

Performance of Assaf Lambs Fed Two Upgraded Agricultural Wastes

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Abstract

Effects of ensiled greenhouse wastes (GHW), alkali-treated GHW and almond hulls (AH) on growth performance were studied on 24 Assaf lambs. All lambs were males with an average weight of 36.2 kg (S.D. = 2.1 kg) at the beginning of the experiment. Animals were randomly divided into 4 groups of 6 lambs each. Lambs in each group received individually corn-soybean meal (SBM) total mixed rations (TMR). Rations were incorporated with a fixed amount (200 g/kg) of the treated raw ingredients: ensiled greenhouse wastes, alkali-treated GHW and ensiled AH. All rations were isonitrogenous and isocaloric. The growth experiment lasted 80 d. Both chemical and biological treatments had significant effects on improving crude protein (CP) and fiber fractions. At termination of the experiment, lambs fed treated ingredients (*i.e.*, ensiled GHW, alkali-treated GHW, ensiled AH) had better ($P < 0.05$) feed conversion ratios and consumed less ($P < 0.05$) feed. Treated GHW and AH had no effect on average daily gain ($P = 0.14$) and total gain ($P = 0.21$). Cost of gain was significantly lower in lambs fed the treated ingredients.

Keywords: Assaf lambs, greenhouse wastes, almond hulls, nutritive value, performance

Introduction

The Middle East is characterized by dry land farming. Depending on regional rainfall, the availability of forages and cereal crops is highly seasonal. The importance of roughage as a feed resource is decreasing at the expense of cereals and agro-industrial by-products [1-6]. Food crops leave a variety of residues (straws) that are utilized for animal feeding. Poor quality roughage comprises the only part of the diet for ruminant animals in most Middle East countries for a considerable period of the year. Crop residues and agro-industrial byproducts can play an important role in the feeding of sheep and goats under different management systems. Such residues can supply a substantial part of the maintenance requirements of small ruminants in the Asian region [7,8].

Crop residues, particularly cereal straws and a few agro-industrial byproducts such as almond hulls (AH), greenhouse wastes (GHW), olive cake, citrus pulp, sesame oil cake, bakery wastes, and fruit and vegetable wastes have gained in importance due to the increasing demand of livestock feeds and due to competitive prices resulting from the removal of feed subsidies. The need to make better use of local feeds (crop residues, agro-industrial byproducts) is considered to be a promising way to alleviate feed deficit.

Difficulty in using most of these byproducts as fresh material for over long periods is one of the constraints in their wider use. The low nutritive value and the imbalanced nutrient profile of these byproducts is another reason which limits their use as components of small ruminant diets. The objectives of this research were to upgrade GHW and AH through ensiling and alkali treatments and to investigate the performance of Assaf lambs fed with these 2 by-products.

Materials and methods

Preparation of raw ingredients

AH and GHW were obtained from local farms located near to the experimental site. The 2 ingredients were treated with NaOH as described by Nefzaoui [9] and were ensiled as described by Hadjipanayiotou [10].

Animals and experimental design

Twenty-four weaned male Assaf lambs with an initial mean weight of 36.2 kg (SD = 2.1 kg) were used in the experiment. The experiment was conducted at a private farm, Tulkarm City, Palestine, after the approval of the Animal Care and Use Committee. Lambs were then assigned randomly to 4 experimental fattening diets (6 lambs/treatment). Lambs in each treatment were fed individually (**Table 1**), and each lamb was considered as an experimental unit. Animals in treatment groups were fed corn-SBM based rations. Fixed amounts (200 g/kg) of GHW, AH silages, and NaOH treated GHW were incorporated in the rations. Conventional rations were fed to lambs in group 1 (the control group); however, ensiled GHW, alkali-treated GHW, and ensiled AH were fed to lambs in groups 2 - 4, respectively, in a completely randomized design, for 80 days, the duration of a regular fattening operation practiced in Palestine (**Table 1**). Rations fed were formulated to meet NRC [11] standards, and all diets were formulated to be isonitrogenous and isoenergetic. Lambs were housed in individual pens (1.5×1.00 m²) with constant illumination and fed the experimental diets twice daily at 0900 and 1700 h. Feeds offered and refused were recorded daily. Animal pens were cleaned weekly. Lambs weights were recorded weekly before the 0900 h feedings. Ingredient compositions of the experimental diets are shown in **Table 1**.

Table 1 Ingredient and chemical composition of experimental feeds incorporated with treated GHW and AH fed to Assaf fattening lambs, g/kg DM.

	Dietary group ¹			
	Control	Ensiled GHW	Alkali-treated	Ensiled AH
Concentrate ^a	800	800	800	800
Wheat straw	200	0	0	0
GHW	0	200	0	0
AH	0	0	200	0
Almond hulls silage	0	0	0	200
Chemical analysis: (DM basis)				
DM	890	550	580	850
OM	825	482	511	782
CP	188	190	190	189
ADF	188	150	160	158
NDF	540	520	490	518
EE	640	631	620	650
Ash	65	68	69	68
Ca	0.9	0.10	0.11	0.1
Phosphorus	0.5	0.6	0.6	0.5
ME ^b , MCal/ Kg DM	1.60	1.57	1.60	1.57
Cost of 1 kg diet, US\$	0.51	0.48	0.46	0.48

¹dietary group: control; ensiled green house waste (GHW); alkali treated; ensiled almond hulls (AH).

^aComposition per 1 kg contained: yellow corn, 400 g; soybean meal, 255 g; wheat bran, 80 g; ammonium chloride, 3 g; dicalcium phosphate, 6 g; NaCl, 3 g; limestone, 17 g; soapstock, 1 g; premix, 1 g (composition per 1 kg: 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 antioxidant).

^bMetabolizable energy: based on tabular values (NRC, 1985).

Chemical analysis

Following AOAC [12] procedures, samples were analyzed for DM (100 °C in an air-forced oven for 24 h; method 967.03), ash (550 °C in an ashing furnace for 6 h; method 942), and CP (Kjeldahl procedure, TECATOR, Box 70, Hoganas, Sweden). Additionally, samples were analyzed for neutral detergent fiber (aNDF; with heat stable-amylase and sodium sulfite) and acid detergent fiber (ADF; ANKOM2000 fiber analyzer, ANKOM Technology Corporation, Fairport, NY, USA) according to Soest *et al.* [13]. Values for aNDF and ADF were expressed inclusive of residual ash. The pH of silages was measured using a glass electrode pH-meter according to Bolsen *et al.* [14]. The volatile fatty acids (VFA; acetate, butyrate and lactate, respectively) were measured by HPLC according to Erwin *et al.* [15].

Statistical analysis

Data were subjected to ANOVA for a completely randomized design using the general linear procedure of SAS [16]. Differences among treatment means for significant dietary effect were detected using Duncan's Multiple Range test. Unless otherwise stated, significance was declared at $P < 0.05$.

Results and discussion

Silage

GHW silage (GHWS) and AH silage (AHS) had higher ($P < 0.05$) CP content compared to CP in raw ingredients (GHW and AH, **Table 2**). The ensiling process resulted in 1.05 and 0.84 increases in CP in AHS and GHWS, respectively. The GHWS and AHS had a lower ($P < 0.05$) NDF fraction compared to raw ingredients (**Table 2**). However, ensiling only decreased the ADF fraction in AH. The ensiling process decreased the NDF fractions in GHWS and AHS by 0.38 and 0.82, respectively. However, the reductions in the ADF fractions were 0.16 and 0.50 for GHWS and AHS, respectively.

Table 2 Chemical analysis of crude, alkali-treated and ensiled almond hulls (AH) and greenhouse wastes (GHW) fed to Assaf lambs.

	DM ¹	OM	CP	NDF	ADF	Ash
AH						
Crude	89.0 ^{a,2}	82.1 ^a	3.4 ^b	83.0 ^a	66.0 ^a	6.9 ^{a,b}
Alkali-treated	82.3 ^b	74.7 ^b	5.5 ^{a,b}	34.0 ^c	51.3 ^a	7.6 ^{a,b}
Ensiled GHW	52.7 ^{d,e}	44.5 ^{d,e}	7.1 ^a	15.3 ^c	32.7 ^b	8.2 ^a
Crude	53.3 ^d	46.1 ^d	3.3 ^b	24.0 ^d	20.3 ^b	7.2 ^{a,b}
Alkali treated	72.3 ^c	65.9 ^c	4.1 ^{a,b}	18.3 ^c	19.3 ^b	6.4 ^{b,c}
Ensiled	48.7 ^c	43.4 ^c	6.9 ^a	15.0 ^b	17.0 ^b	5.3 ^c

¹DM = dry matter, OM = organic matter, CP = crude protein, NDF= neutral detergent fiber, ADF= acid detergent fiber, EE = ether extract.

²Means in the same column with different superscripts are significantly different ($P \leq 0.05$) using Duncan's Multiple Range test for multiple comparisons.

Alkali treatment

The sodium hydroxide treatment increased the CP of GHW and AH by 0.24 and 0.61, respectively. This treatment resulted in about 0.24 and 0.59 decreases in the NDF contents of the treated GHW and AH, respectively. The ADF values of the treated GHW and AH were reduced by 0.05 and 0.22, respectively.

Feeding trial

Animals fed the treated ingredients consumed less ($P < 0.05$) total feed compared to the control animals (**Table 3**). Weight gain was similar in all treatments. However, treated ingredients resulted in 0.02 - 0.09 increases ($P = 0.148$) in lamb weight gain (**Table 3**).

Similar trend was observed for the ADG, where both chemical (*i.e.*, NaOH treatment) and biological (ensiling) treatments had positive effects ($P = 0.140$) on the ADG (**Table 3**). Treated ingredients increased ($P < 0.05$) FCR by 0.08 - 0.11.

The cost per kg gain is shown in **Table 3**. The highest ($P < 0.05$) cost of gain was observed in lambs fed the control ration.

Table 3 Effects of ensiled greenhouse wastes (GHW), almond hulls (AH) and alkali-treated GHW on feed intake, body gain, and feed conversion ratios (FCR) of Assaf lambs.

	Dietary group ¹				P value
	Control	Ensiled GHW	Alkali-treated GHW	Ensiled AH	
DMI, kg	1.84 ^a	1.77 ^b	1.75 ^b	1.74 ^b	0.0002
Initial body weight, kg	36.0	33.4	37.4	37.9	0.097
Final body weight	53.6	53.2	56.5	56.2	
Weight gain, kg	17.9	19.5	19.1	18.3	0.148
Average daily gain, g	288.0	314.5	308.8	295.7	0.140
FCR	6.4 ^{a,1}	5.7 ^b	5.7 ^b	5.9 ^b	0.009
Cost of 1 kg gain, \$	3.26 ^a	2.73 ^b	2.71 ^b	2.83 ^b	0.001

¹Means in the same row with different superscripts are significantly different ($P \leq 0.05$) using Duncan's Multiple Range test for multiple comparisons. FCR = Feed conversion ratio.

Chemical compositions

Laboratory analyses of GHW showed comparable values to those associated with the raw ingredients [17]. The CP of AH measured in this study (34.0 g/kg DM) was higher compared to values in some previous reports [18-23] but was consistent with Fadel's [24] reported values. Differences among studies may be related to species or genetic variation. The CP content of almond hulls usually varies in the range of 48.7 24 and 80.0 10 g/kg DM.

Ensiling of AH and GHW improved the CP content of both ingredients. There are considerable changes in the nitrogenous fractions of forages during ensiling. Microbial proteases appear to be relatively active throughout a period of fermentation. Schaadt and Johnson [25] reported a loss of true protein in corn silage, presumably due to proteolysis during ensiling; however, the time and severity of proteolysis is not clear. Filya [26] reported increasing amounts of NH₃-N in corn and sorghum silages through ensiling. Kleinschmit *et al.* [27] reported a steady increase in NH₃-N in corn silage through ensiling without reaching a plateau. Newbold *et al.* [28] reported increasing amounts of degradable CP with time.

The decrease in fiber content reported in this study may be due to the partial hydrolysis of hemicelluloses and lignin, which could be related to acidic conditions as a result of organic acid development in silage materials and the prevalence of anaerobic bacteria. The lignin fraction might be reduced because of the microbial degradation of the bonds between lignin and carbohydrate polymers (cellulose, hemicelluloses, lignin). High degradation of carbohydrate polymers may be due to the prevalence of anaerobic conditions which were suitable for the development of some microorganisms having the ability to aid in the breakdown of these polymers' carbohydrate active enzymes.

Feeding trial

The improvement in performance might be due to the presence of easily digestible cell walls in the tested materials, which had a positive effect on rumen microflora, and to the high degradability of ADF and NDF in the presence of limited lignin content. Ben-Ghedalia *et al.* [29] showed that there is some improvement in nutrient utilization from by-products due to its positive effect on rumen microflora activity. Moreover, it has been proposed that the highly digestible fibrous fraction of the treated GHW and AH may increase the number of bacteria in ruminal fluid.

The average daily gain (ADG) in lambs fed the 4 rations was 288.8, 314.5, 308.0, and 295.7 g for the control, ensiled GHW, alkali-treated GHW and ensiled AH, respectively. The highest gain was observed in lambs fed ensiled GHW, while the lowest gain was associated with the control lambs. The increase in gain was due to organic acid and lactic acid, which improve the dry matter digestibility. Addition of readily fermented carbohydrates increased the rate of fermentation by increasing organic acids, which resulted in a low pH value. The higher feed intake (FI) observed in the control lambs might be the reason for the low FCR in these lambs.

Similar findings were reported where the ensiling process had some improvement associated with increasing total tract digestibility through effects on the structural carbohydrates [30-33].

The highly digestible fibrous fractions like those in silages and the sodium hydroxide-treated ingredients used in this experiment may have enhanced the number of bacteria in ruminal fluid and may have created favorable conditions in the rumen of lambs for the enhancement of microbial activity. The results of this pattern of fermentation caused the production of acetic acid, which promoted fat syntheses and more gain [34]. However, the differences observed in daily gain among lambs in different experimental groups may be attributed to a different pattern of volatile fatty acid production.

In order to calculate the amount of savings that could be achieved by feeding the treated ingredients, the averages of total gain, the FCR, and the cost of 1 kg feed of the rations (*i.e.*, 19.0 kg, 5.8, and 0.47, respectively) were considered.

Cost of gain was reduced through feeding ensiled ingredients. This can be explained by the significant differences in price per kg among the tested rations (**Table 3**). The reported figures from this experiment show the economic feasibility of feeding such type of ingredients and the savings that could be achieved.

Conclusions

It can be concluded that ensiled GHW and AH or alkali-treated GHW had positive effects on the conversion ratio (CR) of Assaf lambs. Treated GHW and AH can be incorporated into concentrate mixtures, as crude, ensiled, or alkali-treated, at inclusion levels of 200 kg/t, with no adverse effects. Adoption of this option provides the fattening industry with an inexpensive, nonconventional feed ingredient, and reduces the environmental pollution caused by waste disposal.

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