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Incorporation of Dried Tomato Pomace in Growing Sheep Rations

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Abstract: The aim of this study was to investigate the effects of inclusion dried tomato pomace (DTP) at different levels on the growth performance of male Ossimi lambs. Twenty male Ossimi lambs obtained with an initial live body weight of 19.250±0.18 kg were fed the experimental diets. Treatments were arranged in a completely randomized design of four treatments with 5 replicates each (0, 5, 10 and 15% DTP) and observed during 98 days growth period. Dry Matter intake (DMI) was measured daily and daily weight gain (DWG) was determined biweekly. The results showed that, chemical analysis of DTP contained 21.11% CP; 29.33% CF; 9.21% EE; 37.07% NFE; 3.28% ash; 4814 kcal/ kg DM (GE); 1.16% non fibrous carbohydrates (NFC); 65.24% NDF; 40.93% ADF; 22.12% ADL; 24.31% hemicellulose and 18.81% cellulose, respectively. Experimental total mixed rations (TMR) were isonitrogenous (17.04% CP in average) and isocalories (4181 kcal gross energy/ kg DM in average). All nutrients digestibility and nutritive values tended to increase. Dietary treatments had significant effect ($P<0.05$) on all nutrient digestibilities coefficient except for DM and CP digestibilities which not affected. While TDN value was significantly ($P<0.05$) affected, however, DCP was not affected. Total mixed rations contained 10 or 15% DTP significantly increased ($P<0.05$) OM, CF, EE and NFE digestibilities and TDN value. However, insignificantly ($P>0.05$) increased DM and CP digestibilities and DCP compared to control. Nitrogen balance for all experimental groups were positive and its values were insignificantly ($P>0.05$) increased. Ruminal pH value and ammonia nitrogen concentration significantly ($P<0.05$) decreased, while, total volatile fatty acids concentration significantly ($P<0.05$) increased in comparison with control. Final weight (FW), total body weight gain (TBWG) and average daily gain (ADG) were significantly ($P<0.05$) increased with increasing level of DTP. The corresponding values were 37.40, 39.10, 40.42 and 41.55 kg for FW; 18.15, 19.70, 21.27 and 22.35 kg for TBWG and 185, 201, 217 and 228 g for ADG for TMR_1, TMR_2, TMR_3 and TMR_4, respectively. Feed intake of DM, TDN and DCP that expressed as (g/h/d, g/kg$W^{0.75}$ and Kg/ 100 kg LBW) were decreased. Feed conversion was significantly ($P<0.05$) improved. All blood parameters were significantly ($P<0.05$) increased except for plasma total lipid insignificantly ($P>0.05$) decreased. Daily feeding coast decreased while, daily profit above feeding cost and relative economical efficiency improved by 21%, 41% and 57% with increasing level of DTP. Also, feed cost LE/ kg gain was improved by 13.49%, 25% and 33.23% compared to control. The present results revealed that incorporation DTP up to 15% could be useful in feeding lambs without any adverse effect on their performance. Also, dried tomato waste can be used as alternative source of protein in ruminant rations and it can be used as a substitute for good quality roughages (berseem hay), preferably in dried form in ration of lambs. Economic benefits can be realized by using DTP in the formulation of a low-cost ration which improves feed conversion ratio and growth performance. It is therefore appropriate to add this agro-industrial by-product to the ruminant rations.

Key words: Dried tomato pomace · Sheep · Performance · Digestion coefficients · Ruminal fermentation · Nitrogen utilization · Blood plasma constituents · Economic evaluation

INTRODUCTION

Small ruminant production is a very significant component of livestock production throughout the world and more especially in the developing countries [1-3].

Shortage and high price of conventional animal feeds such as lucerne and grains in arid and semi arid areas of the world leads the animal nutrition to effective use of agro-industrial by-products. Developing food industrial factories consequently

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produced large amount of wastes and by-products which can play an important role in livestock nutrition [4, 5].

There is a growing interest in most countries in the use of organic wastes, particularly agro-industrial by-products, as a low-cost alternative feed source for animals. Intensive efforts are being made in Egypt aiming at solving the problem of feed shortage through providing some alternative feed ingredients from such organic wastes. Sizeable amounts of organic wastes are produced annually but some of these organic wastes are being used at small scale in animal feeding [6].

In recent years, the use of agro-industrial by-products in animal nutrition has been successfully adopted as a strategy to reduce feeding costs and also to cope with the need to recycle waste material which is costly to dispose of. This is the case, for example, tomato pomace that has been successfully used as supplements for small ruminant diets [7, 8].

Tomato is one of the major vegetables which come next to potatoes in term of world production [9, 10]. Dried tomato pomace (DTP), as a by-product, is a mixture of tomato skin, pulp and crushed seeds that remain after the processing of tomato for juice, paste and/or ketchup [11-13]. This by product remains from squeeze of tomato is rich in protein, energy and crude fiber. In addition, it contains more essential amino acids compared to alfalfa meal of good quality [14-16].

World tomato production was 152 million tons in 2009. The main tomato producers were China, USA, India, Turkey, Egypt, Italy, Iran, Spain, Brazil and Mexico (75% of the world production [10].

In the year 2006, the average annual production of tomato in Egypt was recorded to be 7.6 million tons resulting in production of 19% as by-product during manufacturing [10].

Ahmed *et al*. [16] stated that in Egypt, about, 550.000 to 660.000 tons of tomato pomace are yearly produced from canning industry. Unfortunately a great part of this by–product is lost without utilization.

High amounts of residues are generated accounting for about 4.5% of the fresh weight% peels and 1.5% seeds. The high crude protein (22-25% DM basis) and this by-product classify among the feedstuffs having high potential for their use in livestock feeding [4, 7, 17-20].

Tomato pomace contains 22.6 to 24.1% protein, 14.5 to 15.7% fat and 20.8 to 30.5% fiber. This by-product is a good source of vitamin B_1 and a reasonable source of vitamin A and B_2 [21, 22].

If tomato pomace was loosed unused, causes serious environmental pollution as well as acting as a substrate for insect and microbial proliferation [23].

Tomatoes contain a solanine-like alkaloid (Saponin) called tomatine which not cause a problem in tomato pomace, also, tomatine may have medicinal properties such as antibiotic, anticancer, anticholesterol, antiinflammatory, antinociceptive and antipyretic effects [24].

The main objectives of the this work was carried out to study the effect of incorporation dried tomato pomace (DTP) in growing Ossimi lamb rations at different levels (0, 5, 10 and 15%) on growth performance, digestion coefficients, nutritive values, nitrogen utilization, blood metabolites and economic evaluation.

MATERIALS AND METHODS

Our study was carried out at the Sheep and Goats Experimental Station Unit in El-Nubaria, Provence 120 km North Western Cairo city belongs to the Animal Production Department, National Research Centre, 33 El-Bohouth Street, Dokki, Giza, Egypt.

Animals and Feeds: Twenty male Ossimi lambs, aged 4-5 months old with an average live weight of 19.250±0.18 kg, were divided randomly into four equal groups (five animals each) to study the effect of incorporation dried tomato pomace (DTP) at different levels (0, 5, 10 and 15%) on growth performance, digestion, ruminal fermentation, blood metabolites and economic evaluation of growing Ossimi lambs.

The feeding trial lasted 98 days and lambs of four groups were offered the experimental total mixed rations (TMR) at 4% of live body weight.

Experimental animals were housed in individual semi-open pens and fed the experimental rations that cover the requirements of total digestible nutrients and protein for growing sheep according to the NRC [25].

Air dried tomato pomace was obtained from "Kaha" factory in Kaha city, Kaliobia, Egypt and incorporated in experimental total mixed rations (TMR) at levels of 0, 5, 10 and 15% for (TMR_1, TMR_2, TMR_3 and TMR_4), respectively.

Daily amounts of experimental TMR were adjusted every 2 weeks according to body weight changes. rations were offered twice daily in two equal portions at 800 and 1600 hours, while feed residues were daily collected, sun dried and weekly weighed. Fresh water was freely available at all times in plastic containers. Individual body weight change was weekly recorded before the morning meal.

At the end of the feeding experiment period, three representative animals from each group were selected randomly and used to determine nutrient digestion coefficients, nutritive value and nitrogen utilization of four experimental total mixed rations (TMR). The nutritive values expressed as total digestible nutrients (TDN) and digestible crude protein (DCP) of experimental TMR that calculated using classic method as described by Abou-Raya [26].

At the end of the digestibility trial rumen fluid samples were collected from 12 animals (Three animals from each group) 3 hours post feeding via a stomach tube and strained through four layers of cheesecloth to study the effect of dietary treatments on some ruminal fermentations parameters (pH, ammonia nitrogen (NH_3–N), total volatile fatty acids (TVFA's) concentrations and molar proportion of volatile fatty acids).

Blood samples were also collected at the end of digestibility trial from the left jugular vein in heparinized test tubes and centrifuged at 5.000 rpm for 15 minutes. Plasma was kept frozen at –20 °C for subsequent analysis of glucose, hemoglobin, total protein, albumin, triglyceride, cholesterol, AST, ALT, Alkaline phosphatase, urea, creatinine, while globulin was calculated by difference between total protein and albumin. Albumin: globulin ratio (A: G ratio) was also, calculated.

Analytical Methods: Representative samples of experimental TMR, feces and urine were analyzed according to AOAC [27] methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were also determined for ingredients and experimental TMR according to Goering and Van Soest [28] and Van Soest *et al.* [29]. NDF and ADF were expressed, inclusive of residual ash. Hemicellulose was calculated as the difference between NDF and ADF, while, cellulose was calculated as the difference between ADF and ADL.

Ruminal pH was immediately determined using digital pH meter. Ruminal total volatile fatty acids (TVFA's) concentrations were determined by steam distillation according to Kromann *et al.* [30]. Ruminal ammonia nitrogen (NH_3–N) concentrations were determined applying NH_3 diffusion technique using Kjeldahle distillation method according to AOAC [27]. Molar proportions of volatile fatty acids were determined according to Erwin *et al.* [31].

Blood plasma of total protein was determined as described by Witt and Trendelenburg [32], albumin [33], triglycerides [34], cholesterol [35], total lipids [36], alanine aminotransferase (ALT) or (GPT) and aspartate aminotransferase (AST) or (GOT) were determined according to Reitman and Frankel [37], Alkaline phosphatase [38], urea [39], creatinine [40], glucose [41, 42] and hemoglobin [43, 44].

Calculations: Gross energy (kcal/ kg DM), (GE) was calculated according to Blaxter [45], where, each g of CP= 5.65 kcal; each g of EE= 9.4 kcal and each g of CF & NFE = 4.15 kcal.

Non fibrous carbohydrate (NFC) was calculated using the equation of Calsamiglia *et al.* [46] and NRC [47] as follows:

$$NFC\% = 100 – (\%NDF + \%CP + \% EE + \%Ash).$$

Economic Evaluation: Economic evaluation was done using the relationship between feed costs (Local market price of ingredients) and sheep live body weight gain. Economic evaluation was calculated as follows:

The cost for 1-kg gain = total cost (Egyptian pound (LE)) of feed intake/ total gain (Kilogram).

Statistical Analysis: Collected data of feed intake, live body weight, average daily gain, feed conversion, nutrient digestibility coefficients, nutritive value, nitrogen balance, ruminal fermentation parameters and blood parameters were subjected to statistical analysis as one way analysis of variance using the general linear model procedure of SPSS [48]. Duncan's Multiple Range Test [49] was used to separate means when the dietary treatment effect was significant.

RESULTS AND DISCUSSION

Chemical Analysis of Feed Ingredients: Chemical analysis of feed ingredients is presented in Table 1. The chemical analysis on DM basis of dried tomato pomace (DTP) contained 21.11% CP; 29.33% CF; 9.21% EE; 37.07% NFE; 3.28% ash; 4814 kcal/ kg DM (GE); 1.16%

Table 1: Chemical analysis of feed ingredients

	Ingredients				
Item	DTP	BH	YC	WB	SBM
Moisture	8.99	8.76	9.06	9.71	7.15
Chemical analysis on DM basis					
Organic matter (OM)	96.72	88.01	98.60	87.79	94.38
Crude protein (CP)	21.11	14.96	9.27	13.72	44.00
Crude fiber (CF)	29.33	25.90	2.27	10.25	4.930
Ether extract (EE)	9.21	2.81	4.01	2.81	0.60
Nitrogen-free extract (NFE)	37.07	44.34	83.05	61.01	44.85
Ash	3.28	11.99	1.40	12.21	5.62
Gross energy (kcal/ kg DM)1	4814	4024	4441	3997	4608
Non fibrous carbohydrates (NFC)2	1.16	7.68	52.69	27.05	14.60
Cell wall constituents					
Neutral detergent fiber (NDF)	65.24	62.56	32.63	44.21	35.18
,Acid detergent fiber (ADF)	40.93	44.24	22.45	32.16	26.72
Acid detergent lignin (ADL)	22.12	7.03	2.13	12.05	8.46
Hemicellulose[3]	24.31	18.32	10.18	28.11	19.88
Cellulose[4]	18.81	37.21	20.32	4.05	6.84

DTP: Dried tomato pomace. BH: Berseem hay. YC: yellow corn WB: Wheat bran. SBM: Soybean meal.

[1]Gross energy (Kcal/kg DM) was calculated according to Blaxter [45]. Each g CP = 5.65 kcal, g EE = 9.40 kcal and g (CF & NFE) = 4.15 kcal.

[2]Non fibrous carbohydrates (NFC), calculated according to Calsamiglia *et al.* [46] and NRC [47] using the following equation: NFC = 100 - {CP + EE + Ash + NDF}.

[3]Hemicellulose = NDF - ADF. [4] Cellulose = ADF - ADL.

non fibrous carbohydrates (NFC); 65.24% NDF; 40.93% ADF; 22.12% ADL; 24.31% hemicellulose and 18.81% cellulose.

These results in the same trend with those obtained by Mirzaei-Aghsaghali and Maheri-Sis [4], Denek and Can [7], Weiss *et al*. [17], Mirzaei-Aghsaghali and Maheri-Sis [20], Aherne and Kennelly [50], Alibes *et al*. [51] and Chumpawadee *et al*. [52] who noted that CP ranged from 19.50 to 23.60%; EE% ranged from 8.90 to 12.30%; CF ranged from 24.10 to 31.30%; NDF ranged from 50.04 to 68.60%; ADF ranged from 36.62 to 43.50% and ADL ranged from 21.70 to 25.80%.

The percentage of crude protein in dried tomato pomace (DTP) in the range obtained by many authors, who recorded that CP ranged between 19% and 30% [53-55] depending on tomato types [56] or methods of tomato processing [57].

The dried tomato pomace seemed to be bulky, because it's high content of crude fiber which was (29.33%) in this study. The percentage of crude fiber in tomato pomace ranged from 17.8% to 39.8% [54, 55, 58] and acid detergent fiber ADF ranged from 40% to 50%, while neutral detergent fiber ranged from 55% to 73% [25, 54, 55]. Lignin content of dried tomato pomace varied between 11% and 34% with an average of 22.5% [25, 54, 55].

Chemical analysis reported by previous authors [19, 59-61] showed that tomato pomace has 91-92% DM, 17-22% CP, 10-29% CF, 7-12% EE, 5-11% ash and 26-31% NFE. According to Aghajanzadeh-Golshani *et al*. [21] who noted that the dried tomato pomace contains 22.6 to 24.1% protein, 14.5 to 15.7% fat and 20.8 to 30.5% fiber.

There are some differences and variations between chemical compositions in current study comparing with some other researches [7, 21, 52, 62, 63]. These variations in chemical composition of by-products can be due to different original materials, growing conditions (seasonal variations, climatic conditions and soil characteristics), extent of foreign materials, impurities and different processing and measuring methods [5]. Also, 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 [64-66]. It is predictable that, different chemical composition can be leads to different nutritive value, because chemical composition is important index of nutritive value of feeds [21, 67].

The non fibrous carbohydrates (NFC) content of DTP in our study (1.16%) was lower than that reported by Mirzaei-Aghsaghali *et al.* [13] and Aghajanzadeh-Golshani *et al.* [21] who recorded that DTP contained 3.7% and 6.63% NFC, respectively.

In general, the chemical analysis of any feedstuff still the preliminary indicator on the possibility of using such material in feeding livestock, but the final evaluation can't

Table 2: Composition (kg/ ton) and chemical analysis of experimental total mixed rations (TMR) containing different levels of dried tomato pomace

	Experimental total mixed rations (TMR)				
Ingredients	TMR_1 (0% DTP)	TMR_2 (5% DTP)	TMR_3 (10% DTP)	TMR_4 (15% DTP)	Price L.E/ kg
1- Composition of experimental rations (kg/ ton)					
Dried tomato pomace (DTP)	----	50	100	150	0.75
Berseem hay	350	300	250	200	1.5
Yellow corn	350	350	350	350	2.3
Wheat bran	125	135	145	155	2.1
Soybean meal	150	140	130	120	5.3
Lime stone	15	15	15	15	0.15
Sodium chloride	5	5	5	5	0.25
Vit. & Mineral mixture[1]	5	5	5	5	10
Price, L.E/ Ton	2441	2372	2302	2233	
2- Chemical analysis of experimental total mixed rations (TMR)					
Moisture	8.58	8.62	8.71	9.02	
Chemical analysis on DM basis					
Organic matter (OM)	91.02	91.39	91.70	92.08	
Crude protein (CP)	17.00	17.00	17.07	17.08	
Crude fiber (CF)	11.88	12.10	12.38	12.60	
Ether extract (EE)	1.91	2.25	2.61	2.84	
Nitrogen-free extract (NFE)	60.23	60.04	59.64	59.56	
Ash	8.98	8.61	8.30	7.92	
Gross energy (kcal/ kg DM)[2]	4133	4166	4199	4227	
Non fibrous carbohydrates (NFC)[3]	27.98	27.8	27.24	27.15	
Cell wall constituents					
Neutral detergent fiber (NDF)	44.13	44.34	44.78	45.01	
,Acid detergent fiber (ADF)	31.37	31.26	31.3	31.21	
Acid detergent lignin (ADL)	5.99	6.78	7.63	8.43	
Hemicellulose4	12.76	13.08	13.48	13.8	
Cellulose5	25.38	24.48	23.67	22.78	

[1] Each 3 kg vitamins and mineral mixture contains: vitamin A 12,000,000 IU, vitamin D3 2,200,000 IU, vitamin E 10,000 mg, vitamin K32,000 mg, vitamin B11,000 mg, vitamin B25,000 mg, vitamin B61,500 mg, vitamin B1210 mg, pantothenic acid 10 mg, niacin 30,000 mg, folic acid 1,000 mg, biotin 50 mg, choline 300,000 mg, manganese 6,0000 mg, zinc 50,000 mg, copper 10,000 mg, iron 30,000 mg, iodine 100 mg, selenium 100 mg, cobalt 100 mg,

[2]Gross energy (kcal/kg DM) was calculated according to Blaxter [45]. Each g CP = 5.65 kcal, g EE = 9.40 kcal and g (CF & NFE) = 4.15 kcal.

[3]Non fibrous carbohydrates (NFC), calculated according to Calsamiglia *et al.* [46] and NRC [47] using the following equation: NFC = 100 - {CP + EE + Ash + NDF}.

[4]Hemicellulose = NDF - ADF

[5] Cellulose = ADF - ADL.

obtained without more information throughout digestibility trials and determining the feeding values of this feedstuff.

Composition and Chemical Analysis of Experimental Total Mixed Rations (TMR): Data of Table 2 showed that different experimental total mixed rations (TMR) were formulated to obtain isonitrogenous (17.04% CP in average) and isocalories (4181 kcal gross energy/ kg DM in average) rations and to cover the requirements of sheep according to NRC [25]. The contents of (NDF and ADF) of different experimental TMR were in the same range approximately. While, with increasing the levels of DTP in TMR caused increasing in the contents of ADL (5.99, 6.78, 7.63 and 8.43, respectively) and hemicellulose (12.76, 13.08, 13.48 and 13.8, respectively), however, it decreased cellulose content (25.38, 24.48, 23.67 and 22.78, respectively). These variations in chemical composition of rations used in our study related to differ in chemical composition of ingredients that used in formulation of the rations.

Nutrient Digestibility Coefficients, Nutritive Values, Dietary Nitrogen Utilization and Ruminal Fluid Parameters: Mean values of nutrient digestibility and nutritive values of rations are shown in Table 3. The results showed that all nutrients digestibility and nutritive values tended to increase when DTP was incorporated in the sheep rations at different levels (5%, 10% and 15%).

Table 3: Nutrient digestibility coefficients, nutritive values, nitrogen utilization and ruminal fluid parameters of sheep fed experimental total mixed rations (TMR) containing different levels of dried tomato pomace

	Experimental total mixed rations (TMR)				
Item	TMR1 (0% DTP)	TMR2 (5% DTP)	TMR3 (10% DTP)	TMR4 (15% DTP)	SEM
Digestibility coefficients					
Dry matter (DM)	64.13	66.07	67.82	69.25	0.95
Organic matter (OM)	66.25[b]	68.31[ab]	69.77[a]	71.12[a]	0.68
Crude protein (CP)	65.36	66.28	67.37	68.17	0.57
Crude fiber (CF)	56.33[b]	57.57[ab]	58.33[a]	59.21[a]	0.39
Ether extract (EE)	78.96[c]	80.32[c]	83.62[b]	86.55[a]	0.93
Nitrogen-free extract (NFE)	60.48[d]	63.22[c]	66.58[b]	69.83[a]	1.09
Nutritive values (%)					
Total digestible nutrient (TDN)	57.62[d]	60.26[c]	63.34[b]	66.22[a]	0.99
Digestible crude protein (DCP)	11.11	11.27	11.5	11.64	0.1
Nitrogen utilization					
Nitrogen intake (NI), g	39.21	37.82	38.12	36.18	0.52
Fecal nitrogen (FN), g	14.15[a]	12.61[ab]	12.86[ab]	10.73[b]	0.49
Digested nitrogen (DN), g	25.06	25.21	25.26	25.45	0.26
Urinary nitrogen (UN), g	18.03	16.88	16.81	16.89	0.23
Total nitrogen excretion, g	32.18[a]	29.49[ab]	29.67[ab]	27.62[b]	0.66
Nitrogen balance (NB),g	7.03	8.33	8.45	8.56	0.28
N-balance of NI, %	17.93[b]	22.03[ab]	22.17[ab]	23.66[a]	0.87
N-balance of DN, %	28.05[b]	33.04[a]	33.45[a]	33.63[a]	0.92
ruminal fluid parameters					
Ruminal pH	6.55[a]	6.31[b]	6.22[b]	6.01[c]	0.06
Ammonia nitrogen mg/ dl	18.32[a]	17.37[ab]	17.06[ab]	16.82[b]	0.25
Total volatile fatty acids meq/ dl	6.82[c]	8.37[b]	8.76[ab]	9.12[a]	0.28
Molar proportion of VFA's and acetate: propionate ratio					
Acetate	41.50[c]	43.40[bc]	45.18[ab]	47.11[a]	0.68
Propionate	19.26[c]	21.64[b]	23.13[b]	25.38[a]	0.7
Butyrate	16.36[d]	17.21[c]	18.43[b]	19.63[a]	0.38
Iso-butyrate	2.16[c]	2.40[b]	2.56[a]	2.66[a]	0.06
Valerate	1.43[d]	1.92[c]	2.16[b]	2.44[a]	0.11
Iso-valerate	0.26[c]	0.39[b]	0.55[a]	0.62[a]	0.04
Acetate: Propionate ratio	2.15[a]	2.01[b]	1.95[bc]	1.86[c]	0.04

a, b, c and d: Means in the same row having different superscripts differ significantly ($P<0.05$).
SEM: Standard error of means.

Dietary treatments had significant effect ($P<0.05$) on all nutrient digestibilities coefficient except for DM and CP digestibilities which not affected. While TDN value was significantly ($P<0.05$) affected, however, DCP was not affected by introduce DTP in the sheep rations. Rations contained 10 or 15% DTP significantly increased ($P<0.05$) OM, CF, EE and NFE digestibilities and TDN value. However, it not significantly ($P>0.05$) increased DM and CP digestibilities and DCP value in comparison with control one. Chemical component of diet has a major effect on nutrient digestibility. Aregheore [68] reported that nutritive value of the feedstuffs can be determined by their chemical compositions. Our results were in agreement with those found by Ibrahem and Alwash [69], Gasa *et al*. [70], Ojeda and Torrealba [71] and Abdollahzadeh *et al*. [72] who reported that feeding of tomato pomace improved the nutritional value of the diet, due to more digestible levels of protein and ether extract.

In contrast, Al-Kalabani and Herb [55] and Jayal and Johri [73] found that, replacing alfalfa hay with tomato pomace at 0, 25, 50, 75 and 100% in Awassi ewes rations reduced the digestibility of all feed constituents, except ether extract. The reduced digestibility value in rations containing tomato pomace may be due to the fact that, the pomace contains a higher percentage of lignin (19.9%) compared to (4.9%) in alfalfa hay [57].

Generally, presence of more NFE, appreciable quantities of soluble carbohydrates and pectin [19, 47] in tomato pomace may lead to higher digestibility of DM and OM in rations containing tomato pomace than control one. On the other hand, Ben Salem and Znaidi [74] noted that partial replacement of concentrate with tomato pulp-based feed blooks (FB) decreased DM and OM digestibility in Barbarine lambs.

In addition, it is generally accepted that increased concentrate in ruminant diets leads to greater DM and OM digestibility [75]. The CP digestibility observed in goats fed diets containing wastes fruits-based FB was greater than reported in Awassi sheep fed diets containing 34% of tomato pomace [76].

Also, Romero-Huelva and Molina-Alcaide [8] found that replacing 50% of cereals based concentrate with feed blocks including tomato wastes in Granadina goat rations significantly ($P<0.05$) decreased of DM, OM and EE digestibilities, however CP and ADF digestibilities were not significantly decreased, meanwhile, NDF digestibility was not significantly increased.

The potential value of by-products in animal feeding depends on their nutritive characteristics, as, the fibrousness, the protein content, organic-matter digestibility and energy value. Palatability is also an important feature. The utilization may not be detrimental for the animal. Apart from the presence of anti-nutritive factors, there are beneficial properties in some by products [4, 7, 20].

Dietary Nitrogen Utilization: The results of nitrogen balance trial given in Table 3 pointed out to that, sheep fed DTP containing TMR had lower fecal and urine nitrogen losses than those fed control ration (0% DTP). Nitrogen balance for all experimental groups was positive. Data cleared that with increasing the levels of incorporation DTP in TMR the nitrogen balance values were insignificantly ($P>0.05$) increased. The corresponding values were 7.03; 8.33; 8.45 and 8.56 (g/h/day) for TMR_1, TMR_2, TMR_3 and TMR_4, respectively. The values were much higher for N-balance (% of N-intake and digestible N), where, TMR containing DTP at 5, 10 and 15% recorded 22.03, 22.17 and 23.66% VS. 17.93% for control (0% DTP) and 33.04, 33.45 and 33.63% VS. 28.05% for control (0% DTP) for N-balance (% of N-intake and digestible N), respectively. These results were in agreement with those obtained by Dawson and Hopkins [77], Fondevila *et al*. [78] and Paryad and Rashidi [79]. The more retention of nitrogen in sheep fed dried tomato pomace can explain by reduced ammonia concentrations in the rumen that appeared to result from increased incorporation of ammonia into microbial protein that probably were the direct result of stimulated microbial activity.

This increased flow of bacterial protein helps to explain some of the very positive responses observed with tomato pomace supplemented with yeast (*Saccharomyces cerevisiae*) in sheep [77, 79]. Also, Fondevila *et al.* [78] noted that nitrogen retention (g/kg $LBW^{0.75}$) significantly increased when tomato pomace used as a protein supplement for feeding growing lambs.

Ruminal Fluid Parameters: Ruminal fermentation parameters for Ossimi lambs fed experimental TMR are presented in Table 3 cleared that inclusion of DTP in sheep ration significantly ($P<0.05$) decreased ruminal pH value and ammonia nitrogen concentration, while, it significantly ($P<0.05$) increased total volatile fatty acids concentration compared to control ration (0% DTP).

These results were in agreement with those found by Romero-Huelva and Molina-Alcaide [8] who found that when replaced 50% of cereals based concentrate with feed blocks including tomato wastes in Granadina goat rations resulted in increasing rumen volatile fatty acids (VFA's) concentration and decreased ruminal ammonia nitrogen (NH_3-N) concentration in comparison with the control one.

The lack of correlation between pH values and VFA's concentration agrees with observations of other authors [8, 80, 81]. The level of concentrate [82] and the buffer properties attributed to leguminous forages, such as alfalfa [83], could contribute to the lack of variations in rumen pH with dietary treatments in the present work. Total VFA concentration in the rumen was within the range of values previously reported for Granadina goats fed diets based on alfalfa hay [8, 75]. The results of ruminal fermentations clear that increasing TVFA's might be related to the more utilization of dietary energy and positive fermentation in the rumen.

The reduction of ammonia nitrogen in the rumen liquor appears to be the result of increased incorporation of ammonia nitrogen into microbial protein and it was considered as a direct result to stimulated microbial activity. While, increasing TVFA's might be related to the more utilization of dietary energy and positive fermentation in the rumen. Addition of more fermentable carbohydrate to ruminant rations causes a decrease in rumen ammonia [84] probably due to a greater uptake of ammonia by rumen microorganisms in support of enhanced microbial growth. The rate of TVFA's production may in this situation exceed the rate of TVFA's absorption through the rumen epithelium and TVFA's concentration in the rumen juice is increased [85].

It should be noted that, TVFA's concentration in the rumen is governed by several factors such as dry matter digestibility, rate of absorption, rumen pH, transportation of the digesta from the rumen to the other parts of the digestive tract and the microbial population in the rumen and their activities [86]. Increasing of ruminal TVFA's concentration is an indicator for better utilization of dietary carbohydrate was observed by Fadel *et al*. [87]. Also, Briggs *et al.* [88] noticed that an increasing in ruminal TVFA's concentration caused a reduction in ruminal pH value.

Ruminal pH is one of the most important factors affecting the fermentation and influences its functions. It varies in a regular manner depending on the nature of the diet and on the time it is measured after feeding and reflects changes of organic acids quantities in the ingesta. The level of NH_3-N and TVFA's as end products of fermentation and breakdown of dietary protein, have been used as parameters of ruminal activity by Abou-Akkada and Osman [89].

Also, results of Table 5 showed an increasing in molar proportion of volatile fatty acids (VFA's) with incorporation DTP in TMR of Ossimi sheep. The heist values of molar proportion of volatile fatty acids were realized by sheep fed 15% DTP containing ration (TMR_4). These results were in agreement with those obtained by Romero-Huelva and Molina-Alcaide [8] who reported that when replaced 50% of cereals based concentrate with feed blocks including tomato wastes in Granadina goat rations resulted in increasing in molar proportions of (Acetate, propionate, isobutyrate and isovalerate, while, it decreased molar proportions of (butyrate and valerate) in comparison with the control one.

On the other hand, Soto *et al.* [90] noted that increasing amounts of tomato waste (50, 100, 150, 200 or 250 g of barley grain/ kg) increased final pH and gas production, without changes in final ammonia-nitrogen (NH_3-N) concentrations, substrate degradability and total volatile fatty acid (VFA's) production, indicating that there were no detrimental effects of tomato waste on rumen fermentation. Also, molar proportions of propionate, isobutyrate and isovalerate were lower and acetate: propionate ratio was greater compared with control. Also, they indicated that tomato waste could replace dietary barley grain up to 250 g/kg of substrate DM without noticeable effects on rumen fermentation.

Growth Performance: Growth performance of sheep fed TMR contained DTP at (0, 5, 10 and 15%) levels is shown in Table 4. The results showed that inclusion DTP in sheep ration had significant effect (P<0.05) on final weight (FW, kg); total body weight gain (TBWG, kg) and average daily gain (ADG, g/day). The present data recorded that with increasing the level of DTP the significantly increased (P<0.05) of FW, TBWG and ADG were occurred. The corresponding values were 37.40, 39.10, 40.42 and 41.55 kg for FW; 18.15, 19.70, 21.27 and 22.35 kg for TBWG and 185, 201, 217 and 228 g for ADG for TMR_1, TMR_2, TMR_3 and TMR_4, respectively. These results in agreement with those reported by Ibrahem and Alwash [69], Fondevila *et al*. [78] and Bahrami *et al*. [91].

In fattening Awassi lambs fed an alfalfa hay-based diet, dried tomato pomace included at up to 75% daily weight gain was highest (132 g/d) at a 50% inclusion rate, which was therefore the maximum recommended rate [69]. On the other hand, Fondevila et al. [78] concluded that supplementation of barley-based diets with tomato pomace at a rate of 200 g/kg ration; it had similar growth performances to soybean protein in young lambs up to 28 kg BW. While, Bahrami et al. [91] stated that both average daily gain and final body weight of male Lori Bakhtiari lambs fed diets containing 5 and 10% dried grape pomace were significantly improved compared to the other treatments.

Generally data of Table 4 cleared that inclusion of DTP in TMR of Ossimi sheep caused a decreasing in feed intakes of DM, TDN and DCP that expressed as g/h/d; $g/kgW^{0.75}$ and Kg/ 100 kg LBW. With increasing the levels of DTP in TMR the different parameters of feed intake recorded were decreased.

Mean dry matter intake (DMI) was 1119, 1082, 1042 and 1002 g/h/d for sheep fed rations containing 0, 5, 10 and 15% DTP, respectively. These results in agreement with those obtained by Al-Kalabani and Harb [55] and Ibrahem and Alwash [69] who noted that there was a decrease in DMI associated with increasing level of dietary tomato pomace. Also, Ralo and Antunes [92] noticed in their fattening trial that DMI by calves decreased when tomato pomace in the ration was increased. On the other hand Jayal and Johri [73] reported that, when sheep were given wheat straw in addition 300g tomato pomace, DMI was 16% less with diets containing tomato pomace. This reduction in DMI could be explained partly due to the low palatability of the tomato pomace [55, 69]. Another reason to explain the reduction in DMI of tomato pomace may be due to decrease the passage of digesta thus caused a reduction in DMI [93].

In contrast Abdollahzadeh *et al.* [72] observed that, DMI was significantly increased (P<0.05) when lactating cows fed diets containing ensiled mixed tomato and apple pomace at level of 15 or 30% compared to control.

Table 4: Growth performance of the experimental groups fed experimental total mixed rations (TMR) containing different levels of dried tomato pomace

	Experimental total mixed rations (TMR)				
Item	TMR_1 (0% DTP)	TMR_2 (5% DTP)	TMR_3 (10% DTP)	TMR_4 (15% DTP)	SEM
Live body weight (LBW)					
No. of animals	5	5	5	5	---
Initial weight (kg)	19.25	19.4	19.15	19.2	0.18
Final weight (FW, kg)	37.400^{d}	39.100^{c}	40.420^{b}	41.550^{a}	0.39
Total body weight gain (TBWG, kg)	18.150^{c}	19.700^{b}	21.270^{a}	22.350^{a}	0.4
Experimental duration, days	98	98	98	98	---
Average daily gain (ADG, g/day)	185^{c}	201^{b}	217^{a}	228^{a}	4.13
Mean body weight (kg)[1]	28.325^{c}	29.250^{bc}	29.785^{ab}	30.375^{a}	0.23
Metabolic body weight size (kg$W^{0.75}$)	12.28^{c}	12.58^{bc}	12.75^{ab}	12.94^{a}	0.07
Feed intake as:					
1- Dry matter (DM)					
g/h/d	1119^{a}	1082^{b}	1042^{c}	1002^{d}	11.40
g/kg$W^{0.75}$	91.12^{a}	86.01^{b}	81.73^{c}	77.43^{d}	1.17
Kg/ 100 kg LBW	3.951^{a}	3.699^{b}	3.498^{c}	3.299^{d}	0.06
2- *Total digestible nutrient (TDN)*					
g/h/d	644.8	652	660	663.5	3.67
g/kg$W^{0.75}$	52.51^{a}	51.83^{b}	51.76^{b}	51.28^{c}	0.12
Kg/ 100 kg LBW	2.276^{a}	2.229^{b}	2.216^{c}	2.184^{d}	0.01
3- *Digestible crude protein (DCP)*					
g/h/d	124.3^{a}	121.9^{ab}	119.8^{bc}	116.6^{c}	0.89
g/kg$W^{0.75}$	10.12^{a}	9.69^{b}	9.40^{c}	9.01^{d}	0.09
Kg/ 100 kg LBW	0.439^{a}	0.417^{b}	0.402^{c}	0.384^{d}	0.05
Feed conversion (kg intake /kg gain) of					
Dry matter (DM)	6.049^{d}	5.383^{c}	4.802^{b}	4.395^{a}	0.15
Total digestible nutrient (TDN)	3.485^{b}	3.244^{ab}	3.041^{a}	2.910^{a}	0.06
Digestible crude protein (DCP)	0.672^{d}	0.606^{c}	0.552^{b}	0.511^{a}	0.01

a, b, c and d: Means in the same row having different superscripts differ significantly ($P<0.05$).

SEM: Standard error of means.

[1]Mean body weight = (Initial weight + Final weight/2)

Table 5: Blood plasma constituents of the experimental groups

	Experimental total mixed rations (TMR)				
Item	TMR_1 (0% DTP)	TMR_2 (5% DTP)	TMR_3 (10% DTP)	TMR_4 (15% DTP)	SEM
Glucose (mg/dl)	66.21^{b}	68.36^{ab}	70.12^{a}	71.32^{a}	0.71
Hemoglobin (g/dl)	11.21^{b}	12.31^{a}	12.71^{a}	13.05^{a}	0.24
Total protein (g/ dl)	6.91^{c}	7.13^{c}	8.45^{b}	8.86^{a}	0.26
Albumin (g/ dl)	4.45^{b}	4.56^{ab}	4.61^{ab}	4.72^{a}	0.04
Globulin (g/ dl)	2.46^{b}	2.57^{b}	3.84^{a}	4.14^{a}	0.23
Albumin: globulin ratio	1.81^{a}	1.77^{a}	1.20^{b}	1.14^{b}	0.1
Cholesterol (mg/dl)	88.11^{c}	92.38^{b}	94.26^{b}	98.22^{a}	1.18
Triglycerides (mg/dl)	9.76^{c}	10.83^{bc}	11.96^{ab}	12.85^{a}	0.41
Total lipids (mg/dl)	390	382	375	370	3.71
GPT (U/I)	38.30^{c}	40.56^{b}	42.78^{a}	43.92^{a}	0.67
GOT (U/I)	21.26^{b}	22.46^{ab}	23.18^{a}	23.52^{a}	0.31
Urea (mg/dl)	23.32^{c}	24.15^{bc}	24.86^{ab}	25.12^{a}	0.24
Creatinin	1.81^{b}	1.93^{ab}	1.98^{ab}	2.02^{a}	0.04
Alkaline phosphatase (U/I)	69.07	69.52	69.93	70.16	0.21

a, b and c: Means in the same row having different superscripts differ significantly ($P<0.05$).

SEM: Standard error of means.

On the other hand, Romero-Huelva and Molina-Alcaide [8] recorded that replacing 50% of cereals based concentrate with feed blocks including tomato wastes in Granadina goat rations had no significant (P>0.05) effect on DMI. Also, Weiss *et al.* [17], Fondevila *et al*. [78] and Belibasakis and Ambatzidiz [94] found that DM intake was not affected when tomato pomace was fed to lactating dairy cows.

Feed conversion (kg intake /kg gain) of DM, TDN and DCP were significantly (P<0.05) improved when DTP incorporated in sheep rations at different levels used in this study. With increasing level of DTP the feed conversion was significantly (P<0.05) improved. These results were in agreement with those noted by Abdollahzadeh *et al.* [72] who observed that feed efficiency was improved with increasing level of ensiled mixed tomato and apple pomace from 0 to 15 or 30% in lactating cow's rations. In contrast, Sawal *et al.* [95] noted that feed conversion efficiency was decreased with increasing tomato pomace levels (0, 10 and 20%) in rabbit rations.

Blood Plasma Constituents of the Experimental Groups: Blood plasma constituents of the experimental groups are illustrated in Table 5. Data obtained showed that except for plasma total lipids and alkaline phoshatase, dietary treatment had significant effect (P<0.05) on the other blood parameters measured.

With increasing the level of DTP in TMR all blood parameters were increased except for plasma total lipid was insignificantly (P>0.05) decreased. The present results are in good accordance with those described by Abdullahzadeh [96] with growing Markhoz goats and [97, 98] with dairy cows that fed on dried and wet tomato pomace containing rations, respectively. They noted that feeding DTP tended to be increased total protein and urea concentrations accompanied by increase of dietary levels of DTP, while there were no significant differences between diets. Also, Abdullahzadeh [96] stated that there was no significant difference in the glucose, total protein, urea and cholesterol and triglyceride concentrations of blood metabolites for Markhoz goats fed different levels of DTP (0, 10, 20 and 30% DTP) for 94 days. On the other hand, Abdollahzadeh *et al.* [99] reported that increasing the presence of soluble carbohydrates and digestible nutrients in ensiled mixed tomato (*Solanum lycopersicum L.*) and apple pomace diets increase concentrations of blood glucose. Also, El Shaer *et al.* [6]; Rakha [100]; Abd El Gawad *et al.* [101] noted that the biochemical constituents (Glucose and urea-nitrogen) and enzymes (GOT and GPT) of blood serum were within the normal ranges.

While, Abdullahzadeh [96] noted that feeding of growing Markhoz goat on rations containing (0, 10, 20 and 30% of dried tomato pomace (DTP) tended to be increased total protein and urea concentrations accompanied by increase of dietary levels of DTP, while there were no significant differences between diets. Also, the present results are in good accordance with those described by Belibasakis [97] and Belibasakis *et al*. [98] when they fed dried and wet tomato pomace to dairy cow, respectively. Addition for that Abdollahzadeh1 and Abdulkarimi [102] noted that feeding multiparous Holstein dairy cows on mixed of tomato pomace (TP) and apple pomace (AP) silage (EMTAP) at (0, 15 and 30%) resulted in higher glucose, cholesterol, triglyceride and total protein (P<0.01) concentrations. In contrast, urea, albumin, calcium, phosphorous, sodium and potassium were not affected significantly (P>0.05) by treatments. In contrast with our results, Belibasakis and Ambatzidiz [94] reported that, replacing maize silage and soybean meal with alone TP at 13% DM of dairy cows diet did not affect significantly same blood metabolites. While, in present study we saw significant differences.

On the other hand with rabbits Gombes [103] reported that addition of TP to the ration may induce some effects on kidney function in rabbits**.** Also**,** Ahmed *et al.* [16] observed that protein level in blood serum of rabbits fed 10, 20 and 30% TP were significantly higher (P<0.05) than that in the control group (0% TP) by 3.51, 6.69 and 5.37%, respectively. On the other hand, serum albumin increased significantly (P<0.05) in 10 and 20% TP fed groups. While, globulin level increased by the same way with increasing TP level to 20 and 30% in the ration. However, A/G ratio was not affected. Serum total lipids values were also, significantly (P<0.05) higher in 10 and 20% TP fed groups than in 0% and 30% TP groups. Also, they revealed that feeding the rations containing 10 and 20% TP caused a significant increases (P<0.05) in serum urea level as compared to the other groups.

Economic Evaluation of the Experimental Rations: Economic efficiency was represented by daily profit over feed cost. The costs were based on average values of year 2014 for feeds and live body weight. Feeding costs and profit above feeding costs are shown in Table 6. The results showed that with increasing level of tomato pomace (DTP) in total mixed ration (TMR) of sheep, daily

Table 6: Economic evaluation for the experimental total mixed rations (TMR)

	Experimental total mixed rations (TMR)			
Item	TMR_1 (0% DTP)	TMR_2 (5% DTP)	TMR_3 (10% DTP)	TMR_4 (15% DTP)
Daily feed intake (fresh, kg)	1.224	1.184	1.141	1.101
Price of 1- kg of TMR	2.441	2.372	2.302	2.233
Daily feeding cost (LE) [a]	2.99	2.81	2.63	2.46
Average daily gain (kg)	0.185	0.201	0.217	0.228
Value of daily gain (LE) [b]	6.66	7.24	7.81	8.21
Daily profit above feeding cost (LE)	3.67	4.43	5.18	5.75
Relative economical efficiency [c]	100	121	141	157
Feed cost (LE/ kg gain)	16.16	13.98	12.12	10.79

LE = Egyptian pound equals 0.14 USS approximately.

[a] Based on prices of year 2014.

[b] Value of 1- kg live body weight equals 36 LE (2014)

[c] Assuming that the relative economic efficiency of control diet equals 100

feeding coast was decreased. The corresponding values were 6.02, 12.04 and 17.73% for 5, 10 and 15% DTP, respectively in comparison with the control ration (0% DTP). Meanwhile, daily profit above feeding cost and relative economical efficiency were improved by 21%, 41% and 57% when sheep fed TMR contained 5, 10 and 15% DTP compared to the control ration (0% DTP). On the other hand, feed cost LE/ kg gain was improved by 13.49%, 25% and 33.23% for sheep fed TMR contained 5, 10 and 15% DTP, respectively compared to control ration.

These results were in agreement with those obtained by Denek and Can [7] who noted that, the use of agro-industrial by-products especially tomato waste in Awassi sheep rations has been successfully adopted as a strategy to reduce feeding costs and also to cope with the need to recycle waste material. Also, Romero-Huelva *et al.* [104] found that the replacement of 35% of concentrate with feed blocks containing waste fruits of tomato, cucumber, or barley grain in diets for lactating goats reducing animal feeding cost. Finaly, El Shaer *et al.* [6] reported that, organic waste feed mixture used as a non-conventional feed could be efficiently used as nutritious, palatable and low-cost feed resources for small ruminants in Egypt.

CONCLUSION

It can be concluded that dried tomato pomace is a good alternative source of protein and fiber for ruminant nutrition. It can be used as a substitute for good quality roughages (Berseem hay), preferably in dried form in diet of Ossimi lambs. Economic benefits can be realized by using DTP in the formulation of a low-cost diet which improves feed conversion ratio and growth performance. It is therefore appropriate to use this by-product to in ruminant rations. Dried tomato waste (DTW) may be used satisfactorily as a nutrient supplement in formulation of sheep rations up to 15% without any adverse effect on performance, digestibility nutritive value and nitrogen balance with normal fermentation. Also, it realized better economic evaluation through out improving the net revenue and decreasing daily feeding cost. Finally based on these results obtained it could be concluded that dried tomato pomace could be incorporated up to 15% in sheep rations formulation without any adverse effect on their growth performance. In addition to, I think that further research is needed to evaluate the effect of high levels of dried tomato pomace on the digestion, ruminal fermentation and growth performance of sheep.

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