Effects of additives on chemical composition, degradability coefficients and ruminal-intestinal disappearance of dry matter and crude protein of laboratory ensiled olive cake

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Summary

The chemical composition, degradability coefficients (in situ) and ruminal-intestinal disappearance (mobile bag procedure) of dry matter (DM) and crude protein (CP) were evaluated for olive cake (OC) silages treated (DM basis) with additives as follows: (1) untreated OC, (2) OC + 0.5% urea, (3) OC + 0.4% formic acid, (4) OC + 8% molasses, (5) OC + 0.5% urea + 8% molasses, (6) OC + 0.5% urea + 0.4% formic acid, (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. The highest reduction in cellulose and ADF content was found for treatment 8 (120 and 117 g kg^{-1} DM, respectively), as compared with the raw material (not ensiled). Taking into consideration the chemical composition, pH values, and the general appearance of silages, ensiling of OC with additives preserved well and enhanced the nutritive value of olive cake. Ruminal maximum potential degradability of DM (a+b), effective and rapid degradability and rate of degradation of treatment 8 were higher than others. The same trend was found for CP except fraction "a" which was highest for treatment 6. Mean ruminal DM ($P<0.05$) and CP disappearances in treatment 8 after 12 hrs incubation were higher than the other treatments. Intestinal digestibility of undegraded DM for treatment 5 was higher ($P<0.05$) than treatment 6 with no differences among other treatments. Intestinal digestibility of undegraded CP for treatments 3, 5, 6 and 7 was higher ($P<0.05$) than the other treatments. Total tract DM disappearance of treatments 4, 5 and 8 was higher ($P<0.05$) than others. Total tract CP disappearance of treatment 8 was higher ($P<0.05$) than treatment 4. Results indicated that treating OC before ensiling with 8% molasses, 0.4% formic acid and 0.5% urea (DM basis) could provide a good and economical source of a non-conventional feed in areas where OC is available; thus, it helps to improve the diet formulation for ruminants.

Key words: Olive cake, Degradability, Silage, Urea, Formic acid

Introduction

In arid and semi-arid parts of the world like Iran, the major nutritional limitation for animal production is low availability of vegetation which limits intake of energy and protein. Under range conditions, nutrients are available only for a short time, and for the rest of the year, the production system requires hand feeding of concentrates and roughages which may be expensive. There is a need to search for non-conventional feedstuffs. On the other hand, the major part of the ruminant diet in developing tropical-areas is supplied by tropical plants that are low in protein and high in cell wall contents with variable mineral concentrations (Göhl, 1981). Therefore, in order to design an optimum diet, it is necessary to evaluate tropical feeds according to the quantity and quality of energy and protein available to the animal (Aregheore, 2000). One of such feedstuffs available in Iran is crude olive cake, the by-product of oil extraction from olive fruits. Under the government planning, the annual production of olive fruits is expected to increase with the expansion of areas allocated to olive plantation (up to 700,000 ha.). Crude olive cake contains the seeds or pits and the pulp, and due to variable processing methods, it varies widely in composition (Morgan and Trinder, 1980; Ohlde and Becker, 1982; Harb, 1986). This by-product is highly fibrous (Ohlde and

Becker, 1982; Alibes and Berge, 1983) and is low in crude protein (CP) content (Nefzaoui, 1983; Hadjipanayiotou, 1994). In addition, a large proportion of the protein (80 to 90%) is linked to the ligno-cellulose fraction (Nefzaoui, 1983).

Despite the shortage of animal feedstuffs, the use of crude olive cake in ruminant diet is limited because of its low nutritive value and seasonal availability (Aguilera *et al*., 1992). Stacking of this by-product near the small local factories results in a considerable deterioration (mould formation) of the material and wastage of potential nutrients due to its relatively high water and oil contents. Fresh olive cake can only be stored for a very short period and should be given quickly to animals or ensiled as soon as possible to prevent its spoilage. Different chemical, physical and biological methods have been used to improve the nutritive value of olive cake (OC) (Karapinar, 1977; Worgan, 1978; Nefzaoui *et al*., 1982, 1983; Vaccarino *et al*., 1982; Hadjipanayiotou, 1994).

Although, tropical feeds have been known to have low ruminal and post-ruminal digestible protein, it seems that the ensiling technique and using additives at ensiling can be used for long-term storage and improving the nutritive value of OC. In vitro and in situ data on ruminal and post-ruminal disappearance of tropical feed dry matter (DM) and protein are limited (Göhl, 1981).

The objective of this study was to investigate the effect of different additives on chemical composition, rumen degradability and ruminal-intestinal disappearance of laboratory ensiled OC.

Materials and Methods

Silage preparation

Fresh OC (76.6% DM) was obtained from an olive mill near the city of Shiraz. Based on several samples of fresh OC, it comprised of almost equal proportions of pulp and pits. The chemical composition of the raw material was determined (see below). OC was ensiled for 60 days in 3-kg plastic buckets (3 per treatment) after the addition of additives (DM basis) as follows: (1) untreated OC, (2) OC + 0.5% urea, (3) OC + 0.4% formic acid, (4) OC + 8% molasses, (5) OC + 0.5% urea + 8% molasses, (6) OC + 0.5% urea + 0.4% formic acid, (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. After 2 months, representative samples were taken for chemical analysis and determination of rumen degradability and ruminal-intestinal disappearance of DM and CP.

In situ rumen degradability and ruminal-intestinal DM and CP disappearance

Rumen degradability was estimated in sacco (Orskov and McDonald, 1979). The dry samples were ground using a grinder with a 2-mm sieve. Approximately, 5 g of each sample (DM) was transferred into polyester bags (12 × 19 cm) with 50 μm pore size. Four bags per treatment and inculcation time, were incubated in the rumen of two fistulated Mehraban male lambs (average weight = 41 kg) for 8, 16, 24, 48 and 72 hrs. Four bags were also washed with cold tap water to estimate zero time wash-out. After each incubation time (including the 0 hr bags), the bags were removed and hand-washed with cold tap water until the water remained clear.

Samples were then dried in an oven at 55°C until a constant weight was achieved before determination of DM disappearance. The degradability coefficients of DM and CP were determined by using the following equation: $P = a+b(1-e^{-ct})$, where P is potential degradability, “a” is the fraction that is soluble or immediately degraded, “b” is the fraction that is potentially degradable but insoluble, and “c” is the rate of degradation of the sample “b” fraction per hour. All lambs were fed a diet consisting of 400 g alfalfa hay, 700 g corn silage and 300 g barley grains. The ration was fed in equal portions every 12 hrs to maintain a relatively stable rumen environment.

Disappearance of DM and CP was determined by using the in situ mobile bag technique (Subuh *et al*., 1996). Four Holstein steers (395 ± 13 kg) fitted with ruminal fistula and a T-shaped intestinal cannula were used. Each steer was fed (DM

basis) daily 5.1 kg alfalfa hay, 1.2 kg corn silage and 2.7 kg concentrate mix (171 g CP kg^{-1} DM). Steers were housed indoors in individual pens, with free access to water. Bags (3 × 6 cm) were made of artificial silk cloth with a pore size of 48 μm. Approximately, 1.2 g of sample DM were placed in each bag (16 bags per sample), then inserted into plastic cylinders (26 × 8 cm, 0.57 mm pore size) and incubated in the rumen for 12 hrs. After removal from the rumen, bags were washed using cold tap water and 8 bags per sample out of 16 were used for determination of post-ruminal digestibility. The bags were inserted into the small intestine via the intestinal cannulae at the rate of one bag every 30 min. The bags were then removed from the voided feces and rinsed in cold running tap water. The bags were dried in a forced-air oven (58°C, 48 hrs) and DM and CP disappearance of samples were calculated.

Chemical analyses

DM was determined by oven-drying at 105°C for up to 24 hrs until a constant weight was achieved. Ash, ether extract (EE) and CP (Kjeldahl N × 6.25) were determined as described by AOAC (2000). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin were measured according to the method of Goering and Van Soest (1970). Hemicellulose and cellulose were calculated as NDF-ADF and ADF-ADL (acid detergent lignin), respectively.

Calculations and statistical analysis

Ruminal, post-ruminal and total tract disappearance were calculated as described by Subuh *et al*. (1996) for the mobile bag technique. Disappearance of DM and CP at 12 hrs incubation in the rumen was calculated as the difference between the feed and the portion remaining after incubation in the rumen. Disappearance in the intestinal tract was calculated as the differences between the rumen residue after 12 hrs of incubation and the portion remaining in the samples recovered from feces. Data, except for degradability experiment, were analysed using the general linear model procedure of the SAS (1996). Mean comparison was performed by using the SNK test.

Results

The DM content of the fresh OC, was 766 g kg^{-1}. Each kg DM of untreated fresh OC contained 56.4 g CP, 680 g NDF, 590 g ADF, 123 g lignin, 90 g hemicellulose, 467 g cellulose, 980 g organic matter and 99.4 g EE (pH = 5.59).

The chemical composition and pH values of OC silages treated with different additives are shown in Table 1. As expected, the CP content of the silages containing urea was significantly ($P<0.05$) higher than those of other silages. Also, pH was affected by the inclusion of additives (Table 1). Cellulose, hemicellulose, ADF, NDF, lignin and organic matter contents of the silages containing additives were not significantly different from the control. There was some non-significant reduction in the ADF content of the ensiled material, as compared with the raw material; the highest reduction was found in treatment 8 (117 g kg^{-1} DM). There was also some reduction in the cellulose content of all silages, more considerable for treatments 2, 3 and 8 (104, 100 and 120 g kg^{-1} DM, respectively).

The DM degradation kinetics of untreated OC and OC treated with additives are presented in Table 2. Fraction “a” was highest (32.44%) for treatment 8 and lowest for treatments 1 (17.2%) and 2 (16.61%). Treatment 8 had the lowest (13.44%) and treatment 1 had the highest (22.13%) values for fraction “b”. The “b” fraction of DM for treatment 8 reflected the inverse of the “a” fraction. The degradation rate (c), effective degradability (ED) and maximum potential degradability (a+b) were highest for treatment 8, indicating the ability of the relevant additives (molasses, formic acid and urea) for enhancing the rumen degradability of OC.

The CP degradation kinetics are presented in Table 3. Fraction “a”, was highest for treatment 6 (42.46%) and lowest for treatment 1 (18.01%). The “b” fraction was highest for treatment 4 (56.98%) and lowest for treatment 6 (36.03%). Constants (c), (a+b) and ED were highest for treatment 8, showing the same trend as for DM

Table 1: Chemical composition (g kg^{-1} DM) and pH values of silages of untreated olive cake and olive cake treated with additives after 60 days of ensiling

Parameters	Treatments							
	1	2	3	4	5	6	7	8
DM (%)	74.07^{ab}	69.24^{b}	74.54^{ab}	71.04^{ab}	72.55^{ab}	75.91^{ab}	78.53^{a}	76.71^{ab}
pH	5.61^{a}	5.72^{a}	5.38^{a}	4.84^{b}	5.48^{a}	4.57^{b}	4.39^{b}	4.56^{b}
CP	63.4^{c}	75.0^{a}	66.7^{bc}	64.80^{c}	72.7^{ab}	75.0^{a}	63.6^{c}	76.4^{a}
NDF	787^{ab}	780^{ab}	800^{a}	713^{b}	767^{ab}	780^{ab}	720^{ab}	723^{ab}
ADF	587^{a}	537^{a}	510^{a}	580^{a}	543^{a}	537^{a}	520^{a}	473^{a}
Lignin	163^{ab}	173^{a}	143^{ab}	130^{ab}	110^{b}	133^{ab}	140^{ab}	127^{ab}
Hemicellulose	200^{ab}	243^{ab}	290^{a}	133^{b}	223^{ab}	243^{ab}	200^{ab}	250^{ab}
Cellulose	423^{a}	363^{a}	367^{a}	450^{a}	433^{a}	407^{a}	380^{a}	347^{a}
Organic matter	976^{ab}	978^{a}	975^{ab}	970^{b}	977^{ab}	978^{a}	977^{ab}	977^{ab}

(1) Untreated OC; (2) OC + 0.5% urea, (3) OC + 0.4% formic acid; (4) OC + 8% molasses; (5) OC + 0.5% urea + 8% molasses; (6) OC + 0.5% urea + 0.4% formic acid; (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. ADF: Acid detergent fiber; CP: Crude protein; NDF: Neutral detergent fiber. $^{a, b, c}$Means within each row with similar letter(s) are not significantly different (SNK-P>0.05)

Table 2: Dry matter degradation kinetics of silages of untreated olive cake and olive cake treated with additives (%)

Constants	Treatments							
	1	2	3	4	5	6	7	8
a	17.20	16.61	24.60	24.97	20.76	26.78	30.02	32.44
b	22.13	15.25	18.06	19.38	17.85	17.44	15.17	13.44
a+b	39.33	31.86	42.66	44.35	38.61	44.22	45.19	45.88
C (h^{-1})	0.031	0.102	0.074	0.061	0.104	0.09	0.111	0.121
ED	25.65	26.86	35.39	35.62	32.80	37.99	40.47	41.95
RSD	0.8	1.66	1.34	1.68	0.817	1.71	2.62	1.54

(1) untreated OC; (2) OC + 0.5% urea; (3) OC + 0.4% formic acid; (4) OC + 8% molasses; (5) OC + 0.5% urea + 8% molasses; (6) OC + 0.5% urea + 0.4% formic acid; (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. a: Fraction that is soluble or immediately degraded. b: Potentially degradable but insoluble fraction. a+b: Maximum potential degradability. c: Rate of degradation of the sample "b" fraction (per hr). ED: Effective degradability values at 0.05 per hr outflow rate. RSD: Residual standard deviation

Table 3: Crude protein degradation kinetics of silage of untreated olive cake and olive cake treated with additives (%)

Constants	Treatments							
	1	2	3	4	5	6	7	8
a	18.01	21.79	24.60	22.28	37.90	42.46	33.77	38.81
b	48.05	49.29	54.98	56.98	43.90	36.03	49.46	44.89
a+b	66.06	71.08	79.58	79.26	81.80	78.49	83.23	83.70
C(h^{-1})	0.048	0.056	0.056	0.046	0.056	0.058	0.056	0.072
ED	41.64	46.32	53.64	49.74	61.07	61.80	60.00	65.27
RSD	3.38	6.63	6.18	6.63	3.45	4.08	4.43	4.41

(1) untreated OC; (2) OC + 0.5% urea; (3) OC + 0.4% formic acid; (4) OC + 8% molasses; (5) OC + 0.5% urea + 8% molasses; (6) OC + 0.5% urea + 0.4% formic acid; (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. a: Fraction that is soluble or immediately degraded. b: Potentially degradable but insoluble fraction. a+b: Maximum potential degradability. c: Rate of degradation of the sample "b" fraction (per hr). ED: Effective degradability values at 0.05 per hr outflow rate. RSD: Residual standard deviation

degradability.

Results of ruminal, post-ruminal and total tract DM disappearance are shown in Table 4. There was a significant effect (P<0.05) of additives on DM disappearance. Mean ruminal DM disappearance (after 12 hrs of rumen incubation) for treatment 8 was higher than the other treatments.

Table 4: Dry matter disappearance in the rumen (12 hrs incubation), in the intestines (percentage of 12 hrs rumen residue) and in the total tract for untreated olive cake and olive cake treated with additives (mean ± SD; % of DM)

Treatments	Rumen	Intestine	Total tract
1	13.33 ±1.37^{c}	10.67 ±2.58^{ab}	22.50 ±3.5^{e}
2	14.50 ±1.05^{c}	13.33 ±2.07^{ab}	26.00 ±1.55^{cde}
3	13.17 ±1.47^{c}	12.67 ±3.67^{ab}	23.17 ±2.14^{de}
4	20.67 ±1.75^{b}	13.67 ±1.86^{ab}	31.33 ±2.94^{abc}
5	21.67 ±2.50^{b}	15.00 ±3.22^{a}	33.33 ±3.56^{ab}
6	19.17 ±3.92^{b}	9.33 ±2.73^{b}	27.50 ±2.66^{bcde}
7	21.67 ±0.82^{b}	10.33 ±1.37^{ab}	28.17 ±1.60^{bcd}
8	26.67 ±3.14^{a}	14.00 ±3.22^{ab}	37.17 ±6.01^{a}

(1) Untreated OC; (2) OC + 0.5% urea; (3) OC + 0.4% formic acid; (4) OC + 8% molasses; (5) OC + 0.5% urea + 8% molasses; (6) OC + 0.5% urea + 0.4% formic acid; (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. $^{a, b, c, d, e}$Means within each column with similar letter(s) are not significantly different (SNK-P>0.05)

The highest intestinal disappearance of DM expressed as a percentage of the rumen residue, was observed for treatment 5 (15.0%), and the lowest one was observed for treatment 6 (9.33%) (P<0.05) with no significant differences between the control and the other treatments. Except for treatment 5, a higher proportion of initial DM in treatment 8 was degraded in the intestine as compared with other treatments. The total tract DM disappearance was highest for treatment 8 (37.17%), and followed the same trend for ruminal DM disappearance (ED; Tables 2 and 3).

Results of ruminal, post-ruminal and total tract CP disappearance are presented in Table 5. There was a significant effect (P<0.05) of additives on CP disappearance. The lowest level of ruminal CP disappearance was observed for treatment 3 (7.6%) and the highest one was for treatment 8 (36.50%), which were significantly different from that of untreated OC silage. Post-ruminal protein disappearance varied from 33.83% for treatment 4 to 71.17% for treatment 7. In contrast to ruminal CP disappearance, post-ruminal disappearance for treatment 3 was relatively high (56.67%), indicating a high value for rumen undegradable protein (RUP). Total tract CP disappearance was highest (77.33%) for treatments 5 and 7, and lowest for treatment 4 (53.67%) with significant difference between treatment 4 and treatments 5, 6, 7 and 8.

Table 5: Crude protein disappearance in the rumen (12 hrs incubation), in the intestines (percentage of 12 hrs rumen residue) and in the total tract for untreated olive cake and olive cake treated with additives (mean ± SD; % of DM)

Treatments	Rumen	Intestine	Total tract
1	20.00 ±2.90^{bc}	49.00 ±13.73^{bc}	57.00 ±10.32^{bc}
2	13.50 ±6.09^{cd}	49.33 ±6.83^{bc}	58.00 ±8.39^{bc}
3	7.60 ±2.98^{d}	56.67 ±5.68^{ab}	59.50 ±4.68^{bc}
4	31.33 ±6.35^{ab}	33.83 ±9.91^{c}	53.67 ±2.94^{c}
5	23.17 ±7.52^{abc}	70.17 ±4.45^{a}	77.33 ±4.97^{a}
6	27.83 ±8.16^{ab}	58.83 ±11.02^{ab}	69.00 ±4.73^{ab}
7	22.17 ±7.73^{abc}	71.17 ±4.26^{a}	77.33 ±2.58^{a}
8	36.50 ±10.89^{a}	50.33 ±16.48^{bc}	67.61 ±14.36^{ab}

(1) Untreated OC; (2) OC + 0.5% urea; (3) OC + 0.4% formic acid; (4) OC + 8% molasses; (6) OC + 0.5% urea + 0.4% formic acid; (7) OC + 8% molasses + 0.4% formic acid and (8) OC + 8% molasses + 0.4% formic acid + 0.5% urea. $^{a, b, c, d}$Means within each column with similar letter(s) are not significantly different (SNK-P>0.05)

Discussion

Determination of chemical composition

is essential for understanding the nutritional potential of a feed, but it is not sufficient (El hassan *et al*., 2000). Therefore, in the present study, untreated OC and OC treated with different additives and ensiled for 60 days were evaluated for in situ ruminal, post-ruminal and total tract DM and CP disappearance. Digestibility of nutrients especially CP in the rumen and post-rumen is the most important criteria of the nutritional potential of OC (Nyambati and Sollenberger, 2003; Sandoval Castro *et al*., 2003). On the other hand, the supply of nutrients depends on voluntary feed intake and nutrient concentration in the feed (Orskov *et al*., 1988). Also, voluntary intake of a specific feed depends mostly on the rate of ruminal and post-ruminal digestion of potentially digestible nutrients (Orskov *et al*., 1988), mostly CP is a reference for feed digestion potentiality. Therefore, accurate estimation of ruminal and intestinal protein disappearance of feed is also important for diet formulation.

The addition of formic acid alone or in combination with other additives reduces the initial pH of the OC rapidly at ensiling (Mayne, 1993). Treating OC with formic acid (treatment 3) resulted in silages with high pH values, probably due to the fermentation restriction property of formic acid (Henderson *et al*., 1982; Chamberlain *et al*., 1990). In the present study, after 60 days, the pH values of treatments 4, 6, 7 and 8 (4.56-4.84) were in an acceptable range for stable silage (Stockes, 1992). The final pH of untreated OC silage was 5.61 which shows that OC silage may not have enough stability without additives like formic acid, molasses or urea. The higher pH value of the OC silage treated with urea alone can be explained by the conversion of urea to ammonia.

The reduction in fiber content of the urea-treated silage compared to the raw material can be due to the effect of ammonia on the cell wall components. One of the aims of urea treatment is to increase the digestibility of the cell wall, by increasing ammoniation (Sundstol and Coxworth, 1984) through breaking some of the chemical bonds between xylans and lignins, allowing penetration of enzymes into its structure. Reduction of fiber content with formic acid treatment may be due to direct acid hydrolysis of fiber (Morrison, 1979). It has been reported that the cellulose content of ADF may be decreased during ensiling by up to 5% (Morrison, 1979). While the increase in ADF and NDF can be explained by the loss of fermentable material during ensiling process (McDonald *et al*., 1962).

The synergistic effect of urea and formic acid (treatments 6, 7 and 8) was reflected in highest degradability of DM and CP (Tables 2 and 3). Since OC is a highly fibrous by-product, fiber reduction can be advantageous. Considering pH, aroma and texture, all silages were better in quality than the untreated OC, especially for treatments 7 and 8.

The “a” values for DM degradation (Table 2) were much higher than the “a” value reported by Hadjipanayiotou (1994) for untreated OC (2.1%), which might be due to the using of additives. The higher “a” value for treatment 8, could be due to the synergistic effect of urea and formic acid in degrading ligno-cellulose fraction of the cell wall and also high water soluble carbohydrates in molasses. The DM degradability values (except those of treatments 1 and 2) were higher than 34% reported for exhausted (solvent extraction) OC by Nefzaoui (1983). There was a 23.72% increase in DM degradability of treatment 8 (41.95%) compared with 32% reported by Nefzaoui (1983). The effective degradability and the rate of degradation of all silages were higher and lower than the values reported by Hadjipanayiotou (1994, 8.7% and 2.69 hr^{-1}, respectively).

For all silages the in situ disappearance of DM after a 12-hr rumen incubation was lower than the effectively fermented fraction calculated from degradation characteristics in the rumen (Chiou *et al*., 1995) using an assumed passage rate of 5% per hr (Table 2).

Since mobile nylon bags were recovered from the feces, the disappearance of DM and CP were calculated as the sum of their disappearance in the small and large intestines. Although in this experiment the disappearance in the large intestine was not measured, other results indicated that large intestine fermentation had only a limited effect on total intestinal disappearance, both in nylon bag (Voigt *et al*., 1985; Van

Straalen *et al*., 1997) and in vivo experiments (Van Straalen and Tamminga, 1990).

Except for treatment 5, a higher proportion of initial DM in treatment 8 was degraded in the intestine compared with the other treatments. It has been documented that pre-incubation significantly increases the total disappearance of protein in the intestine compared with samples without pre-incubation (Hvelplund *et al*., 1992) and it is doubtful whether the 12-hr incubation in the rumen, before transferring samples into the duodenum is representative of actual rumen retention time. Based on values for intestinal DM disappearance (Table 4), if rumen retention time was longer than 12-hr, actual values would be lower than values found in this study.

The percentage of CP escaping rumen degradation (RUP) that is subsequently available for digestion in the small intestine, was also different for all treatments. The highest digestible RUP (disappearance in total tract- disappearance in rumen) value was for treatment 7 (55.16%) and the lowest value was for treatment 4 (22.34%) and treatment 8 was intermediate. It is obvious that feeding treatment 7 containing 55.16% RUP will result in a very different ration than feeding silage 4 containing 22.34% RUP. The results of CP disappearance indicated that treatment with lower ruminal disappearance (such as treatments 3, 5 and 7) was generally compensated for by higher intestinal disappearance.

Based on data from chemical composition, adding (DM basis) 8% molasses, 0.4% formic acid and 0.5% urea to OC (treatment 8) before ensiling not only resulted in a more nutritionally balanced product but it also resulted in better silage characteristics. There was a considerable variation in degradation kinetics, and ruminal, post-ruminal and total tract DM and CP disappearances among silages, but treatment 8 had the highest effective degradability, constant "c", total tract DM digestibility, although it was intermediate in total tract CP disappearance (with 33.17% RUP). Also, these findings could be used to improve the diet formulation for ruminants in different stages of production.

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