Effect of exogenous fibrolytic enzymes on digestibility and rumen characteristics in Shami goats

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Abstract

Twelve Shami male goats with average weight 43.3±1.2 kg and 3-4 years old were used to study the effect of exogenous fibrolytic enzymes (EFE) either pre–treated barley straw or supplemented with concentrate diet at different levels (0, 2,and 4%) on nutrient digestibility and rumen characteristics. All Shami goats were divided randomly into six groups (2 bucks each). All goats individually fed concentrate diets in a 2×3 factorial experiment according to maintenance requirement at 1% live body weight (LBW) while barley straw was offered *ad libitium*. The results showed that all nutrients digestibilities were not significantly affected by methods of application, levels of EFE and their interaction. There were numerical increases with increasing levels of EEE on dry matter (DM), organic matter (OM), nitrogen (N), neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibilities (%). Ruminal pH, ammonia–N, total volatile fatty acids (TVFA) concentrations, percentage of acetate, propionate and butyrate, were also not affected significantly by methods of application, levels of EFE and their interaction. There were numerical increased in TVFA and numerical decreased in NH_3-N concentrations as levels of EFE increased.

The results of this study indicated that both methods of application EFE may enhance digestibility and rumen fermentation in Shami goats when used higher enzyme levels.

Keywords: Exogenous fibrolytic enzymes, digestibility, rumen fermentation, Shami goats

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Introduction

Agricultural byproducts such as cereal straws are considered as stable source for ruminant feed in Iraq and the major limitation of using their residues as ruminants feed are their poor in nutrient such as protein content and vitamins but they are rich in fiber and lignin with low digestibility and palatability (16). Several methods used to improve the nutritive values of barley straw using physical, chemical and biological treatments (15, 16).The soundest strategy nowadays is using exogenous fibrolytic enzymes (EFE) as a driver for specific digestive and metabolic processes in the rumen which may maximize neutral digestive processes and increase nutrient bioavailability (4). The use of EFE to improve feed digestion and utilization has been focused of considerable research (6), but most of them have been conducted with mixed diets for high-producing ruminants or with medium- to high-quality forages, and consequently, there is little published information on how fibrolytic enzyme application can affect the digestion of low quality forages (6). Increasing the digestibility of low-quality forages using EFE could lead to significant improvements in ruminant performance (4). EFE can be used in two ways pre- treated and supplemented (6). Many researchers found that supplemented animal diets with EFE can improve feeds utilizations and animal performance by enhancing fiber degradation *in vitro*, *in situ* and *in vivo* (6, 31). Beauchemin *et al.* (6) reported applying EFE in ruminant diet improved feed digestibility but the result was varied. Positive effects of supplementing the diet with fibrolytic enzyme have been reported in dairy cows and beef steers, but the use of enzymes in the feeding of small ruminants has received little attention (36). The proper methods of enzyme applying to feed, enzyme levels, type of enzyme and proper conditions for adding enzyme is not known yet (4).

The objective of this study was to investigate the effect of methods of application EFE (pre-treated barley straw or supplemented to concentrate diet according to barley straw consumed), levels of EFE (0, 2, and 4%) and their interaction on nutrient digestibility and rumen fermentation characteristics in Shami goats.

Materials and methods

This study was carried out in Animal Farm of Animal Resources Department at College of Agriculture, University of Baghdad, Iraq.

Enzyme Product and cellulase assay

The commercial enzyme product used in this study was Farmazyme®

(Farmavet International, Istanbul, Turkey), and it was available in local market in powder form. According to the information provided by the manufacturer, Farmazyme® is a mixture of enzymes derived from fungi source, containing: cellulase (1,000,000 IU), xylanase (1,500,000 IU), ß-glucanase (100,000 IU), and α-amylase (160,000 IU) activities per kg of enzyme preparation. The cellulase activity in Farmazyme® was determined by measuring the concentration of reducing sugar (glucose) released by using dinitrosalicylic acid (DNS) method of (25). The cellulase activity was 22.33 IU/mg. measured at pH 6.5 and 40°C.

Animals and Management

Twelve Shami male goats, averaging 43.3±1.2 kg of body weight and 3-4 years old were used, from 18, November to 17, December 2013. Goats were divided into 6 groups of 2 goats each. All goats were vaccinated against enterotoxaemia and treated against internal parasites before starting the experiment. Goats separately were randomly allocated to the treatment according to live weight, and housed in individual pens (1.5× 2 m) in experimental field, all pens were supplied with two buckets to be used to offer concentrate and roughage diets separately. Pens were also supplied with mineral blocks. Free unlimited access to clean fresh water.

Barley straw, concentrate preparations and Enzyme treatments

Barley straw was chopped (approximate 1-2 cm) using a forage chopper and pre-treated with EFE (Farmazyme®) with two levels of enzyme 2 and 4%. (2 and 4 kg of EFE were dissolved in 100 liter of water, respectively). The barley straw (25 kg) was soaked in large containers contain each certain level of enzyme solution for 24 hrs., at the end of treatment period the treated barley straw was transferred into plastic sheets for dried by sun (3-5 days). Samples were stored in air tied containers for analysis. These were considered as pre- treated barley straw with EFE. For EFE supplemented treatment, Farmazyme® was introduced in powder form and mixed with concentrate diets according barley straw consumed. EFE was added to the concentrate with two levels of supplementation (2 and 4%) according to weight of straw consumed. The addition was made just before concentrate diets offered at every morning thought experiment. Shami goats were received same concentrate diet; it was composed primarily of barley grain (45%), soybean meal (15%), yellow corn (8%), and wheat

bran (30%) and minerals and vitamins (2%).The diets were: 0% EFE (untreated) barley straw+concentrate, 2% EFE pre-treated barley straw+ concentrate, 4% EFE pre-treated barley straw+ concentrate, untreated barley straw+unsupplement concentrate, untreated barley straw+2% EFE supplemented to concentrate, untreated barley straw+ 4% EFE supplemented to concentrate. Chemical composition of each ingredient, formulation and chemical composition of concentrate diets and barley straw are presented in Table 1.

Table 1.Chemical composition of ingredients, concentrate diet and barley straw used in this study (on DM% basis)

Ingredients	Barley grain	Soybean meal	Yellow corn	Wheat bran	Conc.	0% EFE BS	2% EFE Pre-treated BS	4% EFE Pre-treated BS
Dry Matter(DM) of fresh	**92.18**	**92.88**	**90.34**	**91.03**	**91.91**	**94.41**	**96.32**	**96.84**
Organic Matter (OM)	**96.77**	**92.67**	**98.65**	**94.25**	**92.94**	**88.17**	**85.68**	**84.14**
Ash	**3.23**	**7.33**	**1.35**	**5.75**	**7.06**	**11.83**	**14.32**	**15.86**
Crude Protein(CP)	**10.49**	**44.07**	**8.91**	**10.95**	**13.83**	**2.25**	**2.26**	**2.27**
Crude Fiber (CF)	**6.13**	**5.81**	**1.97**	**11.05**	**8.67**	**44.16**	**44.08**	**44.00**
Ether extract (EE)	**3.28**	**1.63**	**4.40**	**4.03**	**2.37**	**2.08**	**2.08**	**2.09**
Nitrogen free extract (NFE)	**76.87**	**41.16**	**83.37**	**68.22**	**68.08**	**39.68**	**37.26**	**35.79**
Neutral detergent fiber (NDF)	**24.10**	**16.48**	**14.71**	**50.66**	**38.73**	**81.39**	**80.81**	**80.62**
Hemicellulose (Hemi)	**16.83**	**6.60**	**11.30**	**35.85**	**28.72**	**26.96**	**26.80**	**26.88**
Acid detergent fiber (ADF)	**7.27**	**9.88**	**3.41**	**14.81**	**10.01**	**54.43**	**54.01**	**53.74**
Cellulose (Cell)	**5.48**	**7.29**	**1.81**	**11.53**	**7.51**	**42.89**	**42.49**	**42.23**
Acid detergent lignin (ADL)	**1.79**	**2.59**	**1.60**	**3.28**	**2.5**	**11.54**	**11.52**	**11.51**
ME*(MJ/KgDM)	**13.34**	**11.86**	**14.20**	**12.67**	**13.36**	**6.87**	**7.03**	**7.05**
IVOMD goats						**45.82**	**46.87**	**46.98**

BS= barley straw, EFE= Exogenous fibrolytic enzyme (Farmazyme®), Conc. =concentrate, IVOMD= *in vitro* organic matter digestibility

*Metabolizable energy (ME) values are estimated according to following equations of MAFF (22),

ME (MJ/kg DM) = IVOMD×0.15 for barley straw

ME (MJ/kg DM) = 0.012CP+0.031EE+0.005CF+0.014NFE for concentrate diet.

Digestibility of experimental diets

Before the start of the experiment, concentrate diets were gradually introduced to the animals over a 2 weeks preliminary period, barley straw and concentrate diets offered in the same time at 8.00 am. Concentrate diets which were offered to Shami goats at a rate of 1% of live body weight (LBW). While barley straw (either pre-treated or untreated) was offered *ad libitium*, offered feed and orts (refused feed) were sampled weekly and stored in air tied containers for chemical analysis.

Digestibility trail was conduct to determine the digestibility coefficients of total diets. All Shami goats were used over a 21 days preliminary period. Feces were collected by using special handmade digestion sacs and ensured separation of urine without sticking to their movement inside the individual pens housed in. Fresh feces excreted by each lambs were weigh precisely, and mixed thoroughly by hand, and about 10% were sampled daily, and stored at -20°C. At the end of the collection period, samples of feces will thoroughly mixed and one sample of each is obtained and stored in deep freezing (-20°C) for the subsequent chemical analysis.

Chemical Analysis

Dried samples (feeds, orts, feces) were ground through a Wiley with 1 mm screen, samples of feeds, orts, feces were analyzed for dry matter (DM), organic matter (OM), crude protein (CP) = nitrogen(N)×6.25, crude fiber(CF) and Ether extract (EE) according to standard method of AOAC (3).While nitrogen free extract (NFE) was calculated by difference. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest (14). Hemicellulose (Hemi) was calculated as the difference between NDF and ADF. Cellulose (Cell) was calculated as the difference between ADF and ADL. *In vitro* organic matter digestibility (IVOMD) of enzyme treated (24 hrs. Pre-treated with EFE at 2 and 4% barley straw) were determined with the first stage of Tilley and Terry (35).

Rumen fermentation characteristics

Moreover, the same treatments were used to determine rumen fermentation characteristics, rumen liquor samples were collected from all Shami goats using a smooth rubber stomach tube which connected to 50 ml syringe and inserted into the rumen via the esophagus at the last 2 days of digestibility trails. Rumen liquor samples were collected at zero time (just

before feeding) then 3 hrs. and 6 hrs. after morning feeding. Ruminal pH was measured immediately using handheld digital pH meter (HANNA Pocket pH-Meter SKU HI 98107).Total volatile fatty acids (TVFA) were estimated according to Warner (38). Ammonia –N was analyzed as described by AOAC (3). The molar proportions of individual VFA (acetate, propionate and butyrate) were determined by chromatography technique using high performance liquid chromatography (HPLC) model 10AV-LC, LC-10A, UV-Vis 10A-SPD Shimadzu, Japan, according to method described by Mathew *et al.* (23), in which sulfuric acid (0.013Molar) was used as a mobile phase.

Statistical analysis

Data were statistically analyzed as a 2×3 factorial experiment with completely randomized design (CRD) using ANOVA procedure of the SAS (32) to study the effect methods of application (pre-treated and supplemented) with levels of EFE (0, 2,and 4%). Duncan's multiple range tests was used to determine the significance of differences among treatments means (9).Sampling time were not introduce in the statistical analysis. Analysis of variance was carried out by using the following model:

$$Y_{ijk} = \mu + M_i + L_j + ML_{ij} + e_{ijk}$$

Where:Y_{ijk} = the response; μ = the overall mean; M_i = the effect of methods of application (i=1,2); L_j = the effect levels of enzyme (j=1,2,3); ML_{ij} = the interaction $method_i \times level_j$; e_{ijk} = the experimental error $_{ijk}$

Results and discussion

Nutrient digestibility

Main effect of methods of application EFE on nutrient digestibility

The results show no significant effected (P>0.05) using methods of application EFE (Farmazyme®) on all nutrient (DM, OM, NDF, Hemicellulose, ADF, Cellulose, ADL, CF, EE, and NFE) digestibilities in Shami goats (Table 2). This may be due to limited enzyme activity in the EFE (Farmazyme®) for pre-treated barley straw. Similar results were reported by Gallardo *et al*.(12) and Yescas-Yescas *et al*.(40) who found that 24 hrs. pre-treated of low quality forages with EFE (Fibrozyme®; cellulase and xylanase) did not improve *in situ* DM, NDF and ADF degradability in steers and sheep. Wang *et al.* (37) stated that the commercial EFE (containing cellulase, xylanase and β-glucanase activities) currently available can not destroy estrified bound in structural carbohydrate-lignin complex due to limited

activity. Similar results were reported by Hong *et al*. (17) and Wahyuni *et al*. (36) who showed that supplemented EFE (cellulase and xylanase) to the concentrate diets did not affect DM, CP, NDF and ADF digestibilities in goats. On contrary, other studies (4, 5, 19, 31) reported significant improve on DM, OM, CP, NDF and ADF digestibilities in goats by EFE supplemented, they revealed this improvement in digestibility probably due to the beneficial effect of EFE on fiber hydrolysis in rumen and rumen fermentation. Morgavi *et al.*(26) demonstrate synergism between exogenous enzymes and ruminal enzymes such that the net combined hydrolytic effect in the rumen was much greater than that estimated from individual enzyme activity.

The lack of EFE to improve digestibility in a current study may be due to an inappropriate methods of feed the enzyme product. EFE (Farmazyme®) supplemented to the concentrate diet according to barley straw used at time of feeding. Muwalla *et al*. (28) reported no significant difference in DM, OM, CP, NDF and ADF digestibilities in sheep when EFE (Maxicell®; cellulase) supplemented to the concentrate diet according to forage consumed. Beauchemin *et al.*(6) stated that the enzymes are most effective when added to feed in liquid form prior to feeding. In a current study, there was not pre-incubation period between the enzyme and the substrate (concentrate diets). Thus, a pre-incubation period is very important (20) to allow before feeding, a proper adsorption and binding of the enzyme to substrate, attachment and protection against degradation by rumen proteases and a stable enzyme feed complex (6).

Main effect of levels of EFE on nutrient digestibility

Statistical analysis revealed no significant effect as levels of EFE increased on all nutrient digestibilities in Shami goats (Table 2). This may be due to insufficient enzyme activity. Similar results reported by Wahyuni *et al*. (36) who found that apparent digestibilities of DM, OM and CP in goats were not affected by increased levels of EFE (cellulase, xylanase β-glucanase and amylase activities). Exogenous fibrolytic enzyme has typically been observed to increase the initial rate but not the extent of DM digestion when used in ruminant diets (10).

There were numerical increased in nutrient digestibilities as levels of EFE had been increased in a current study. This may be due to high level of EFE which was more efficient than low level. With high

level of EFE, there were insignificant increased in TVFA in Shami goats (Table 3). Similar results reported by Tang *et al.* (34) who found that higher level of EFE was better than low level in improved *in vitro* DMD and OMD of low quality forages using rumen liquor from goats. In contrast, Beauchemin *et al*. (6) stated that a high level of enzyme application was less effective than a low level at increasing total tract digestibility in dairy cows. The reason for poor response at higher level is partly attributed to negative feed back inhibition, which is one of the classical modes of enzyme action, this feedback mechanism occurred when enzyme action is inhibited by production of fermented sugars produce from cell wall hydrolysis may reduce the ruminal pH to levels that inhibit cell wall digestion in the rumen (1). The ruminal pH was not affected in the current study (Table3).

Interaction effect between methods of application and levels of EFE on nutrient digestibility

Statistical analysis revealed no significant differences (P>0.05) by interaction between methods of application and levels of EFE on all nutrient digestibilities in Shami goats (Table 2).This may be due to a lack of synchrony between fermentable energy and protein. As levels of EFE increased with pre-treated barley straw there were numerical increased on all nutrient digestibilities especially with high level (4%EFE Pre- treated barley straw) but not low levels (2%EFE) this may be due insufficient enzyme activity when pre treated barley straw at low levels (2%EFE Pre-treated). The results showed that EFE (Farmazyme®) has no effect *in vitro* OMD digestibility when pre treated barley straw used (Table 1), this may be due to enzyme feed specificity. The result obtained in a current study agrees with results reported by Gallardo *et al.* (12) who found no positive effect of EFE on digestibilities of low quality forages. Similar results were reported by Wahyuni *et al*. (36) who found that increasing levels of EFE (0, 2, 4 and 6g/kg) supplemented to the concentrate diets did not improve DM, OM, NDF and ADF digestibilities in goats. In contrast, Bala *et al.* (5) reported significant increased on digestibility of DM, OM, NDF, ADF and total carbohydrate in goats when supplemented concentrate diets with EFE product. As levels of EFE increased with supplemented to the concentrate diets there were numerical increased on all nutrient digestibilities in Shami goats but not significant (Table 2). This may be due to small increase in hydrolytic activity in the

rumen. There was increased in TVFA but not in NH_3-N concentration (Table 3).

There was positive effect of supplemented EFE to the concentrate diet, Salem *et al.*(31) reported that EFE (ZADO®; cellulase, xylanase, α-amylase and protease) supplemented daily(10g/head /day) leads to significant increased in apparent DM, OM,CF, CP, EE, NDF and ADF digestibility of goats. They revealed this improvement in digestibility probably due to the beneficial effects of ZADO® enzyme on fiber hydrolysis and rumen fermentation activity. Similar results were reported by Gado and Borhami (11) in Ossimi sheep. Azzaz *et al*. (4) also reported significant increase in all nutrient digestibilities in goats when supplemented EFE (cellulase). Generally, the mode of action by which enzyme can improve digestion is still subject to speculation, till now; little is know about the way that EFE improve feed digestibility in ruminants (4). Several modes of action have been proposed. These include: (a) Pre-ingested (pre-treated) with enzyme were found to increase microbial colonization of feed particles, by increase soluble carbohydrate released from undigested feed particles, which provides additional energy for microbial growth (39). (b) Enhance attachment and/or improve access to the cell wall matrix by ruminal microorganisms and accelerate the rate of digestion (29) and (c) enhancing the hydrolytic ability of ruminal microorganisms due to add enzyme activity (18) and/ or synergy EFE with rumen microbial enzymes (26). The lack effect of EFE to improve digestibility in a current study may be due the animal target. Shami goats fed on concentrate diet as 1% of LBW to meet the requirement of maintenance. Animal responses to EFE are expected to be greatest when energy was the first limiting and when fiber digestion was compromised in high production diary cows and fattening steers but not at maintenance level (6).

Rumen fermentation characteristics

Main effect of methods of application on rumen fermentation characteristics

The results showed that ruminal pH, NH_3-N, and TVFA concentration were unaffected (P>0.05) by methods of application EFE (Farmazyme®) in Shami goats (Table 3). This may be due to the methods of application EFE did not change the diversity of the ruminal microbial commitunities enough to affect TVFA concentration because enzyme has limited activity. There was no significant difference in fiber digestibility by method of application (Table2). Similar results

were reported by Hong *et al.* (17) who found that methods of application EFE (either intraruminal dose or supplementation to concentrate diet) did not affect ruminal pH, NH_3-N, TVFA concentrations and molar portion of VFA in goats. They attributed that may be related to animal types which affect enzyme efficiency in ruminant. Yescas-Yescas *et al.* (40) also found no change on ruminal pH and TVFA concentrations in lambs fed corn stover or oat straw 24 hrs. Pre-treated with EFE (Fibrozyme®; 1g/kg). However, Lewis *et al.* (21) reported that ruminal pH did not change in steers fed with EFE (Grasszyme®) 24 hrs. pre-treated grass, but they noted that it reduce ruminal pH when EFE applied 0 hr. pre-treated grass, 0 hr pre-treated barley grain and intraruminal dose.

Ruminal NH_3-N concentration in the current study showed no significant difference (P>0.05) by methods of application EFE in Shami goats (Table 3). Similar results were reported by Hong *et al.* (17), who found that EFE has no effect on NH_3-N concentration in goats by different methods of application. Bowman *et al.* (7) also reported that NH_3-N concentration was not affected when EFE applied to TMR, concentrate, or intraruminal dosage to dairy cows diet. Similar results obtained by Feng *et al*.(10) and Lewis *et al.* (21).

Gado and Borhami (11) reported significant increase in NH_3-N concentration in Ossimi lambs when supplemented with 10g of ZADO®/sheep/day. They conclude this increase in NH_3-N capability of enhance rumen protein degradation, probably because it contained protease. Similar attribution was reported in goats with the ZADO® enzyme (4, 19). The results show no significant difference (P>0.05) by methods of application EFE on molar proportion of acetate, propionate, butyrate and Ac: Pr ratio in Shami goats (Table 3). Similar results were reported in goats (17), and in sheep (40). Lewis *et al.* (21) also reported molar percentage of individual rumen VFA in steers were not affected by methods of application EFE either 24 hrs. Pre-treated or supplemented to the concentrate diet.

A possible mode of action of EFE was pre- treated of feed with EFE could release the reducing sugar (29), while reducing sugar and other products of hydrolysis can enhance ruminal microbial colonization (13), and consequently release particle size of fiber and increase DM digestion (10). Enzyme addition tended to increase the total valuable bacteria count, but had not effect on cellulolytic bacteria populations (8).

Main effect of levels of EFE on rumen fermentation characteristics

The main effect of levels of EFE (Farmazyme®) on rumen fermentation characteristics, are presented in Table 3 for Shami goats.

Results showed that ruminal pH and TVFA were unaffected (P>0.05) as levels of EFE increased in Shami goats. Similar results obtained by Miller *et al.*(24) who reported that increasing level of EFE (cellulase and xylanase) supplemented did not effect ruminal pH and TVFA concentration in lambs. Ruminal pH closes to neutrality, because animal received a high proportion of barley straw in current study. Some EFE seemed to work better to neutrality (8). However, Hirstov *et al.* (18) reported that intraruminal administration of increasing dosage (0, 100, 200, and 400g) of EFE caused a linear descent in ruminal pH and linear increased in TVFA concentration in heifers, they attributed that it could be due to a higher fermentation of carbohydrate liberated with the highest level of enzyme supplementation.

Regarding NH_3-N concentration, results show no significant difference as levels of EFE increase (Table 3). Similar results reported by Miller *et al.*(24) who found no change in NH_3-N as level of EFE increase. In the current study, there was numerical decreased on ruminal NH_3-N concentration in Shami goats as levels of EFE increased. Wahyuni *et al.* (36) reported that ruminal NH_3-N concentration were significantly decreased by EFE supplementation at 2 g/kg DM in comparison with other levels 0, 4 and 6 g/kg, they attributed that to the low level of enzyme supplementation decreased NH_3-N concentration which was likely caused by an increase in ruminal availability of slowly digestible carbohydrate due to enzyme supplementation. Adesogan *et al.* (1) also reported that enhanced uptake of NH_3-N by the ruminal microbes was perhaps because of the availability of fermentable metabolizable energy from the diet. In the current study, the concentration of ruminal NH_3-N was higher than 2-5 mg/100 ml, which is the optimal level of NH_3-N for microbial protein synthesis (33).The results showed no significant difference (P>0.05) as levels of EFE increased on molar proportion of acetate, propionate, butyrate and Ac: Pr ratio in Shami goats (Table 3). Similar results reported by Hong *et al.* (17) with no change on individual VFA in sheep. Similar results reported by Hirstov *et al.* (18) who reported no change in propionate concentration as levels of EFE increase.

Interaction effect between methods of application and levels of EFE on rumen fermentation characteristics

Statistical analysis revealed that ruminal pH, NH_3-N and TVFA concentrations were not affected significantly in Shami goats by interaction between methods of application and levels of EFE (Tables 3). Similar results were reported by many investigators with no change on ruminal pH, and TVFA concentration in goats (17), and in sheep (24) by method of application (either when EFE applied to forage, concentrate, total mixed ration, or intraruminal dose) or fed on highly concentrate diet or high roughage diet. Even when fed high concentrated diet supplemented with EFE contains amylase activity no change in ruminal pH (24). In current study, ruminal pH did not fall below 6.1 that could inhibit cellulolytic activity of rumen microorganisms (27). In contrast, Allam *et al.* (2) found increase TVFA and decrease NH_3-N in goats when supplemented with EFE (ZADO®). But Khattab *et al.* (19) reported increase NH_3-N and TVFA when goats fed on ration supplemented with EFE (either ZADO® or ZAD®).

The results show no significant difference ($P>0.05$) by interaction between methods of application and levels of EFE on molar proportion of acetate, propionate, butyrate and Ac: Pr ratio in Shami goats (Table 3). Hirstov *et al.* (18) reported neither propionate concentration nor Ac:Pr ratio were affected significantly by increasing levels of supplemented EFE in heifers. It has been shown that EFE enhanced the number of cellulolytic and non cellulolytic bacteria (29).Furthermore, EFE work in synergy with rumen microbial system which increased their hydrolytic potential in the rumen (26). However the uses of EFE products differing in their biochemical properties make direct comparison difficult (8).

The results of this study indicated that both methods of application EFE may enhance digestibility and rumen fermentation in Shami goats when used higher enzyme levels.

Table 2. Main effect of methods of application, levels of EFE (Farmazyme®) and their interactions on nutrient digestibility (%) in Shami goats

Items	DMD %	OMD %	ND %	NDFD %	HemiD %	ADFD %	CellD %	ADLD %	CFD %	EED %	NFED %
Methods of application (M)											
Pre (M_1)	66.17[a]	69.57[a]	72.20[a]	67.67[a]	79.64[a]	59.22[a]	59.13[a]	58.29[a]	68.67[a]	81.05[a]	73.16[a]
Supp(M_2)	66.35[a]	70.48[a]	71.07[a]	71.40[a]	80.00[a]	60.36[a]	59.01[a]	59.08[a]	68.61[a]	79.87[a]	74.99[a]
Sign.(N=6)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of EFE(L)											
0% (L_1)	65.16[a]	69.53[a]	70.49[a]	67.16[a]	79.03[a]	58.82[a]	58.88[a]	58.62[a]	66.97[a]	81.29[a]	73.94[a]
2% (L_2)	65.98[a]	69.54[a]	71.25[a]	66.97[a]	78.87[a]	58.65[a]	59.13[a]	58.69[a]	68.32[a]	78.96[a]	73.58[a]
4% (L_3)	67.63[a]	71.23[a]	73.17[a]	69.98[a]	81.55[a]	61.91[a]	60.55[a]	58.75[a]	70.64[a]	81.13[a]	74.71[a]
Sign.(N=4)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interactions (methods of application and levels of EFE) (ML)											
M_1L_1	65.16[a]	69.53[a]	70.49[a]	67.16[a]	79.03[a]	58.82[a]	58.88[a]	58.62[a]	66.97[a]	81.29[a]	73.94[a]
M_1L_2	65.24[a]	68.48[a]	71.93[a]	65.85[a]	79.24[a]	56.38[a]	57.22[a]	58.66[a]	67.80[a]	80.07[a]	71.72[a]
M_1L_3	68.11[a]	71.25[a]	74.19[a]	70.00[a]	80.64[a]	62.47[a]	61.31[a]	57.60[a]	71.24[a]	81.78[a]	73.82[a]
M_2L_1	65.16[a]	69.53[a]	70.49[a]	67.16[a]	79.03[a]	58.82[a]	58.88[a]	58.62[a]	66.97[a]	81.29[a]	73.94[a]
M_2L_2	66.73[a]	70.61[a]	70.57[a]	68.08[a]	78.51[a]	60.93[a]	61.05[a]	58.72[a]	68.83[a]	77.07[a]	74.45[a]
M_2L_3	67.16[a]	71.21[a]	72.16[a]	69.96[a]	82.64[a]	61.36[a]	59.80[a]	59.90[a]	70.04[a]	80.49[a]	75.61[a]
(±SE)	(21.43)	(19.57)	(42.18)	(16.38)	(15.97)	(14.54)	(6.47)	(14.39)	(8.18)	(81.34)	(2.51)
Sign.(N=2)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a,b,c] column means for each item with unlike subscript letters different ($P < 0.05$), NS: not significant, EFE= exogenous fibrolytic enzyme, M_1 and M_2 represent methods of application Pre- treated barley straw with EFE and supplemented EFE to the concentrate diet respectively. L_1, L_2 and L_3 represent 0, 2,and 4% of EFE levels respectively.

Table 3. Main effect of methods of application, levels of EFE (Farmazyme®) and their interactions on rumen fermentation characteristics in Shami goats

Items	pH	NH_3-N (mg/100ml)	TVFA (mmol/L)	Acetate (Ac)(%)	Propionate (Pr) (%)	Butyrate (Bu) (%)	Ratio Ac:Pr
Methods of application (M)							
Pre (M_1)	6.74 [a]	27.14 [a]	55.62 [a]	72.36[a]	14.39[a]	11.80 [a]	5.04[a]
Supp (M_2)	6.77 [a]	26.07 [a]	56.72[a]	73.03[a]	14.46[a]	11.74 [a]	5.06 [a]
Sign.(N=6)	NS	NS	NS	NS	NS	NS	NS
Levels of EFE(L)							
0% (L_1)	6.64 [a]	30.06 [a]	54.50 [a]	71.94[a]	14.93 [a]	11.71[a]	4.82[a]
2% (L_2)	6.84 [a]	24.95 [a]	56.00 [a]	73.42[a]	14.06 [a]	12.37 [a]	5.23 [a]
4% (L_3)	6.78 [a]	24.81 [a]	58.00 [a]	72.73[a]	14.30 [a]	11.23 [a]	5.10 [a]
Sign.(N=4)	NS	NS	NS	NS	NS	NS	NS
Interactions (methods of application and levels of EFE) (ML)							
M_1L_1	6.63 [a]	30.06 [a]	54.50 [a]	71.94[a]	14.93 [a]	11.71 [a]	4.82 [a]
M_1L_2	6.72 [a]	25.98 [a]	57.15 [a]	73.69[a]	14.08 [a]	12.38 [a]	5.24 [a]
M_1L_3	6.87 [a]	25.39 [a]	55.20 [a]	71.45[a]	14.17 [a]	11.30 [a]	5.06 [a]
M_2L_1	6.63 [a]	30.06 [a]	54.50 [a]	71.94[a]	14.93 [a]	11.71 [a]	4.82 [a]
M_2L_2	6.97 [a]	23.93 [a]	54.85 [a]	73.14[a]	14.03 [a]	12.35 [a]	5.22 [a]
M_2L_3	6.70 [a]	24.23 [a]	60.80 [a]	74.00[a]	14.43 [a]	11.15 [a]	5.13 [a]
(±SE)	(0.06)	(15.58)	(7.01)	(3.45)	(3.44)	(2.33)	(5.72)
Sign.(N=2)	NS	NS	NS	NS	NS	NS	NS

[a,b,c] Column means for each item with unlike subscript letters different ($P < 0.05$), NS: not significant. EFE= exogenous fibrolytic enzyme, M_1 and M_2 represent methods of application Pre- treated barley straw with EFE and supplemented EFE to the concentrate diet respectively, L_1, L_2 and L_3 represent 0, 2,and 4% of EFE levels respectively.

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تأثير المعاملة بالانزيمات المحللة للالياف في معامل هضم العناصر الغذائية ومتغيرات التخمر في الكرش في الماعز الشامي

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المستخلص

أستخدم 12 ذكرا من الماعز الشامي ، معدل أوزانها (43.3±1.2 كغم) و معدل أعمارها 3-4سنة ، لدراسة تأثير طريقة المعاملة بالانزيم (الهضم المسبق لتبن الشعيربالانزيم والاضافة بالانزيم الى العليقة المركزة) مع مستويات مختلفة من الانزيم (0 و 2 و4%) في معامل هضم العناصر الغذائية وتخمرات الكرش إذ قسمت الحيوانات بصورة عشوائية إلى ستة مجاميع متساوية العدد (2 تيس لكل مجموعة).غذيت بصورة فردية في تجربة عاملية 2×3 على عليقة مركزة على اساس احتياجات الادامة 1% من وزن الجسم الحي في حين تم تقديم التبن بصورة حرة.

أظهرت نتائج التجربة إن طريقة المعاملة ومستويات الانزيم والتداخل بينهما لم توثر معنوياً في معاملات الهضم لجميع العناصر الغذائية.إذ وجد ان هنالك زيادة حسابية عند زيادة مستوى المعاملة في معاملات هضم المادة الجافة والمادة العضوية والنتروجين ومستخلص الالياف المتعادل ومستخلص الالياف الحامضي وخاصة عند المستوى 4% . كما أظهرت النتائج عدم حدوث تاثير معنوي لكل من طريقة المعاملة ومستويات الانزيم والتداخل بينهما في تخمرات الكرش كالاس الهيدروجيني لسائل الكرش وتركيز نتروجين الامونيا والأحماض الدهنية الطيارة الكلية والاحماض الدهنيةالطيارة الفردية (حامض الاستيك والبروبيونيك والبيوتيريك) . كما ظهرت زيادة حسابية في في تركيز الاحماض الكلية مع انخفاض في تركيز نتروجين الامونيا في سائل الكرش عند المستويات العالية من المعاملة بالانزيم.

أشارت نتائج هذه الدراسة، الى أن كلتي الطريقتين قد تعزز معاملات الهضم للعناصر الغذائية وتخمرات الكرش في الماعز الشامي عند استعمال المستويات العالية من الانزيمات المحللة للالياف.

الكلمات المفتاحية : الانزيمات المحللة للالياف ، معامل هضم العناصر الغذائية ، متغيرات التخمر في الكرش، الماعز الشامي

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