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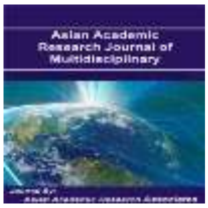

FEED INTAKE, APPARENT NUTRIENT DIGESTIBILITY AND GROWTH PERFORMANCE OF FINISHING ASSAF LAMBS FED BY- PRODUCTS SILAGE

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Abstract

Effects of silage (S) made of a mixure of different by-products on growth performance and nutrient digestibility were studied in 24 male Assaf lambs of 35.0 ± 0.110 kg initial body weight. Animals were randomly divided into 4 groups of 6 lambs each. Lambs were individually fed a fixed amount of concentrate along with by-products silage as total mixed ration (TMR). The by-products silage (S) replaced 0, 50, 75 and 100% of wheat straw (*i.e.* 0S, 50S, 75S and 100S). Silage was prepared from a mixure of olive cake (OC), tomato wastes (TW) and poultry litter (PL) at levels of 700, 100 and 200 g/kg DM, respectively. All diets were isonitrogenous and isoenergic. A digestion trial was performed during the last week of the feeding trial. All lambs were slaughtered at the termination of the 70d feeding study. Results showed that lambs fed the 75S and 100S diets had lower ($P < 0.05$) feed intake and better ($P < 0.05$) feed conversion ratios (FC) compared to lambs fed the 0S and 50S diets. Silage (i.e., 100S) increased ($P < 0.05$) the digestibility of dry matter (DM), acid detergent fiber (ADF), neutral detergent fiber (aNDF) and fat. These results show the positive effects of silage, made prepared from local by-products, when used at high levels on most tested parameters.

Keywords: Assaf lambs, silage, performance, by-products, digestibility

1. Introduction

Feed cost in fattening projects of lambs in Palestine is estimated at 80% of production costs (Abo Omar *et al.*, 2012). The high cost of feeds is one of the major obstacles facing fattening projects (Abo Omar, *et al.*, 2012; Saghir *et al.*, 2012). In order to reduce feed costs, it is important to find nontraditional feed ingredients. Several studies were conducted to investigate the feasibility of incorporating local by-products in small ruminant rations (Abo Omar et al., 2012). The results of feeding rations with agro-industrial by-products showed the economic feasibility of adoption of this practice (Abo Omar et al., 2012), however, the high moisture content of some of these by-products (*i.e.* OC and TW) causes storage and handling problems (Zaza, 2010). Silage is a simple, cheap, and efficient procedure to preserve the agro-industrial by-products, either alone (Hadjipanayiotou, 1999; Abo Omar *et al.*, 2012) or mixed with poultry manure (Nefzaoui, 1991) or conventional feedstuffs (Hadjipanayiotou, 1999; Zaza, 2010). Large amounts of green house wastes are annually produced in Palestine (*i.e.* 0.5 million tons of tomato wastes, Palestinian Central Bureau of Statistics, 2010) . These wastes include stems, leaves and downgraded fruits. However, there is no information about the use of such by-product silage along with PL and OC in fattening rations. The objectives of this study were to investigate the effects of feeding silage made of OC, PL and TW on the general performance and digestibility in Assaf finishing lambs.

2. Materials and methods

2.1. Study site

The study was conducted at Al Qaisi farm, Tulkarm city, Palestine (semi-coastal area) after the approval of the Animal Care and Use Committee of the Palestinian Ministry of Agriculture.

2.2. Silage preparation

Poultry litter (PL) was collected from a commercial broiler house, bedded with wood shavings. The poultry litter was screened using a 20 mm metal screen to remove all foreign materials. PL was a mixture of bird excreta, wasted feed, bedding and feathers. Tomato wastes (TW) (*i.e.* stems, leaves, downgraded fruits) were collected from neighboring vegetable greenhouses, chopped to about 5 cm pieces and mixed before incorporation into the silage mixture. Olive cake (OC) is the residue obtained at the mill after extracting the oil by pressing and centrifuging. Silage was composed of 70% fresh OC, 20% screened PL and 10% chopped TW. The silage ingredients were placed in 100-liter plastic barrels in alternate layers, the first and the last layers being crude OC. PL and chopped TW were roughly mixed and placed as a single layer. Water (5 liters/100 kg mixture) was added to reach a moisture content of about 55%. The silage mixture was pressed using an electric impactor. The pressed materials (Table 1) were covered with black polyethylene sheets. Preparation of silage was made in one day and the barrels were opened after a fermentation period of 42 days.

2.3. Silage Sampling

Representative samples were taken for pH measurement. Each sample weighed about 400g and was randomly selected from different barrels. The sampling was done in the morning at d 1, 4, 7, 14, 28, 35 and 42.

2.4. pH Measurements

pH measurements were done using an electronic pH meter (Mettler Toledo MP 220 pH meter). A 25g sample was mixed with 50 ml distilled water in an Erlenmeyer flask and the mixture was put on a shaker for 30 minutes. The pH was then measured for each sample by entering the electrode into the filtrate.

2.5. Animals, design and dietary treatments

Twenty-four male Assaf lambs (initial body weight (BW) = 35.0 ± 0.110 kg) at 90 d of age were used. Lambs were individually housed in shaded pens (1.5 m × 0.75 m) and were treated with IVOMEC (Merial Limited, Luluth, Ga, USA) and Cogla Vac (Cogla Laboratories, Libourne, France) against internal and external parasites and enterotoxaemia, respectively.

Lambs were assigned to one of four TMR dietary treatments (Table 2) containing 0 silage (0S; *n* = 6), 50% silage (50S; *n* = 6), 75% silage (75S; *n* = 6) and 100% silage (100S; *n* = 6) for a duration of 70 d. A fixed amount (*i.e.* 90%; concentrate: roughage ratio was 9:1) of concentrate mixtures (Table 2) were fed to lambs to make diets isonitrogenous and iso ME, and to meet all nutrient requirements for finishing lambs (NRC, 1985).. At termination of the trial, lambs were fed a regular fattening diet for another month in order to be approved for human consumption. Lambs were weighed on weekly basis before the morning feeding throughout the study. Average daily gain (ADG) was calculated by subtracting initial from final BW and dividing by the duration of study. Diets were fed as total mixed rations (TMR) once a day at 08:00 h and lambs had free access to clean water throughout the study.

2.6. Chemical analysis

Representative samples of the ingredients used in the silage mixure were taken prior to ensiling and proximate analyses were made on dried (65^{o}C) ground (1 mm sieve) samples as outlined by Harris (1970). Silage DM content was determined twice a week by drying to constant weight in an air forced oven at 105^{o}C for two days. Silage analyses for total N, NH_3-N, volatile fatty acids and pH were made once weekly on a fresh sample. NH_3-N and pH measurements were performed according to Hadjipanayiotou (1982; 1994). Digestibility *in vitro* was determined by the procedure described by Tilley and Terry (1963).

Samples of TMR were collected and saved (−20^{o}C) for later analysis according to procedures of AOAC (1990) for dry matter (DM; 105◦C in a forced-air oven for 24 h; method 967.03), organic matter (OM; weight loss upon ashing at 550^{o}C for 8 h; method 942.05), N (Kjeldahl procedure; method 976.06), and ether extract (EE; Soxhlet procedure, Soxtec System, TECATOR, Hoganas, Sweden; method 920.29). Additionally, samples were analyzed for neutral detergent fiber (aNDF; with heat stable -amylase and sodium sulfite) and acid detergent fiber (ADF; ANKOM 2000 fiber analyzer, ANKOM Technology Corporation, Fairport, NY, USA) according to Van Soest *et al*. (1991). Values for aNDF and ADF are expressed inclusive of residual ash. The offered and refused amounts of TMRs were recorded daily for each lamb and were adjusted to ensure refusals of about 0.10 of intake and ad libitum consumption. For each lamb, samples of refused feed were collected daily, composited at the end of study, and saved (−20◦C) for later analysis of DM, OM, CP, EE, aNDF and ADF to determine daily nutrient intake.

2.7. Digestion trial

At termination of the trial, a 6-d total collection feed and fecal trial was performed using 4 lambs from each experimental group. Data were utilized to calculate the apparent digestibility of CP, ADF, NDF, and NFE. All experimental animals had an adaptation period of about 10 days and a total collection period of 7 d where feed intake and feces were monitored. Animal weights were recorded on weekly basis and final live weight gain was calculated on the last day of the trial.

2.8. Statistical analysis

Data were subjected to ANOVA for a completely randomized design using SAS (1989). Differences among treatment means for significant dietary effect were detected using the LSD procedure in SAS. Unless otherwise stated, significance was declared at $P < 0.05$.

3. Results

The DM, CP, ADF and aNDF values were within the normal ranges of similar silages prepared of agricultural wastes (Table 1). All diets contained comparable amounts of CP, aNDF, ADF and ash (Table 2) Some silage characteristics are shown in Table (3). There was no sign of mould. The microbiological analyses (Salmonella, Listeria, Clostridium) on the PL, OC, TW and on the silage were all negative. All animals were healthy throughout the feeding trial. The silage pH was within the acceptable values (Table 3).

3.1. Lambs performance

Silage at high levels (*i.e.* 75S and 100S) had significant effects on DM intake compared to that of lambs in other treatments (Table 4). Lambs fed the 75S and 100S had lower ($P <$ 0.05) intake compared to other lambs. The DM intake at 75S and 100S levels was reduced 22 and 19% compared to 0S lambs, respectively. Lambs under all treatments grew the same, however, lambs fed the 75S and 100S diets had the highest ($P < 0.05$) feed CR compared to lambs fed the 0S and 50S diets (Table 4).

3.2. Nutrient digestibility

Level of silage had significant effect on nutrients digestibility. The 100S improved ($P <$ 0.05) the apparent digestibility of DM, ADF, NDF and crude fat (Table 5) compared to that of other silage levels.

4. Discussion

Laboratory analyses of silage showed comparable values to those associated with the silage made of similar ingredients (Zaza, 2010). Optimum DM content for high quality silage production was reported in the range of 20–35% (?????). However, DM of silage in this study was 450 g/kg DM. Lambs in this study showed no disease problems associated with feeding PL, TW and OC silage (Hammad, 2002; Zaza, 2010). The lack of salmonella and other pathogens was due to the silage pH which was 5, a value that has been proposed (Roothaert *et al.*, 1992) to destroy Salmonella and other pathogens. The decrease in pH values after ensiling is in agreement with the objective of the ensiling technique to achieve a sufficient concentration of lactic acid produced as a result of presence of microorganisms in order to inhibit other forms of microbial activity and preserve the silage material (Christodoulou *et al.*, 2006). The silage pH was similar to what was reported by previous research using similar ingredients (Hadjipanayiotou 1982; Hammad, 2002; Zaza, 2010). Martin et al., (1967) indicated that good quality silage should have a pH of 4.6 or lower.

The ensiling period of six weeks in this study is shorter than that suggested by Hadjipanayiotou (1994) who indicated a 60 d fermentation period for crude olive cake. However, Colombato *et al*., (2004) reported that the ensiling period of 3 weeks is optimum. On the other hand, Hadjipanayiotou (1994) showed that ensiling could be for 2 weeks and observed no advantage in prolonging treatment time beyond two weeks. Moreover, mixing olive cake with other supplements at ensiling resulted in a balanced silage mixture and better silage characteristics (Hadjipanayiotou, 1994). There was no significant difference in the chemical composition of diets offered and refused indicating that there was no apparent selection of any of the ingredients used.

Feed intake of lambs in the 75S and 100S diet groups (24.1 and 25.7 g DM/kg BW, respectively) was lower compared to feed intake of lambs in the other diet groups. This indicates that palatability might be reduced at high silage levels. Similar trend of intake (25.1 g DM/kg BW) was reported by Abo Omar *et al.*, (2012) when finishing goat kids were fed a high level of olive cake silage. In contrast, high intake of poultry litter/ crude olive cake/ wheat bran silage (45:45:10) by fast-growing lambs has been reported by Hadjipanayiotou et al.,(1993). Higher voluntary intake of poultry litter/citrus pulp silage by lambs than by kids was also reported by Hadjipanayiotou et al.,(1993).

The improvement in the digestibility of most of the nutrients associated with the 100S diet might be the reason behind the significant increase in feed conversion ratio in the high-silage groups .

The improvement in performance associated with 100S in this study might be explained by the increase in the degradability of OM, CP, NDF, and ADF. In this experiment, DM digestibility of 100S was 0.78, 12% higher than that of 0S diets. Lower digestibility of DM was reported by previous research, 0.56 and 0.58 (Bartocci *et al.,* 1982). The high level of silage used in this study (*i.e.* 100S) may have influenced rumen function as indicated in the significant improvement in digestibility of most tested feed nutrients compared to other silage levels. Tahmasbi *et al.*, (2002) reported that increasing protein level in silage increased CP digestibility of the silage. In this study, digestibility of CP was significantly higher at the highest level of silage even though all diets were isonitrogenous.

5. Conclusion

It is concluded that the ensiling process is an effective, simple and low-cost technique for preserving crude olive cake with poultry litter and tomato waste. Such a product can make a significant contribution to livestock production, not only as replacement for scarce roughage in dry periods of the year, but also as part of a total mixed ration in intensive operations.

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Table 1

The ingredients and chemical composition of experimental feeds incorporated with silage (S) fed to Assaf fattening lambs

	Treatment			
	0S	50S	75S	100S
Ingredient composition, g/kg D				
Concentrate				
Yellow corn grain	495	510	51(	55(
Soybean meal,44%	295	280	280	240
Wheat bran	79	79	79	79
Ammonium chloride	3	3	3	3
DCP	6	6	6	6
Limestone	17	17	17	17
Salt	3	3	3	3
Premix[1]	1	1	1	1
Soap stock	1	1	1	1
Roughage				
Barley straw	100	50	25	0
Silage[2]	0	50	75	100
Chemical analysis: g/kg DM[3]				
Dry matter	900	894	89(	89(
Crude protein	184	186	18:	18:
Acid detergent fiber	173	175	17(	18(
aNeutral detergent fiber	550	540	51(	53(
Ash	65	64	71	67
Calcium	9.1	9.2	9.2	9.3
Phosphorus	6.2	6.4	6.2	6.4
ME, MJ/ kg[4]	11.6:	11.64	11.'	11.66

0S = no silage; 50S = 50% silage; 75S = 75% silage; 100S= 100% silage

[1]composition per 1 kg contained, vitamin A, 2000000 IU; vitamin D3, 40000 IU; vitamin E, 400 IU; Mn, 12.8 mg; Zn, 9.0 mg; I, 1.56 mg; Fe, 6.42 mg; Co, 50 mg; Se, 32 mg plus an antioxidant.

[2]silage (S) composition: olive cake, tomato wastes and poultry litter at levels of 700, 100 and 200 g/kg DM, respectively.

[3]composition values obtained from the analysis of final diets.

[4]metabolizable energy; based on tabular values (NRC, 1985).

Table 2

Chemical composition and in vitro digestibility values of ingredients used for preparing silage(S), g/kg DM[1]

Nutrier	Concentı	Poultry li	Olive ca	Tomato w	Silage	Wheat st
DM	900	910	900	500	450	880
CP	182	280	56	120	100	40
Ash	67	57	110	70	123	66
EE	50	43	80	64	45	25
NDF	535	380	700	410	620	540
ADF	174	210	510	280	500	344
DMD[4],	86.0	48.0	15.5	57.0	32.0	41.0

[1]composition values obtained from the analysis of raw ingredients.

[2]DM: dry matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber.

[3]silage (S) composition: olive cake, tomato wastes and poultry litter at levels of 700, 100 and 200 g/kg DM, respectively.

[4]DMD: dry matter digestibility.

Table 3

Characteristics of silage[1] (S) fed to Assaf lambs

	Value[2]
pH	4.7
NH3N, mg/dl	14.9
Acetic acid, mg/g DM	51.0
Propionic acid, mg/g DM	38.2
Butyric acid, mg/g DM	5.4
DM	450
CP	100
Ash	123
EE	45
NDF	620
ADF	500
DMD[3]	32

[1]silage (S) composition: olive cake, tomato wastes and poultry litter at levels of 700, 100 and 200 g/kg DM, respectively.

[2]values are means of three tests.

DM: dry matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber.

[3]DMD: dry matter digestibility.

Table 4

Effect of silage[1] (S) on feed intake, body gain, slaughter body weight (BW), empty body weight (EBW) and dressing percentages (DP) of Assaf fattening-lambs

Group	0S	50S	75S	100S	SEM[2]	P value
DMI, g/kg	1927^{a}	1909^{a}	1504^{b}	1620^{b}	65.3	0.05
Initial BW, kg	35	35	35	35	2.1	
Final BW, kg	61.6	62.0	62.3	63.1	4.22	0.44
ADG, g	380	385	390	387	16.9	0.32
FCR[3], g/g	5.1^{a}	5.0^{a}	4.0^{b}	4.2^{b}	0.34	0.05
CW, kg	28.3	29.1	29.2	29.1	2.44	0.35
EBW, kg	52.3	52.4	53.0	52.0	3.91	0.26
CDP, %	46.0	46.9	46.8	46.8	2.98	0.56

0S = no silage; 50S = 50% silage; 75S = 75% silage; 100S= 100% silage

[1]silage (S) composition: olive cake, tomato wastes and poultry litter at levels of 700, 100 and 200 g/kg DM, respectively.

[2]SEM = standard error of the mean.

[3]FCR = feed conversion ratio.

DMI = dry matter intake; ADG = average daily gain; CW = carcass weight; EBW = empty body weight; CDP = commercial dressing percentage.

Means in the same line with different alphabets (a, b) are significantly different ($P < 0.05$).

Table 5

Effect of silage[1] (S) on the nutrients digestibility in diets fed to Assaf fattening lambs, %

Group	0S	50S	75S	100S	SEM	*P* value
DM	69.7^{b}	70.8^{b}	70.6^{b}	78.7^{a}	5.07	.05
CP	80.6^{b}	82.2^{b}	81.8^{b}	85.9^{a}	6.33	.05
ADF	65.0^{b}	64.7^{b}	63.3^{b}	70.8^{a}	5.12	.05
NDF	65.8^{b}	66.2^{b}	65.8^{b}	75.1^{a}	5.9[illegible]	.05
EE	69.7^{b}	73.9^{b}	70.6^{b}	78.0^{a}	4.8[illegible]	.05

[1]silage (S) composition: olive cake, tomato wastes and poultry litter at levels of 700, 100 and 200 g/kg DM, respectively.

[2]SEM = standard error of the mean.

DM = dry matter; CP= crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; EE = ether extract.

Means in the same column with different alphabets (a, b) are significantly different (*P* 0.05).