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Utilization of Date by Product on Sheep Feeding: Its Ruminal Degradation, Nutrient Digestibility and Its Effect on Sheep Growth

Research Article

M. Taghinejad-Roudbaneh[1*], S.R. Ebrahimi-Mahmudabad[2], H. Ghoreyshi[1] and M. Kazemi-Bonchenari[3]

[1] Department of Animal Science, Faculty of Agriculture Science, Tabriz Branch, Islamic Azad University, Tabriz, Iran
[2] Department of Animal Science, Faculty of Agriculture Science, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran
[3] Department of Animal Science, Faculty of Agriculture and Natural Resources, Arak University, Arak, Iran

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*Correspondence E-mail: mtaghinejad@iaut.ac.ir

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ABSTRACT

This study was conducted in two separate experiments. Four rumen-cannulated sheep were allocated in the first experiment to evaluate date by-product (DBP) and date seed (DS) nutrients degradation in rumen. In experiment two eighteen fattening lambs were allocated in three different treatments (6 animals/treatment) to evaluate DBP effects on animal performance and nutrients' digestibility. Three experimental treatments were as follow; 1) control group (C, diet without DBP inclusion), 2 and 3) diets with DBP at two inclusion levels of 10(DBP10) and 20(DBP20) %, respectively. The performance trial lasted 90 days. The results of degradation kinetics showed that both wash out fraction (a) and potentially degradable fraction (b) were greater in DBP compared to DS for dry matter (DM), organic matter (OM) and neutral detergent fiber (NDF) degradation. Effective degradability for DM, OM and NDF was differed between DBP and DS in all measured passage rate times. Results of the performance trail revealed that inclusion of 20% DBP decreased daily gain (DG) and hence increased feed conversion ratio (FCR; 7.1, 7.7 and 8.6 for C, DBP10 and DBP20, respectively). Daily gain was 210, 200 and 160 g/d for C, DBP10 and DBP20; respectively showing that inclusion of 20% decreased gain but the inclusion of 10% had an acceptable gain compared to control treatment. The diet cost was decreased by inclusion of DBP. Considering the degradation rate of DBP in rumen and also the performance trial results, it could be suggested that limited inclusion of DBP in sheep diet could decrease dietary costs and improve economic efficiency without reducing gain or efficiency in intensive lamb fattening system.

KEY WORDS date by-product, digestibility, rumen degradability, sheep.

INTRODUCTION

A major problem that limits livestock production in countries of the arid region is the high cost of animal feed. This is mainly due to an acute shortage in fresh water that limits the utilization of arable land for the production of food for human and animal consumption. In recent years, the price of energy supplements has increased dramatically with the increase of demand for feeds to animals. The increase in feed price encouraged nutritionists to search for cheaper feed ingredients. Recycling of agricultural wastes and their utilization as alternative energy sources for ruminant feeding is important for economical and environmental reasons. In Iran, around one million tons of date is produced annually (FAO, 1993). Waste disposal and by-product management in food processing industry pose problems in the areas of environmental protection and sustainability (Jayathilakan *et al.* 2012). In date (*P. dactylifera*) packing and processing operations a number of by-products are becoming available. The main by-products are cull dates and date pits from packing operations, and pits, press cakes and mixed date seed and fiber, from date processing, which could be used to feed animals (Al-Yousef *et al*. 1993). Agricultural by-products and agro-industry wastes are commonly used in cattle diets in Iran. Regarding the sheep production industry in Iran, usually diets contained barley grain, wheat bran and grass or legumes hay in feeding animals. Dates could be used as an energy source to replace a part of the concentrates in the ration (Al-Dabeeb, 2005; Rekik *et al*. 2008; Ziaei, 2010; Mebirouk-Boudechiche and Araba, 2011). Energy level and source in the diet affect the animal performance and feed utilization (Nunes, 1994). The level of energy supplementation in the diet depends on animal species, climatic condition, and productive performance (Brydt *et al*. 1995; Sumeghy, 1995; Strzetelski, 1996). There are some papers regarding the using of date by-product in livestock diets (El-Hag *et al*. 2002; Al-Dabeeb, 2005; Rekik *et al*. 2008). Use of date palm by-products in animal feed has long been practiced by local farmers in a traditional way. However it seems that for this by product it needs to conduct more studies to evaluate the rumen degradation kinetics and digestibility. The objective of the present study was to investigate the ruminal degradation of nutrients in mixed date seed and fiber, which called date by-product (DBP). Moreover the inclusion of this feed on economical and nutritional characteristics in Ghezel lamb fattening was conducted as well.

MATERIALS AND METHODS

Laboratory analysis

The date seed (DS) and date by-product (DBP) was supplied by a Lavashak industrial unit and the date processing factory of Shahdbab in Azerbaijan-e-sharghi region, Iran. The by-product was consisted of seed and fiber residuals after processing in factory. Feed samples were analyzed for DM, CP, crude fiber (CF), ether extracts (EE) and Ash as described by AOAC (2000). The DM content was determined in feed samples by oven drying at 95 ˚C for 12 h (method 934.01, AOAC, 2000) and for nylonbag residues at 60 ˚C for 48 h. The N in feed samples was determined according to AOAC method (method 976.05, AOAC, 2000). Ash was determined by burning duplicate 2 g samples at 600 1C for 2 hina muffle furnace (method 942.05, AOAC, 2000).

Ether extraction was determined after extractionwith ether (method 920.39, AOAC, 2000). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined, using an automatic fiber an lyzer (Fibertec System M, Tecator, Hoganas, Sweden).

In situ experiment

Four rumen-cannulated Ghezel sheep averaging 45.6 kg (SD=2.5 kg) were used to study the rumen degradability of DM, OM and NDF of DBP. The ruminal degradation of this feed was compared to date seed (DS) in this study. Basal diet was consisting of 600 g/kg alfalfa hay, 100 g/kg barley grain and 300 g/kg wheat bran. The animals were kept in individual cages and have free access to water. The animals were fed two times daily at 07:30 and 15:30. The DBP and DS samples ground to pass 2.5 mm screen size. 4 g of samples were weighed into nylon bags with 45 µm pore size. Duplicates of each feed were incubating for 4, 8, 16, 24, 48, 72 and 96 h, just before morning meal. After incubation, bags were removed from the rumen and rinsed with cold tap water, until the rinse water remained clear. The same procedure was applied to obtain the zero time value. Then, they were dried at 60 ˚C for 48 h in a forced air oven and then weighed. Aliquots of the bag residuals were used for different chemical composition determination. The degradation profiles were calculated by the nonlinear model described by McDonald *et al*. (1995). The effective degradability (ED) in the rumen was calculated by using NEWAY software.

$$ED= a + [(b\times c) / -(c+k)]$$

Where:
a: water-soluble fraction.
b: potentially degradable fraction.
c: rate of degradation of b.
k: passage rate of the digesta out of the rumen.

Performance trial

Performance trail was conducted on Ghezel lamb breed. The eighteen Ghezel male lambs (with an average BW of 25±2.1 kg and an average age of 120±14 days) were randomly allocated into three groups (six animals per each). The fattening period lasted 90 days. The animals in control group was fed diet containing 40% alfalfa hay, 30% wheat bran and 30% barley grain (control; C). Two levels of DBP in the diets (10 and 20%) were included as DBP10 and DBP20 treatments, respectively (Table 1). Animals in this experiment were fed *ad libitum* individually. The lambs were fed twice daily at 0800 and 1600 h. The study lasted 90 days and the first week was considered to adaptation of the animals to experimental conditions. The animals had free access to water. Orts were collected and weights recorded and the feeding rates were adjusted daily to yield orts of about 5-10% intake. Animals were weighed on weekly intervals basis before offering fresh feed allowance. Feed conversion rate (FCR) was calculated by dividing of BW changes to average intake of animal.

Table 1 Chemical composition and dry and organic matter digestibilities of date by-product (replicate=4)

Chemical composition	Date seed (DS)	Date by product (DBP)
Dry matter, %	91.5±1.10	93.5±1.26
Organic matter, %	90.1±0.45	91.3±0.98
Crude protein, %	4.5±1.18	5.6±1.37
Ether extract, %	6.0±1.12	8.0±1.40
Crude fiber, %	19.5±1.17	18.3±2.24
Neutral detergent fiber, %	52.4±3.57	48.8±4.12
Acid detergent fiber, %	44.5±3.40	42.3±3.74
Ash, %	1.4±0.26	2.2±0.31
NFE[1], %	68.6±1.95	65.9±1.82
Dry matter digestibility, g/kg DM	373±27.2	440±26.5
Organic matter digestibility, g/kg DM	381±24.5	453±22.0
ME[2], Mcal/kg	1.46±0.9	1.73±0.08

[1] Nitrogen free extract= 100 - %(crude protein+ether extract+crude fibre+ash).
[2] Metabolizable energy value was calculated: ME (MJ/kg DM)= 0.016 × DOMD, Mc Donald *et al*. 1995).

Intake of DM was computed based on the 60 ˚C DM determinations for total mixed ration and orts. After drying, ingredients and total mixed ration were ground through a 1 mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA). The samples were analyzed for total nitrogen, ether extract, DM and ash (AOAC, 2000), sequentially for NDF and ADF (Van Soest *et al*. 1991). For measurement of experimental diets digestibility, on the last seven days of experiment, fecal samples were collected daily from the lambs. Fecal samples were dried in a forced draft oven (60 ˚C; 72 h) and then ground through a 1 mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA). Equal DM from each fecal subsample was mixed to obtain one composite sample for each lamb. Chemical analyses were performed for fecal samples the same as to feed samples. Apparent total tract digestibility of nutrients in different experimental diets was measured by using acid insoluble ash as an internal marker (Van Keulen and Young, 1977).

Statistical analysis

Data were analyzed using Proc Mixed in SAS (SAS, 1996). The following model was fitted to variables that did not have repeated measurements over time:

$$Y_{ij}= \mu + S_i + T_j + \varepsilon_{ij}$$

Where:
Y_{ij}: dependent variable.
μ: overall mean.
S_i: effect of sheep i.
T_j: effect of treatment j.
ε_{ij}: residual error.

The following model was used for repeated measures variables over time (body weight and dry matter intake):

$$Y_{ijk}= \mu + S_i + T_j + Z_k + ST_{ij} + ZT_{jk} + \varepsilon_{ijk}$$

Where:
Y_{ijk}: dependent variable.
μ: overall mean.
S_i: effect of sheep i.
T_j: effect of treatment j.
Z_k: effect of sampling time k.
ZT_{jk}: interaction between time k and treatment j.
ST_{ij}: interaction of sheep i and treatment j.
ε_{ijk}: residual error.

All terms were considered fixed except for ε_{ijk} which was considered random. Differences between least square means were considered significant at $P < 0.05$ and differences were considered to indicate a trend toward significance at $0.05 < P < 0.10$.

RESULTS AND DISCUSSION

Chemical composition

The chemical analyses of date seed and date by-product are presented in Table 2. The results show that crude protein content of DS was lower (4.5%) compared to DBP (5.6%) and the NDF content also were 54.2 and 48.8%, for DS and DBP, respectively.

Table 2 Feed ingredients, chemical composition and dry and organic matter (DM and OM) digestibility of different experimental diets

	Treatments[1]		
	C	DBP10	DBP20
Alfalfa, (% in diet)	40	40	40
Barley grain, (% in diet)	30	30	30
Wheat bran, (% in diet)	30	19.5	9
Urea, (% in diet)	0	0.5	1
Date by-product	0	10	20
Chemical composition			
Dry matte[2], g/kg	891	905	903
Crude protein[2], g/kg	137	137	137
Crude fibre[2], g/kg	122	128	134
Ether extract[2], g/kg	270	260	240
Neutral detergent fibe[2], g/kg	357	359	364
Acid detergent fibe[2], g/kg	322	335	342
DM digestibility, g/kg DM	736	668	594
OM digestibility, g/kg DM	764	681	609
ME[3], Mcal/kg	2.42	2.38	2.34

[1] Treatments were as follow, C: control (with no inclusion of date by-product in diet); DBP10: 10% date by-product inclusion in diet and DBP20: 20% date by-product inclusion in diet.
[2] Each value is the mean of four observations.
[3] Metabolizable energy value was calculated: ME (MJ/kg DM)= 0.016 × DOMD, Mc Donald *et al*. 1995).

Rumen degradability kinetics

The wash out fraction “a” was 124, 116, and 90 g/kg for DM, OM, and NDF, for DBP and was 113, 103 and 85 g/kg for DS, respectively.

The parameters “a” and “b” values of OM and NDF were significantly different between DS and DBP (P<0.05). The effective degradation of nutrients in DBP and DS was significantly different for all outflow rates in this study (P<0.05) (Table 3).

Nutrients digestibility and performance

Results of growth performance, feed intakes and conversions in the fattening experiment are shown in Figure 1 and Table 4. The data for apparent digestibility of nutrients in experimental diets is presented in Table 4 as well. The digestibility of all nutrients in performance trail was decreased (except than that for EE) as DBP was included in diet.

The digestibility of DM decreased from 73.6% in lambs fed the control diet to 66.8 and 59.4% in those fed 10 and 20% DBP in diet, respectively. The average daily feed intake, average daily gain (210, 200 and 160 g/d) and final body weight (44, 43 and 39 kg) were significantly differentamong treatments (P<0.05). Lambs on 20% DBP diet consumed less feed compared to other two treatments. Diet supplemented with 10 and 20% DBP increased FCR compared to control group (FCR was 7.1, 7.7 and 8.6 for C, DBP10 and DBP20, respectively).

The digestibility of OM, CP, CF and NFE had shown to have the similar pattern with feed effiviency; being higher for the control group compared to the diets with DBP. Economic evaluation of the dietary treatments are summarized in Table 4. Supplementation of diets with DBP reduced feeding costs during the whole fattening period of Ghezel lambs by about 3.67 and 13.04 US $ in DBP10 and DBP20, respectively. On the other hand, the results show that the diet supplemented with the 20% DBP had the lowest net income. The diet supplemented with 10% DBP was higher in economic efficiency by about 3.4% relative to control diet. Nevertheless, the diet supplemented with 10% DBP was lower in economic efficiency by about 7.4% relative to the control diet.

It is obvious from the chemical composition of DBP that this feed is relatively fibrous with low protein content. However the ether extract was relatively high compared to other feeds used in ruminant nutrition.

Overall it seems the DBP has a relatively low nutritional value compared to typical feed used in the fattening lamb’s diet. Other studies also showed that this product had low nutritional value (El-Hag *et al.* 1993; Al-Dabeeb, 2005). The degradation kinetics for both wash out fraction “a” and potentially degradable fraction “b” showed that both DBP and DS had low degradation rate in rumen. Since the fiber content of this product is relatively high (48.8%) from one hand and the protein content is low (5.8%) from the other hand, it seems that chemical and physical processing of this product could help improve its degradation in the rumen. Bryant (1973) stated that ammonia nitrogen in rumen fluid could stimulate the activity of cellulolytic bacteria that subsequently cause to increase fiber digestion and degradation. Moreover the reports by Yang (2002) clarified that increase in nitrogen concentration in rumen fluid could directly affect fiber digestibility. The digestibility results of this study showed that the digestibility of DM, OM, CP, NFE and CF decreased with the increase of DBP level in the diet which is probably because of high fiber content and low nutritional value of this by-product.

Abdel-Rahman *et al.* (2002) included dates in the ration of Najdi sheep and found a drop in the rumen pH and a widening of the anion gap. They reported that digestibility of DM, OM, CP, NFE and CF decreased with the increase of the level of dates in the diet. El-Hag *et al.* (1993) reported a similar drop in digestion coefficients of CP and CF due to the inclusion of dates in the ration of sheep. Hmeidan *et al.* (1993) reported that using dates as an energy source up to 44% (based on DM) resulted in a significant drop in nutrient digestibility, nitrogen retention and energy utilization. Al-Yousef *et al.* (1993) reported a decrease in the apparent digestibility of CP and CF of the discarded dates.

Table 3 Nutrients degradability kinetics for date by-product (DBP) and date seed (DS) in sheep rumen

Nutrients		Degradation parameters			Effective degradability at outflow rate (g/kg)		
		a (g/kg)	b (g/kg)	c (h^{-1})	0.02 h^{-1}	0.05 h^{-1}	0.08 h^{-1}
Dry matter	DBP	124.2^{a}±23	436.7±43	0.039±0.01	414.4^{a}±33	317.0^{a}±28	268.6^{a}±29
	DS	113.4^{b}±16	440.0±52	0.032±0.02	275.0^{b}±28	198.4^{b}±21	169.2^{b}±17
	SEM	6.19	10.2	0.003	9.21	7.14	3.98
Organic matter	DBP	116.1^{a}±21	452.4^{a}±39	0.042^{a}±0.07	423.5^{a}±50	323.8^{a}±48	272.9^{a}±45
	DS	103.4^{b}±28	382.0^{b}±48	0.028^{b}±0.002	304.2^{b}±26	223.8^{b}±20	192.6^{b}±14
	SEM	3.71	8.12	0.004	11.2	8.3	6.4
Neutral detergent fiber	DBP	90.3^{a}±7.2	323.2^{a}±54	0.032±0.01	290.1^{a}±39	217.4^{a}±37	183.7^{a}±36.3
	DS	85.4^{b}±11	298.0^{b}±31	0.028±0.01	268.0^{b}±28	198.4^{b}±16	176.2^{b}±17
	SEM	3.13	5.16	0.002	7.32	5.12	4.09

a: wash out fraction degradation; b: potentially degradable fraction and c: rate constant of degradation of b fraction.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Total digestible nutrients decreased from 60.4% in the control ration to 54.2% in the 20% included discarded dates in diet. Same as the degradation, digestibility of nutrients especially fiber could be improved with nitrogen supplementation in diet (Bryant, 1973).

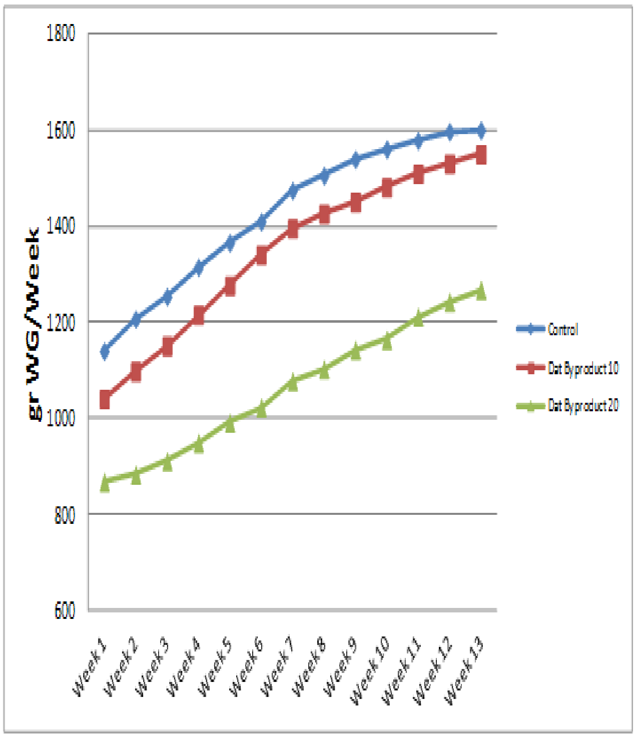

Figure 1 Weekly weight gain of lambs fed experimental diets

The results from the fattening experiment indicated that dietary inclusion of DBP at the level of 20% decreased the growth rate of the lambs compared to the control group (Figure 1). The gain was decreased by inclusion of DBP in lamb's diets showing the lower feed efficiency of this feed. The lower intake in this treatment compared to other two treatments might be the most important reason in reducing growth rate. The result observed in the present study to some extent is in agreement with results of Al-Dabeeb and Ahmed (2005) who reported that replacing the concentrates with 10 or 20% flesh date was associated with a decrease in daily gain. This finding is contrary to the results of El-Hag *et al.* (1993), who reported that the addition of discarded dates at the levels of 15 or 25% of ration (% of DM) was associated with an increase in growth rate of Awassi lambs, while feed intakes and feed conversion ratios (ranging between 7.51 and 8.30) were similar in all groups. Some contradicts between our results and the results of El-Hag *et al.* (1993) might be due to the date byproduct source, which was rich in fiber in our study while in the experiment of El-Hag *et al.* (1993) was rich in non-fibrous-high energy carbohydrate.

In the present study feed intake decreased and FCR increased by dietary inclusion of DBP at 20.

Table 4 Growth performance, feed conversion ratio, apparent nutrients digestibility and economy parameters in lambs fed experimental diets

	Treatments[1]		
Growth parameters	C	DBP10	DBP20
Initial body weight (kg)	25.6 ±1.75	25.2 ±1.90	25.4 ± 1.68
Final body weight (kg)	44.5^{a} ±4.05	43.2^{ab} ±4.05	39.8^{c} ± 4.05
Average daily gain (g/day)	210.3^{a} ±24.33	200.2^{ab} ±19.83	160.5^{c} ± 27.40
Total feed intake (kg)	134.2^{ab} ±4.10	138.6^{a} ±4.52	124.3^{b} ± 3.34
Daily feed intake (g/day)	1491.0^{ab} ±51.20	1540.4^{a} ±67.5	1380.2^{b} ± 48.9
Feed conversion ratio (kg DM per kg gain)	7.1^{a} ±0.29	7.7^{b} ±0.45	8.6^{c} ± 0.31
Nutrients digestibility, g/kg DM			
Dry matter	736^{a} ±34.5	668^{b} ±41.4	594^{c} ±31.1
Organic matter	764^{a} ±32.1	681^{b} ±49.0	609^{c} ±28.5
Ether extract	702^{b} ±23.0	748^{a} ±38.0	727^{ab} ±29.3
Crude fibre	573^{a} ± 43.9	498^{b} ±29.8	425^{c} ±31.0
Nitrogen free extract	772^{a} ± 33.6	676^{b} ±35.2	562^{c} ±41.6
Neutral detergent fiber	637^{a} ± 48.5	585^{ab} ±36.1	501^{c} ±36.1
Acid detergent fibe	601^{a} ± 39.0	537^{b} ±33.7	486^{bc} ±33.7
Economy parameters			
Total gain in weight (kg)	18.9^{a}	18.0^{ab}	14.4^{b}
Total feeding cost (US$)	48.60^{a}	44.93^{b}	35.56^{c}
Total costs [a] (US$)	60.6^{a}	56.93^{b}	47.56^{c}
Price of kg live weight (US$)	5.3	5.3	5.3
Selling income [b] (US$)	100.17^{a}	95.40^{b}	76.32^{c}
Net income [c] (US$)	39.57^{a}	38.40^{ab}	28.76^{b}
Economic efficiency [d]	65.3^{ab}	67.5^{a}	60.5^{b}
Relative economic efficiency [e], RFE (%)	100	103.4	92.6

[1] Treatments were as follow, C: control (with no inclusion of date by-product in diet); DBP10: 10% date by-product inclusion in diet and DBP20: 20% date by-product inclusion in diet.
[a] Total costs in US$= feeding + fixed costs.
[b] Selling income in US$= total gain in weight × price of kg live weight.
[c] Net income in US$= selling income - total costs.
[d] Economic efficiency= (net income/total costs) × 100.
[e] REE: economic efficiency of DBP supplemented diet relative to the control diet.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

The lower daily gain with DBP diets was the main reason for greater FCR in DBP diets compared to control group from an economic point of view, although supplementation of DBP in the diets reduced the feeding costs during the fattening but the diet supplemented with 20% DBP had the lowest net income.

The greatest economic efficiency was achieved with 10% inclusion of DBP in the diet (65.3, 67.5 and 60.5 for C, DBP10 and DBP20, respectively).

CONCLUSION

In conclusion as inclusion rate of DBP was increased in this study, ration cost also was decreased. But reducing the intake, digestibility and consequently growth rate dictated the using no more than 10% of this by-product in sheep nutrition.

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