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Effect of olive tree leaves and twigs on intake, digestibility, growth performance and blood variables of Shami goats

Ashraf Alkhtib[1] | Muhannad Muna[2] | Emily Burton[1] | Jane Wamatu[3] | Mohammad Darag[2] | Eyad Alkhaled[2] | Ziad Al-asa'ad[2] | Hana Almoufachi[2] | Ruba Zaeowd[2]

[1]School of Animal, Rural and Environmental Sciences, Brackenhurst Campus, Nottingham Trent University, Southwell, Nottinghamshire, UK

[2]General Commission of Scientific Agricultural Research (GCSAR), Damascus, Syria

[3]International Centre for Agricultural Research in Dry Areas, Addis Ababa, Ethiopia

Correspondence
Muhannad Muna, General Commission of Scientific Agricultural Research (GCSAR), PO Box 12573, Damascus, Syria.
Email: muhannadmuna@yahoo.com

Abstract

The effect of replacing wheat straw and a portion of commercial concentrate with olive twigs and leaves treated with urea and molasses on nutrient digestibility, growth performance and blood variables was determined. Forty-two Shami goat kids (20 ± 2.47 kg live weight and 133 ± 5.44 days of age) were randomly allotted to three dietary treatment groups, control (75% commercial concentrate and 25% wheat straw), OTU (62.3% commercial concentrate + 37.7% olive twigs and leaves treated with 4% urea for 14 days), OTUM (51.5% concentrate mixture + 48.5% olive twigs and leaves treated with 4% urea for 14 days then sprayed by 10% molasses). Cost (SYP/t) of control, OUT and OTUM was 12,600, 10,066 and 10,106 respectively. The study consisted of a growth trial of 100 days and a digestibility trial of 12 days (7 days of adaptation and 5 days of urine and faeces collection). Serum urea, total protein, albumin, alanine aminotransferase activity, aspartate aminotransferase activity, glucose, cholesterol, creatinine, haemoglobin and packed cell volume were determined. Daily dry matter intake, digestibility of crude protein, ether extract and nutrient detergent fibre did not significantly differ among the dietary treatments ($p > .05$). Nitrogen intake, nitrogen excretion in urine and faeces and nitrogen balance was not significantly affected ($p > .05$) by the dietary treatment. The dietary treatment did not have any significant effect on average daily gain, feed conversion ratio or blood variables ($p > .05$). Olive twigs treated with 4% urea and OTUM replaced 37.7% and 48.5% of conventional diets of growing Shami goat kids without negative effects on growth performance nor health and potentially reduced fattening costs for farmers in olive-livestock mixed systems by 19.8 and 20%, respectively. OUT is technically simpler than OTUM, thus, it could replace the conventional fattening ration of Shami male goat.

Shami goat were fed on Olive twigs treated with 4% urea and 10% Olive twigs treateb with 4% urea replaced 48.5% of the ration without negative effect on growth

Ashraf Alkhtib and Muhannad Muna are contributed equally to the article.

performance This replacement did not affect goat health but decreased feeding cost by 20%.

KEYWORDS
digestibility, feed conversion ratio, growing male-goats, health, Olive twigs and leaves, urea

1 | INTRODUCTION

Chronic feed deficits represent a major constraint to livestock production leading to subsequent increase in feeding costs and reduction in profitability of livestock production systems. This is because natural pastures, the basal diet of livestock in arid and semi-arid areas, are continuously deteriorating in productivity and nutritive value due to deforestation (Alkhateeb, 2008). Furthermore, yield of cereal and pulse grains and their corresponding co-products is decreasing due to drought and global climate change (Ben Salem et al., 2008).

Many studies have been conducted with the aim of introducing underutilized feed resources to decrease pressure on grains, which are the main food for human consumption and increase feed supply to livestock systems. The successful use of agro-industrial by-products as livestock feed including citrus processing by-products (Bampidis et al., 2006), sugar beet pulp (Shdaifat et al., 2013), pistachio by-products (Alkhtib et al., 2017), dry grape pomace (Bahrami et al., 2010), palm pruning by-products (Tonobey et al., 2010) and olive production and processing by-products (Molina-Alcaide et al., 2008a) was reported.

The olive tree (*Olea europaea L.*) is an evergreen tree with a long life-span, cultivated on wide areas of the world for its edible fruits. It has been reported that worldwide olive fruit production was 21,066,000 t harvested from an area of 10,513,000 hr (FAOSTAT, 2018).

Olive leaves and twigs, by-products from pruning of olive trees, have high potential as ruminant feed in terms of quantity. One olive tree yields annually 22 kg of leaves and twigs with a diameter less than 4 cm (Sansoucy et al., 1985). It has been reported that Syria has 103,719,000 olive trees (MOA, 2018) which is associated with a production of 2.3 million tonne of leaves and twigs.

Goat and sheep are more likely to utilize these by-products as these species have been shown to utilize forages of relatively poorer quality (Martín García et al., 2003). High variation in pruning residual biomass, chemical composition and energy content type was reported due to pruning type and genetic factors (Sansoucy et al., 1985). On average, olive leaves and twigs have high dry matter (DM) (898 g/kg), low crude protein (78 g/kg DM) (CP), low ether extract (EE) (46 g/kg DM), high neutral detergent fibre (NDF) (525 g/kg DM), high acid detergent fibre (387 g/kg DM), high lignin (179 g/kg DM), high condensed tannins (70 g/kg DM) and low metabolizable energy (ME) (4.5 MJ/kg DM) (Heuzé et al., 2015). However olive leaves and twigs have high level of condensed tannins (Heuzé et al., 2015), they did not have negative effect on nutrient utilization of sheep and goat (Yáñez-Ruiz et al., 2008). Feeding olive leaves ad libitum to lactating sheep and goats did not decrease milk yield (Tsiplakou et al., 2008).

Urea treatment, the most practical treatment of crop residue because it is inexpensive and easy to apply, is reported to improve the nutritive value of crop residues by enhancing nitrogen content and digestibility (Van Soest, 2006). It has been reported that ammonia treatment improved nutritive value of olive leaves (Fegeros et al., 1995). Olive leaves and twigs treated with 4% urea were introduced to growing sheep ration at a level of 30% in replacement to berseem hay without adverse effects on growth performance (Aziz et al., 2009). Copper content of olive leaves was reported to be high ranging from 10 to 80 mg/kg DM due to the fungicide application (Fernández-Escobar et al., 1999). A short term trial of 27 days on sheep and goat showed that high level of cupper might restrict use of olive leaves in practical ruminant nutrition (Yáñez-Ruiz et al., 2008). However, no studies evaluated effect of long-term feeding olive leaves and twigs on growing goat.

Urea and molasses treatment are expected to improve the nutritive value of olive leaves and twigs leading to an increase in the level of inclusion in goat diets.

To our knowledge, there is scarce information on the effects of feeding olive tree pruning by-products treated with urea and molasses on growing goat for a prolonged period of time. Therefore, the objective of this study is to analyse the possibility of replacing traditional fattening rations by olive twigs and leaves treated with urea and molasses on growth performance, nutrient utilization and health of growing Shami kids.

2 | MATERIALS AND METHODS

The experiment was carried out at Karahta station in Damascus suburb (33° 4′ N, 36° 5′E), located at an altitude of 616 meter above sea level with an average rainfall of 125 mm.

2.1 | Animals, diets and housing

Forty-two Shami male goat (20 ± 2.47 kg live weight and 133 ± 5.44 days age) were randomly allotted into three dietary treatment groups (*n* = 14 for each group), the control group was fed a conventional ration (75% commercial concentrate mixture and 25% wheat straw), OTU (62.3% concentrate mixture + 37.3%

air-dried olive twigs and leaves treated with 4% urea for 14 days) and OTUM (51.5% concentrate mixture + 48.5% air-dried olive twigs and leaves treated with 4% urea for 14 days then sprayed with 10% molasses). The commercial concentrate and wheat straw were fed separately. The commercial concentrate mixture consisted of barley grain (590 kg/t), cotton seed meal (150 kg/t), wheat bran (100 kg /t), maize grain (140 kg/t), dicalcium phosphate (10 kg/t), salt (8 kg/t) and mineral and vitamins mixture (2 kg/t). All kids were fed at a level of 3.1% live weight of DM to meet the nutrient requirements as recommended by Kearl (1982). All experimental diets were similar in energy and protein content. Kids were drenched with Ivermectin (200 mcg/kg live weight) to control common parasites, vaccinated against common diseases of fattening ruminant in Syria (anthrax, pasteurellosis and enterotoxaemia) and then adapted to pens and diets for 10 days before a 90-day growth trial.

Olive twigs and leaves (with a diameter less than 2 cm) were collected from a local olive farm immediately after pruning, chopped to a theoretical length of 4 cm and air-dried for 2 weeks. Olive twigs and leaves were dived up into two portions then mixed thoroughly with either urea solution (4 urea + 40L water + 100 kg olive leaves and twigs) or urea-molasses solution (4 kg urea + 40 L water + 10 kg molasses + 100 kg olive leaves and twigs). Both portions were tightly covered by plastic sheets and tyres to remove as much air as possible, sealed with mud then ensiled for 14 days. The treated olive leaves and twigs were air-dried for 2 weeks. The kids were housed individually in adjacent pens (1.5m × 0.75m) in an open-sided barn and fed twice a day (two equal portions at 0,900 hr and 1,600 hr). All experimental kids had free access to clean drinking water and salt licks.

Residual feeds were removed before morning feeding and weighed on daily basis then stored in a fridge at −20°C for further chemical analyses. Live weight of kids was recorded before the morning feeding at the start of the trial and every 10 days to estimate daily weight gain.

The experimental animals were hosted in individual pens (2*2 m) of a semi-open barn.

2.2 | Nutrient digestibility and nitrogen balance

At the end of the feeding trial, six kids from each group were randomly selected and housed in individual metabolism crates (1.05 × 0.80 m) outfitted with water drinkers and feed troughs to determine nutrient digestibility and nitrogen balance. The selected kids were allowed a collection period of 5 days proceeded by 7 days of adaptation to the crates. Faeces were collected daily for each kid, aliquoted at rate of 10%, oven dried at 55°C to reach a constant weight, then ground to pass through 1 mm sieve and stored for further analyses. Urine was collected in plastic bottles containing 100 ml of 10% sulphuric acid (to avoid nitrogen loss), weighed and stored at −20 °C until analysed. Representative samples of offered and residual feeds were daily collected for each kid. Digestibility (Apparent digestibility of protein) of diets was obtained from measurement of nutrient intakes and losses in faeces. Nitrogen balance was calculated for every experimental animal by subtracting faecal and urine nitrogen from nitrogen intake.

2.3 | Blood sampling and analysis

Blood samples were collected from each kid into two tubes on the start day, then monthly (4 samplings in total) before the morning diet, through the jugular vein; one containing heparin to estimate haematological parameters and the other one without heparin to obtain serum. Serum samples were obtained by centrifuging (1677 × g; 20 min; 4°C) whole blood after which the sera were stored at −20°C for analysis. Specific commercial kits (Katal, Belo Horizonte, MG, Brazil) and a UV spectrophotometer were used at recommended wavelengths to analyse serum urea, total protein, albumin, alanine aminotransferase activity, aspartate aminotransferase activity, glucose, cholesterol and creatinine. Automated haematology analyser (Diatron, Abacus 5, Austria) was used to determine haemoglobin and packed cell volume.

2.4 | Feed, faeces and urine analyses

All samples of feed, refusal feeds and faeces were dried at 105 °C overnight in a forced air oven to determine DM ((AOAC, 2003); method 934.01). Ash was determined using a muffle furnace at 550 °C overnight ((AOAC, 2003); method 942.05). The nitrogen and EE were analysed according to Kjeldahl ((AOAC, 2003); method 954.01) and Soxhlet method ((AOAC, 2003); method 920.39), respectively. Crude protein content was calculated by multiplying nitrogen content by 6.26. Neutral detergent fibre was determined according to Van Soest et al. (1991) without use of an alpha amylase but with sodium sulphite and expressed as residual ash exclusive. Cupper was determined using an atomic absorption spectrophotometer. Table 1 shows chemical composition of the experimental diets.

2.5 | Statistical analysis

Data of blood parameters was analysed using a repeated measurements design, with the kid as subject, according to the following model:

$$Y_{ij} = \mu + TRT_i + M_j + (TRT \times M)_{ij} + \varepsilon_{ij}$$

Where Y is the response variable, TRT is the effect of the treatment, M is the effect of the measurement, TRT × M is the effect of the interaction between treatment and measurement and Ɛ is the residual.

Data of digestibility trial, nitrogen balance and growth performance was analysed according to the following model:

$$Y_{ij} = \mu + TRT_i + \varepsilon_{ij}$$

Where Y is the response variable, TRT is the effect of the treatment and Ɛ is the residual. Least significant difference at $p = .05$ was used for means comparison in both models. All statistical analyses were carried out using R software (R core Team, 2017).

3 | RESULTS

Table 1 shows that cost of diet of OTU and OTU was less than the control by ~ 20%. Urea treatment alone and combined with molasses resulted in doubling CP content of olive twigs with a slight change in NDF and EE (Table 1).

Daily DM intake, OM intake, CP intake, nutrient digestibility and N balance of the experimental kids are presented in Table 2. Daily DM, OM and CP intake of the experimental kids was not significantly affected by the dietary treatment ($p > .05$). The digestibility of NDF of OTU and OTUM was not significantly different from the control ($p > .05$). The effect of the dietary treatment on digestibility of DM, CP, EE and N-free extract was insignificant ($p > .05$). Nitrogen intake, N excreted in faeces and urine and N balance did not significantly differ among the dietary treatments (Table 2).

Growth performance, daily dry matter intake and feed conversion ratio were not significantly different among the dietary treatments ($p > .05$) (Table 3).

Effect of the treatment, measurement and the interaction between treatment and measurement on all blood chemistry parameters was not significant ($p > .05$) (Table 4).

4 | DISCUSSION

Olive twigs used in the current study had less content of CP and NDF compared to what was reported by Heuzé et al. (2015). This confirms the existence of wide variability in chemical composition which could be due to many factors including variability in morphological structure of the by-product, age of tree at pruning and pruning type (Molina-Alcaide et al., 2008b). Accordingly, nutritional composition of olive twigs should be determined before the inclusion into ruminant diets and literature analysis of olive leaves and twigs is not reliable in practical nutrition in olive leaves and twigs context.

Untreated olive leaves and twigs were reported to have low content of CP and high content of lignocellulose. Thus, replacing standard goat fattening diet by untreated olive twigs would result in a decrease in digestibility, DM, CP intake and growth performance. Urea treatment proved to improve nutritive value and feed intake of crop residue by increasing digestibility and nitrogen balance (Gunun et al., 2013). The absence of significant difference among the dietary treatments in nitrogen balance means that all experimental animals retained similar amounts of nitrogen. This is because nitrogen bonds to lignocellulose of

TABLE 1 Ingredients and nutritional composition of the experimental diets (on dry matter basis)

Item	DM	OM	CP	EE	NDF	Cu	ME	Cost ($/t)
Feed ingredient								
Concentrate mixture	918	951	150	24.1	220		10.7	
Wheat straw	965	917	46.1	8.1	771		6.19	
Molasses	776	886	147	2.4	-		11	
Olive leaves and twigs	650	920	42	30	480	74	4.5	
Olive leaves twigs treated by 4% urea	890	932	75.6	25.2	465		6.12	
Olive leaves and twigs treated by 4% urea and 10% molasses	850	901	88	21.5	460		6.5	
Experimental diets								
Control	923	943	124	20.1	358	17.5	9.6	84
OTU	907	944	122	24.5	312	49	8.96	67.1
OTUM	885	927	120	22.8	336	41.1	8.66	67.4

Note: DM dry matter (g/kg), *OM* organic matter (g/kg DM), *CP* crude protein (g/kg DM), *EE* ether extract (g/kg DM), *NDF* neutral detergent fibre (g/kg), *control* 75% concentrate mixture + 25% wheat straw, *OTU* 62.3% concentrate mixture + 37.3 olive twigs and leaves treated by 4% urea for 14 days, *OTUM* 51.5% concentrate mixture + 48.5 olive twigs and leaves treated by 4% urea for 14 days then sprayed by 10% molasses *Cu* mg/kg DM, *ME* Metabolizable energy (MJ/kg DM), Cost of the feeds was calculated based on feed prices in the local market

TABLE 2 Effect of inclusion of olive twigs treated by urea and molasses on digestibility and nitrogen balance of Shami goat kids

	Control	OTU	OTUM	*SEM*	*p*-value
Intake (g/Live weight$^{0.75}$)					
Daily dry matter intake	78	77.6	79	0.76	.087
Organic matter	73.5	73.3	73.2	0.72	.077
Crude protein	9.65	9.47	9.46	0.089	.068
Digestibility coefficient					
Dry matter	0.691	0.659	0.674	0.029	.065
Crude protein	0.718	0.683	0.7	0.026	.123
Nitrogen free extract	0.835	0.792	0.795	0.018	.334
Neutral detergent fibre	0.247^{ab}	0.206^{a}	0.337^{b}	0.03	<.001
Ether extract	0.776	0.758	0.753	0.016	.232
Nitrogen balance					
Nitrogen intake (g/day)	19.9	21.8	19.9	0.714	.435
Nitrogen of faeces (g/day)	6.54	7.3	6.71	0.213	.076
Nitrogen of urine (g/day)	8.02	9.48	8.73	0.415	.098
Nitrogen balance (g/day)	5.33	4.98	4.88	0.126	.112
Nitrogen balance (%)	66.2	66.5	67.1	0.228	.095

Note: Control 75% concentrate mixture + 25% wheat straw, *OTU* 62.3% concentrate mixture + 37.3 olive twigs and leaves treated by 4% urea for 21 days, *OTUM* 51.5% concentrate mixture + 48.5 olive twigs and leaves treated by 4% urea for 21 days then sprayed by 10% molasses, *a-b* means within a row with similar superscript are not significantly different at $p \le .05$

TABLE 3 Effect of inclusion of olive twigs treated by urea and molasses on growth performance of Shami goat kids

	Control	OTU	OTUM	*SEM*	*p*-value
Initial live weight (kg)	20.1	20.1	19.9	0.677	.342
Final live weight (kg)	33	32.5	32	0.913	.765
Weight gain (kg)	12.8	12.4	12.2	0.65	.544
Average daily gain (g)	149	144	142	7.56	.087
Daily dry matter intake (g)	912	906	908	7.63	.113
Feed conversion ratio	6.17	6.34	6.45	0.292	.432

Note: Control 75% concentrate mixture + 25% wheat straw, *OUT* 62.3% concentrate mixture + 37.3 olive twigs and leaves treated by 4% urea for 14 days, *OTUM* 51.5% concentrate mixture + 48.5 olive twigs and leaves treated by 4% urea for 14 days then sprayed using 10% molasses

olive leaves and twigs during urea treatment leading to an increment in CP content (Van Soest, 2006). Ammonium hydroxide produced during urea treatment in forage causes a swelling in the hemicelluloses-lignin matrix (Mapato et al., 2010) which would increase surface area for the activity of rumen microorganisms. That would leverage cell walls breakdown rate and overall digestibility in the rumen (Ha et al., 2001). That might explain the absence of any significant differences among the experimental diets in nutrient digestibility.

The similar nutrient intake and digestibility of the animals in the experimental treatments in addition to the absence of health problems explains the similar growth performance. This agrees with a study on fattening lambs that were fed on olive twigs treated with urea and yeast (Aziz et al., 2009). Similar results were obtained when tree leaves were fed to goat as reported by Yáñez-Ruiz et al. (2008) and summarized by Kibria et al. (1994).

Wide range of fungicides and pesticides are used to control fungus (olive leaf spot caused by *Spilocea oleagina* and Anthracnose (*Colletotrichum gloeosporoides*)), pests (black scale (*Saissetia oleae*), Parlatoria scales (*Parlatoria oleae*) and apple weevils (*Otiorhynchus cribricollis*)) of olive trees (Spooner-Hart et al., 2007). That would result in high accumulation of fungicides and pesticides especially in old twigs (Fernández-Escobar et al., 1999) which would affect negatively functions of liver and kidney (Molina-Alcaide et al., 2008a). In current study, levels of albumin, total protein, urea, packed cell volume and haemoglobin, alanine transferase, aspartate transferase, glucose, cholesterol, creatinine were similar across all treatments which pinpoint normal function of liver and kidneys. This in agreement with Molina-Alcaide et al., (2008a) and Yáñez-Ruiz et al. (2008).

Farmers tend to formulate rations using locally available crop by-products or agro-industrial by-products as the conventional balanced diets are expensive and may not be readily available. Introducing alternative feed into livestock ration reduces the cost of feeding and, consequently cost of production. By-products are cheaper than conventional feedstuffs because they are co-products of agriculture based industries (Obeidat, 2017). Results of this study showed that using urea and molasses treated twigs in growing kids feeding reduced price of one tonne of the ration by almost 20%. These results are in agreement with Salami et al. (2019) and Obeidat et al., (2016), who

TABLE 4 Effect of inclusion of olive twigs treated by urea and molasses on blood metabolites of Shami goat kids

Item	Treatment			*SEM*	*p*-value		
	Control	OTU	OTUM		T	M	T × M
Protein metabolism							
Albumin (g/l)	36.3	39.5	39.2	2.46	0.5	0.065	0.564
Total protein (g/l)	68	71.3	71.4	3.49	0.22	0.086	0.741
Alanine transferase (IU/l)	15.5	14.4	15.8	2.5	0.32	0.078	0.55
Aspartate transferase (IU/l)	64.5	75.1	75.9	4.79	0.75	0.45	0.63
Urea (mg/dl)	53.6	56.8	56.6	7.59	0.08	0.335	0.658
Energy metabolism							
Glucose (mg/dl)	72.5	75.5	75.9	4.7	0.25	0.067	0.367
Cholesterol (mg/dl)	50.2	41.6	42.6	2.82	0.65	0.074	0.478
Creatinine (mg/dl)	1.42	1.8	1.74	0.35	0.45	0.667	0.589
Mineral metabolism							
Packed cell volume (%)	29	30.1	28.5	3.55	0.099	0.441	0.478
Haemoglobin (g/dl)	11.3	12.1	11.5	1.37	0.89	0.589	0.254

Note: Control 75% concentrate mixture + 25% wheat straw, *OTU* 62.3% concentrate mixture + 37.3 olive twigs and leaves treated by 4% urea for 14 days, *OTUM* 51.5% concentrate mixture + 48.5 olive twigs and leaves treated by 4% urea for 14 days then sprayed by 10% molasses, *T* effect of treatment, *M* effect of period of sampling, T × M: interaction between treatment and period of sampling

reported on a considerable reduction in feeding cost as a result of using agro-industrial by products in livestock feeding.

5 | CONCLUSIONS

It is concluded that inclusion of OTU and OTUM could replace the conventional fattening ration of Shami male goat decreasing the feeding cots by 19.8% and 20% respectively with no detrimental effect on efficiency of nutrient utilization, health, growth performance and feed conversion ratio. Thus, OUT could be recommended as a replacement of the conventional Shami male goat.

Application of urea treatment to olive leaves and twigs presents challenges which include high bulk density and physical structure of the by-product. This tends to be relatively tedious with high requirements of labour. Further studies are needed to simplify urea treatment methods of olive leaves and twigs so that farmers in livestock-olive mixed systems could easily adopt the technique.

6 | ETHICAL STANDARDS

All experimental procedures were in compliance with the use of animals in research as approved by the Ethical Committee of Damascus University, Syria.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTION

Ashraf Alkhtib: Formal analysis; Software; Writing-original draft; Writing-review & editing. muhannad muna: Conceptualization; Data curation; Supervision; Writing-original draft; Writing-review & editing. Emily Burton: Writing-review & editing. Jane Wamatu: Writing-review & editing. Mohammad Darag: Data curation; Investigation; Resources; Supervision. Eyad Alkhaled: Data curation; Resources; Supervision. Hana Almoufachi: Data curation; Formal analysis. Ruba Zaeowd: Investigation; Methodology.

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ORCID

Ashraf Alkhtib https://orcid.org/0000-0002-3381-0304

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