8.50b | 9.17c | 9.83d | 0 | 0.221 |
| Specific gravity ($mg/cm^{-2}$) | 1.08 | 1.08 | 1.08 | 1.08 | 0.972 | 0.001 |

[a]T1 = Control group, T2 = diet with 150 g/kg of DTP, T3 = diet with 170 g/kg of DTP, T4 = diet with 190 g/kg of DTP.

Contrary to our results, Nobakht and Safamehr (2007) found that inclusion of DTP at levels higher than 7.5% in diets of laying hens increased EM. These discrepancies in results may be attributed to tomato variety, type of tomato by-product, levels of dietary supplementation with tomato by-product, tomato processing conditions, breed of laying hen, age of hens and stage of production.

## Effect of DTP on egg quality

Specific gravity, EST, ESW, HU, SI, YI and yolk color score for first (65 to 69 weeks) and second (70 to 74) periods are summarized in Table 4. Supplementation of different levels of DTP had no significant influence on egg SI, YI, HU, ESW, EST, and SG in both periods. The difference in YCS was significant between treatments, and the YCS was higher in T4 treatment than others ($P < 0.01$). Other experiments indicated that the inclusion of tomato by-product in laying hen diets had no effect on the SG (Nobakht and Safamehr, 2007), EST (Yannakopoulos et al., 1992; Dotas et al., 1999; Jafari et al., 2006; Nobakht and Safamehr, 2007; Mansoori et al., 2008; Calislar and Uygu, 2010), ESW (Yannakopoulos et al., 1992; Dotas et al., 1999; Jafari et al., 2006; Nobakht and Safamehr, 2007; Mansoori et al., 2008; Calislar and Uygu, 2010) and HU (Jafari et al., 2006; Nobakht and Safamehr, 2007; Mansoori et al., 2008; Calislar and Uygu, 2010). The reason for the lack of an effect of DTP on ESW and EST could be due to the similar calcium, phosphorus and vitamin D contents in all treatment diets. In contrast, Gregoriades et al. (1984) reported that the inclusion of DTP affected the EST in layer diets. Our finding on HU confirms the low effect that nutrition exhibits on HU. As dietary DTP increased from 0 to 19%, YCS significantly increased from 7.25 to 9.67 and 7.25 to 9.83 in the first and second periods, respectively. In agreement with our result, Yannakopoulos et al. (1992), Mlodowski and Kuchta (1998), Dotas et al. (1999), Karadas et al. (2006), Mansoori et al. (2008) and Calislar and Uygu (2010) found that the inclusion of DTP increased YCS. Contrary to our result, Persia et al. (2003) and Jafari et al. (2006) reported that the inclusion of DTP in diets of laying hens had no significant effect on the YCS. A notable increase in YCS of eggs was most likely due to the presence of appreciable amounts of carotenoid pigments, particularly lycopene in DTP. Lycopene is responsible for the red color of tomato and DTP. In fact, feeding laying hen diets containing tomato by-products transfer the dietary lycopene and β-carotene to the egg yolk (Karadas et al., 2006; Calislar and Uygu, 2010).

## Effect of DTP on serum metabolites

The results for serum metabolite contents of laying hens are summarized in Table 5. The addition of DTP to the diets at first and second periods had no effect on serum glucose, total protein, cholesterol, triglycerides, LDL, HDL

**Table 5.** Effect of DTP supplementation on glucose, total protein, cholesterol, triglycerides, LDL, HDL and albumin at first and second experimental periods.

| Parameter | Treatment[a] | | | | P-value | SEM |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | | |
| **1-5 weeks** | | | | | | |
| Glucose (mg/dl) | 226±7.16 | 219.5±8.35 | 210.75±3.30 | 212.50±12.50 | 0.092 | 2.458 |
| Total protein (mg/dl) | 6.40±0.69 | 6.2±0.65 | 6.12±0.93 | 5.70±0.74 | 0.628 | 0.183 |
| Cholesterol (mg/dl) | 169.25±31.08 | 175.50±17.86 | 188.75±51.49 | 174.25±50.77 | 0.914 | 9.213 |
| Triglycerides (mg/dl) | 1588.7±266.75 | 1988.7±606.68 | 1741.2±668.42 | 1127.5±75.55 | 0.123 | 133.09 |
| LDL (mg/dl) | 91.75±14.01 | 95.50±8.37 | 94.00±14.81 | 89.00±16.23 | 0.914 | 3.124 |
| HDL (mg/dl) | 58.25±14.81 | 52.50±6.81 | 53.75±8.30 | 55.75±11.95 | 0.887 | 2.507 |
| Albumin (mg/dl) | 2.85±0.17 | 2.55±0.26 | 2.62±0.41 | 2.35±0.17 | 0.131 | 0.077 |
| **5-10 weeks** | | | | | | |
| Glucose (mg/dl) | 234.00±10.42 | 230.50±11.96 | 234.25±8.06 | 230.50±27.59 | 0.977 | 3.70 |
| Total protein (mg/dl) | 5.55±0.71 | 6.50±0.96 | 5.77±0.15 | 5.80±0.78 | 0.424 | 0.205 |
| Cholesterol (mg/dl) | 127.75±28.22 | 207.25±56.64 | 170.50±21.83 | 168.25±45.11 | 0.076 | 11.89 |
| Triglycerides (mg/dl) | 990.0±386.09 | 2105.0±886.12 | 1346.20±378.98 | 1098.70±603.95 | 0.085 | 175.11 |
| LDL (mg/dl) | 64.25±18.48 | 91.25±23.61 | 95.25±11.47 | 91.75±18.37 | 0.118 | 5.24 |
| HDL (mg/dl) | 40.75±10.72 | 64.75±16.72 | 48.00±8.17 | 47.75±7.09 | 0.060 | 3.40 |
| Albumin (mg/dl) | 2.55±0.24 | 2.70±0.32 | 2.40±0.26 | 2.40±0.46 | 0.534 | 0.08 |

[a]T1 = Control group, T2 = diet with 150 g/kg of DTP, T3 = diet with 170 g/kg of DTP, T4 = diet with 190 g/kg of DTP. Values represent means ± SD.

and albumin. There was no significant difference between levels of inclusion of DTP with regard to serum metabolites. Other experiments indicated that the inclusion of tomato by-product in laying hen diets had no effect on the cholesterol (Nobakht and Safamehr, 2007), LDL (Nobakht and Safamehr, 2007), glucose (Rahmatnejad et al., 2009), albumin (Rahmatnejad et al., 2009) and triglycerides (Rahmatnejad et al., 2009). Rahmatnejad et al. (2009) showed that feeding DTP at an inclusion rate of 24% to broiler chicks increased serum total protein compared with 8, 16% DTP and control diets. Also, dietary supplementation of 16 and 24% DTP were found to cause a significant increase in the mean values of HDL and a decrease in serum cholesterol and LDL, as compared with other dietary treatments. As mentioned above, tomato by-product contains high amounts of fiber. Moundras et al. (1997) reported that the serum cholesterol decreasing effect of crude fiber could be due to its ability to enhance faecal excretion of cholesterol and bile acids. Daggy et al. (1997) reported that the fiber induces both enhanced liver excretion and diversion of intestinal steroids to the faeces. Burr et al. (1985) suggested that there is a negative correlation between dietary fiber content and serum cholesterol level. It is possible that for a significant reduction of serum cholesterol, a higher inclusion level of DTP in laying hen diets is required. These discrepancies in results may be attributed to breed of poultry, tomato variety, types of tomato by-product, levels of dietary tomato by-product and tomato processing conditions. These initial results need to be confirmed and extended by future investigations.

## Conclusion

The results of the present research suggest that DTP up to 19% is a good suited substitute for feedstuff in laying hen rations without any negative effect on the performance of laying hens, compared with hens fed the corn-soybean meal control diet. It was observed that the DTP used in this study did not exhibit any negative effects on the egg quality and benefited the birds to lay eggs with deeper yolk colors. In this experiment, supplementation with DTP did not influence serum cholesterol, LDL, HDL, glucose, albumin, total protein and triglycerides as compared with control group. However, further works should be carried out to find out the effects of different levels of DTP in various ages on performance, egg quality and serum metabolites of laying hen breeds.

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