EFFECT OF CRUDE GLYCEROL AS A SUBSTITUTE FOR CORN WITH OR WITHOUT FIBROLYTIC ENZYMES ON PRODUCTIVE PERFORMANCE OF LACTATING BALADI GOATS

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SUMMARY

This study was carried to investigate the effect of corn substitution by 50% crude glycerol with or without fibrolytic enzymes in lactating Baladi goats ration on digestibility, nutritive values, rumen liquor and blood parameters and lactation performance. Thirty multiparous lactating Baladi goats after 7 days of parturition were divided into three groups (10 animals each) according to its production then, the experimental groups were randomly assigned to fed one of the following experimental rations, control ration (R1) consists of 60% concentrate feed mixture and 40% Egyptian clover, R2, 50% of corn was substituted with crude glycerol or R3, consists of R2 supplemented with fibrolytic enzymes (ALLZYME™) at level of 6 g/kg DM. Although, inclusion of glycerol alone (R2) or with fibrolytic enzymes (R3) in lactating goat rations decreased nutrients and fiber fractions digestibility and nutritive value as TDN, but they did not significantly ($P<0.05$) differ with control (R1) in DCP, blood and rumen liquor parameters, milk yield and composition. Addition of fibrolytic enzymes to glycerol ration (R3) increased nutrients digestibility, nutritive values and milk fat content compared with ration containing glycerol alone (R2). It could be concluded that crude glycerol could be used as a source of energy in ruminant rations with fibrolytic enzymes as additive without negative effects on lactating goats' health and performance.

Keywords*: Crude glycerol, fibrolytic enzymes, lactating Baladi goats and productive performance.*

INTRODUCTION

The expansion of the biofuels production around the world has provided opportunities for alternative energy sources for livestock feeding. This industry expansion is expected to increase availability and promote favorable pricing of glycerol (Thompson and He, 2006). It is estimated that by 2016 the world biodiesel market will achieve the quantity of 37 billion gallons, which means that more than 4 billion gallons of crude glycerol will be produced every year (Kośmider *et al.,* 2011).

Glycerol, the main component of glycerine, is a glucogenic substrate for ruminants that can be converted to glucose in the liver and provide energy for cell metabolism (Goff and Horst, 2001). Therefore, glycerol may be a good source of energy for lactating animals. The energy value of glycerol was estimated by several studies which found to be similar to that of corn grains (Schröder and Südekum, 1999 and Mach *et al*., 2009). According to the FDA (2006), glycerol is recognized as a safe ingredient for use in animal feeds. It contains 80–90% glycerol and water with small amounts of ash (mainly NaCl), free fatty acids and traces of methanol and protein (Kerr *et al.*, 2009).

Donkin *et al.* (2009) indicated that glycerol can replace corn grain as much as 15% in rations for dairy animals. Abo El-Nor *et al.* (2010) observed that corn substitution with glycerol at low level (36 g/kg DM) had no adverse effect on digestibility of DM, NDF and ADF compared with control. Also, Wilbert *et al.* (2013) stated that addition of glycerol up to 120 g/kg of total DM intake in partial replacement of ground corn grain had no negative effect on productive performance of dairy cows or nutrients digestibility. Rumen propionate and butyrate concentrations (expressed as percentages of total VFA) were significantly greater ($P < 0.05$) for cows fed glycerol, at the expense of acetate and isobutyrate (Boyd *et al.*, 2013 and Carvalho *et al*., 2011), which caused a decrease in milk fat content. Different additives such as fibrolytic enzymes were suggested to alleviate the negative effect of glycerol on milk fat content by their effects on rumen pH stabilization or digestion improvement (Arriola *et al.*, 2011 and Kung *et al*.,

2000). Hanafy *et al.* (2015) observed that substitution of 25 or 50% yellow corn by crude glycerol had the potential to improve *in vitro* DM and OM disappearance and gas production especially when combined with fibrolytic enzyme (ALLZYME™). In lactating goats, Khattab *et al.* (2012) stated that feeding lactating goats on ration contained glycerol plus 4 g/kg DM fibrolytic enzyme improved nutrients digestibility of DM, OM, CP, NDF, ADF and milk production compared with feeding glycerol ration without additives.

The objective of this study was to investigate the impact of corn substitution with crude glycerol by 50% with or without fibrolytic enzyme on lactation performance, digestibility and rumen and blood parameters of lactating baladi goats.

MATERIALS AND METHODS

Experimental animals and rations:

Thirty multiparous lactating Baladi goats, 5 years old and an average weight 33 kg, after 7 days of parturition were divided into three groups (10 animals each) according to its production then, the experimental groups were randomly assigned to fed one of the following experimental rations control ration (R1) consists of 60% concentrate feed mixture and 40% Egyptian clover (*Trifolium alexandrinum*) according to nutrients requirement recommendation of NRC (1981), R2, 50% of corn was substituted with crude glycerolor R3, consists of R2 supplemented with fibrolytic enzymes (ALLZYME™) at level of 6 g/kg DM. The experiment consisted of two experimental periods (21 days adaptation period and 9 days collection period).

The experimental rations used in this study were formulated to be iso-caloric and iso-nitrogenous (Table 1).

Table (1). Formulation of the experimental rations.

Ingredients %	Experimental rations	
	R1	R2, R3
Yellow corn	25	12.5
Soybean meal	5	5
Cottonseed meal	7.5	7.5
Wheat bran	20	20
Crude glycerol	0	12.5
Clover hay	40	40
Urea	0	0.5
Minerals and vitamins	2.5	2

R1: control ration (without glycerol). R2: replacing 50% of corn with crude glycerol. R3: R2 + 6 g/kg DM fibrolytic enzymes (ALLZYME™SSF containing per gram: 300 standard phytase units, 700 protease unit, 40 carboxymethyl cellulase units, 100 xylanase units, 200 beta glucanase units, 30 fungal amylase units, 4000 pectinase units).

Feeding procedures:

The concentrate feed mixtures and Egyptian clover were divided into two equal portions fed twice daily at 0800 and 1600 h. Fresh water was available at all times.

Milk sampling:

Goats were milked twice daily by hand milking at 0700 and 1900 hr. Milk yields were recorded during five successive days from the collection period. Milk samples were collected three times during the collection period (at first, third and fifth day). Whereas, one tenth of the morning and the evening milk yields were mixed for each animal and stored at (-18°C) for further analysis.

Digestion trial:

After milk collection period, digestion trial was carried out using all animals for three successive days via acid insoluble ash (AIA) method according to Gallups *et al.* (1945) and Forbes and Garrigus (1948). Nutrients digestibility were calculated according to the following formula:

Digestion coefficient = $100 - \left[100 \times \frac{\%\ idicator\ in\ feed}{\%\ indicator\ in\ feces} \times \frac{\%\ nutrient\ in\ feces}{\%\ nutrient\ in\ feed}\right]$

Feces sampling:

Feces samples were taken during the collecting periods from each animal using fecal grab method. Subsample (10%) of total collected feces was sprayed with 10% sulfuric acid, and then dried at 70° C for 24 hour. Dried feces were ground and kept individually for chemical analysis.

Rumen liquor sampling:

At the end of feces collection period, rumen liquor samples were collected by stomach tube from each animal at zero, 2, 4 and 6 hrs post-feeding. Samples were strained through two layers of cheese cloth and immediately used for determination of ruminal liquor pH using digital pH-meter. Rumen fluid samples were stored in glass bottles after adding ortho-phosphoric acid and stored at deep freeze (-18°C) for analysis of ammonia nitrogen (NH3-N), total volatile fatty acids (TVFA's).

Blood sampling:

Blood samples were taken from jugular vein from each animal at the last day of experimental period after 4 hrs. of the morning feeding in tubes contains Ethylene Diamine Tetra Acetic acid (EDTA) as anticoagulant. Blood plasma was obtained by centrifugation at 4000 rpm for 20 minutes and kept at deep freeze (-18°C) for further analysis.

Analytical procedures:

Feeds and feces analysis:

Chemical analysis of feedstuffs and feces samples were carried out according to AOAC (2012). The nitrogen free extract (NFE) was calculated by difference. Fiber fractions were determined in feeds and feces according to Goering and Van Soest (1970).

Rumen liquor analysis:

Values of rumen pH were determined using Hanna digital pH meter. The concentration of ammonia-nitrogen (NH_3-N) in the rumen liquor was determined by Kjeldahl distillation method (AOAC, 1995). Rumen total volatile fatty acids were determined by steam distillation method as described by Warner (1964) using Mrkham micro distillation apparatus.

Blood plasma analysis:

Blood plasma total protein and creatinine were measured as described by Tietz (1986 and 1990). Blood plasma albumin was determined according to Doumas *et al*. (1971). Blood plasma urea was determined according to Patton and Grouch (1977). Alanin amino transferase (ALT) and of aspartate amino transfearse (AST) were determined by the methods of Young (1990).

Milk analysis:

Milk samples were analyzed for total solids, fat, true protein and lactose by infrared spectrophotometer (Foss matic 120 Milko-Scan, Foss Q3 183 Electric, Hillerød, Denmark) according to AOAC (1995). Solids not fat content of milk was calculated by the difference between total solids and fat content.

Statistical analysis:

Data were analyzed by the least squares procedure of the General Linear Models Program of SAS (2009) according to procedures outlined by Snedecor and Cochran (1982).

Data of milk yield, milk composition, nutrients digestibility's and blood plasma parameters were analyzed using one way analysis of variance. The model used was as following:

$$y_{ij} = \mu + T_i + e_{ij}$$

Where:

y_{ij} : The j^{th} animal of the i^{th} treatment.

μ: The overall mean.

T_i : The fixed effect of the i^{th} treatment.

e_{ij}: The random error assumed to be normally and independently distributed.

Model for repeated measures was used for rumen liquid parameters analysis. The model was as following:

$$y_{ijk} = \mu + T_i + B_j + (TB)_{ij} + e_{ijk}$$

Where

y_{ijk}: The k^{th} animal of the i^{th} treatment within the j^{th} sampling time.

μ: The overall mean.

T_i: The fixed effect of the i^{th} treatment.

B_j: The fixed effect of the j^{th} sampling time.

$(TB)_{ij}$: The interaction between the i^{th} treatment and the j^{th} sampling time.

e_{ijk}: The random error assumed to be normally and independently distributed.

The Duncan's New Multiple range test (Duncan, 1955) and Least Square Means, LSM (Steel and Torrie, 1980) procedures were used to test the significance among means for data of milk yield, milk composition, nutrients digestibility's, rumen parameters and blood plasma parameters. Significance level was set at $p < 0.05$.

RESULTS AND DISCUSSION

Chemical composition and fiber fractions of concentrate feed mixtures, clover and total mixed rations:

The data of chemical composition (Table 2) showed that concentrate feed mixture containing glycerol (CFM2) had lower DM content compared with control concentrate feed mixture (CFM1).

Table (2). Chemical composition of clover, concentrate feed mixtures and experimental rations (DM basis).

Item	Feedstuffs			Experimental rations	
	Clover	CFM1	CFM2	R1	R2&R3
DM	91.20	92.70	82.40	92.09	86.21
Chemical composition, % (DM basis):					
OM	89.76	87.81	87.60	88.60	88.53
CP	15.57	12.73	13.35	13.88	14.31
CF	27.48	5.23	5.63	14.23	15.09
EE	2.30	3.95	4.22	3.28	3.39
NFE	44.41	65.90	64.40	57.21	55.74
Ash	10.24	12.19	12.40	11.40	11.47
Fiber fractions, %:					
NDF	42.76	22.57	21.71	30.74	30.83
ADF	37.87	12.36	13.42	22.68	24.01
ADL	7.25	4.12	4.68	5.39	5.79
Hemicelluloses	4.89	10.21	8.29	8.06	6.82
Cellulose	30.62	8.24	8.74	17.29	18.22
Lignin	6.56	2.68	2.50	4.25	4.26

CFM1: control concentrate feed mixture (without glycerol), CFM2: replacing 50% of corn with crude glycerol, R1:CFM1 + clover, R2: CFM2 + clover, R3: CFM2 + clover + fibrolytic enzymes.

Also, rations contained glycerol (R2 and R3) had the same trend. This reduction in DM content was expected as a result of corn replacement (solid form) by crude glycerol (liquid form).

The contents of OM, CF, EE, NFE and ash were similar for CFM1 and CFM2. While, CP was little bit higher in CFM2 than in CFM1. This could be attributed to urea addition in CFM2 to formulate iso-nitrogenous rations. Fiber fractions contents either of control or 50% glycerol CFM were almost equal in ADL, cellulose and lignin. Otherwise, the NDF and hemicellulose fractions were less in CFM2 as a result of non-fiber material (glycerol) included in ration. On the same trend, all nutrients and fiber fractions

contents were similar in all experimental rations. While, Khattab *et al*. (2012) found that dietary NDF, ADF and ether extract contents decreased with glycerol containing rations.

Nutrients digestibility and nutritive values:

Effect of different experimental rations fed to lactating Baladi goats on digestion coefficients and nutritive values are presented in Table (3). Data indicated that replacing 50% of corn with crude glycerol (R2) significantly (P<0.05) decreased the digestibility of DM, OM, CP, CF, NFE, NDF, ADF, hemicelluloses and cellulose compared with the control ration (R1). Ether extract did not significantly (P<0.05) differ among the tested ration. The strong negative effect of high glycerol levels included in rations on cellulolytic microbial activity, and consequently, fiber digestion may explain the previous results (Abu Ghazaleh *et al*., 2011).

In the same trend, Abo El-Nor *et al.* (2010) found that feeding glycerol at 72 or 108 g/kg DM reduced digestibility of NDF and ADF compared with control. Also, Khattab *et al.* (2012) recorded significant (P<0.05) decreases in digestibility of DM, OM, NDF and ADF when replaced 30% of yellow corn by glycerol in lactating baladi goats ration. On the other hand, Donkin *et al.* (2009), Wang *et al.* (2009) and Boyd *et al.* (2011) observed an increase in DM digestibility when glycerol was included in rations. However, Wilbert *et al.* (2013) and Chanjula *et al.* (2014) observed that digestibility of DM, OM and NDF were not affected (P>0.05) by inclusion of glycerol either in the rations of dairy cows or goats, respectively.

Table (3). Effect of experimental rations fed to lactating goats on digestion coefficients.

Item	Experimental rations			
	R1	R2	R3	±SE
Nutrient digestibility (%):				
DM	77.62[a]	70.62[c]	72.99[b]	1.07
OM	80.39[a]	73.34[c]	75.60[b]	1.05
CP	79.33[a]	73.81[b]	76.36[ab]	0.98
CF	52.62[a]	41.02[c]	48.64[b]	1.72
EE	72.67	69.93	70.00	0.62
NFE	88.00[a]	82.17[b]	83.04[b]	0.97
NDF	63.93[a]	47.97[c]	52.16[b]	2.43
ADF	64.74[a]	46.67[c]	55.40[b]	2.64
Hemicellulose	61.65[a]	52.58[b]	40.76[c]	3.08
Cellulose	73.78[a]	60.10[c]	66.52[b]	2.05
Nutritive value (%):				
TDN	74.21[a]	67.89c	69.89[b]	1.01
DCP	11.01	10.56	10.93	0.11

[a, b, c……] *Means in the same row with different superscript are significantly different (P<0.05).*

Adding fibrolytic enzymes in R3 significantly (P<0.05) enhance nutrients and fiber fractions digestibility compared with R2. Khattab *et al.* (2012) found that combination of fibrolytic enzymes with glycerol ration significantly (P<0.05) improved the digestibility of all nutrients compared either with control or glycerol without additives. Boyd *et al.* (2011) explained the improvement in DM and ADF digestibility when direct-fed microbial was added to dairy cows ration contained glycerol by the improvement in ruminal fermentation.

The positive effect of fibrolytic enzymes might be explained by creating a stable enzyme-feed complex that protects free enzymes from proteolysis in the rumen (Kung *et al*., 2000). Several potential modes of action have been proposed, included: 1) increasing the microbial colonization of feed particles (Yang *et al*., 1999), 2) enhancing attachment and /or improve access to the cell wall matrix by ruminal microorganisms which result in accelerating the rate of digestion (Nsereko *et al*., 2000) , 3) enhancing the hydrolytic capacity of the rumen due to added enzyme activities and/or synergy with rumen microbial enzymes (Newbold, 1997 and Morgavi *et al.*, 2000) and 4) enzymes were able to degrade complex substrate to simpler ones, allowing a faster ruminal microbial colonization and fermentation (Colombatto *et al*., 2003).

There was a significant (P<0.05) difference among the experimental rations in the nutritive value as TDN where the control recorded the best TDN value followed by R3 then R2. No significant difference was observed in DCP among the experimental rations.

Rumen liquor parameters:

Data concerning rumen liquor parameters (Table 4) showed that goats fed R3 had the highest mean value of ruminal pH compared to those fed R2 and R1. While, Khattab *et al*. (2012) and Chanjula *et al*. (2014) recorded no significant difference between lactating goats fed glycerol or control ration in ruminal pH value. Ruminal pH values, especially for animal fed R3 were above 6.5 that indicated a better digestion of cellulolytic materials (Mertens, 1978). These results may be due to the intensive fermentation process of both nonstructural and structural carbohydrates and the production of volatile fatty acids. Such results are supported by the finding of Azzaz (2009) and Farahat (2014) who observed that fibrolytic enzymes treatment significant increased ruminal pH.

Table (4). Effect of experimental rations on rumen liquor parameters of lactating goats.

Item	Sampling Time	Experimental rations			±SE
		R1	R2	R3	
Rumen pH	0	7.06	7.00	7.05	0.11
	2	6.11^{b}	6.23^{b}	6.60^{a}	0.26
	4	6.40^{b}	6.72^{a}	6.81^{a}	0.22
	6	6.77^{b}	7.02^{a}	7.14^{a}	0.18
	Mean	6.59^{b}	6.74^{ab}	6.90^{a}	0.01
TVFA's (meq/dl rumen liquor)	0	2.60	3.73	3.60	0.32
	2	6.07	6.13	6.60	0.18
	4	4.27	5.53	5.87	0.55
	6	3.67	3.27	2.60	0.33
	Mean	4.15	4.67	4.67	0.28
NH_3-N (mg/dl rumen liquor)	0	6.53^{b}	5.38^{b}	9.64^{a}	0.68
	2	20.83	16.81	18.32	0.93
	4	8.55^{b}	9.38^{b}	15.76^{a}	1.39
	6	4.67	4.46	4.96	0.37
	Mean	10.15	9.01	12.17	1.00

$^{a, b, c \ldots\ldots}$ *Means in the same row with different superscript are significantly different (P<0.05).*

No significant differences were observed in the mean values of TVFA's among treatments. In the same trend, Khattab *et al*. (2012) and Chanjula *et al*. (2014) recorded the same result on lactating goats.

The mean values of rumen NH_3-N concentrations did not significantly differ among treatments. In contrast, mean values of ruminal NH_3-N concentrations were increased either with glycerol alone or with fibrolytic enzymes compared with control (Khattab *et al*., 2012). Regarding all sampling times, NH_3-N concentrations were the highest for R3 compared to R2 and R1. The increase in rumen NH_3-N concentration with the fibrolytic enzymes treatment may be due to higher CP content and digestibility which mean higher fermentation rate with fibrolytic enzymes addition.

Blood plasma parameters:

Data in Table (5) showed that inclusion of glycerol with or without fibrolytic enzyme in lactating goats rations had no significant (P<0.05) effect on all blood plasma parameters. Also, Khattab *et al.* (2012) found the same result. Boyd *et al.* (2013) showed that using glycerol in dairy cows rations had no significant effect on blood urea concentrations, which means a good balance between rationary energy and rumen degradable protein among treatments (Wilbert *et al.,* 2013).

All measured blood plasma parameters of the experimental animals are within the normal physiological range reported by Merck (2014). So, these data showed that adding crude glycerol have no negative effect on animals' health.

Table (5). Effect of experimental rations on blood plasma parameters of lactating goats.

Parameters	Experimental rations			±SE
	R1	R2	R3	
Total protein (g/dl)	6.10	6.20	6.20	0.001
Albumin (g/dl)	2.95	2.90	2.97	0.001
AST (u/L)	72.25	74.00	72.75	0.49
ALT (u/L)	19.00	15.00	19.00	1.14
Urea-N (mg/dl)	27.00	29.25	29.00	1.21
Creatinine (mg/dl)	0.65	0.90	0.95	0.001

Milk yield and composition:

Data dealing with dry matter intake (DMI), milk yield and composition and efficiency are presented in Table (6). Although, there was no significant (P<0.05) difference in DMI among treatments, goats fed control (R1) had the highest DMI value. In the same trend, Zymon *et al.* (2012), wilbert *et al.* (2013) and Chanjula *et al.* (2014) found that feeding glycerol did not affect on DMI. While, a decrease in DMI with glycerol inclusion in rations was recorded by Boyd *et al*. (2013).

No significant differences were observed either in actual milk yield or 4% fat corrected milk (FCM) among treatment, but control group recorded the best values. The decrease in milk production with glycerol inclusion (R2 and R3) may be due to the decrease in DMI and digestibility. Khattab *et al*. (2012) found that goats fed glycerol alone had lower milk and FCM yields while, adding fibrolytic enzyme to glycerol ration improved milk production. However, Kass *et al.* (2012) and Wilbert *et al.* (2013) did not find any significant differences in milk yield when dairy cows fed glycerol.

Table (6). Effect of experimental rations on dry matter intake, milk yield and composition and efficiency of lactating goats.

Item	Experimental rations			±SE
	R1	R2	R3	
DMI, g	1053	922	931	33.59
Milk Yield (g/h/d)	1173	977	965	85.60
4% FCM (g/h/d)	1032	754	837	82.76
Milk composition, %				
Fat	3.18[a]	2.46[b]	3.08[ab]	0.15
Protein	3.45	3.52	3.31	0.01
Lactose	3.40	3.51	3.27	0.01
TS	10.58	10.05	10.17	0.23
SNF	7.40	7.59	7.09	0.14
Ash	0.55	0.56	0.51	0.001
Milk constituents yield, g/h/d				
Fat	37.30	24.03	29.72	3.36
Protein	40.47	34.39	31.94	3.22
Lactose	39.88	34.29	31.56	3.17
TS	124.10	98.19	98.14	10.04
SNF	86.80	74.15	68.42	6.89
Ash	6.45	5.47	4.92	0.54
Efficiency				
Milk yield/DMI, g/g	1.11	1.06	1.04	0.01

[a, b, c.....] *Means in the same row with different superscript are significantly different (P<0.05).*
TS: total solids SNF: solids non fat.

Contents and yields of protein, lactose, TS, SNF and ash and fat yield were not affected by treatment, with the exception of the milk fat content which was significantly (P<0.05) decreased with glycerol inclusion to the ration (R2). It was showed that the main components generated from complete fermentation of glycerol are propionate and particularly butyrate. Therefore, lower milk fat contents could

be expected as glycerol inclusion in lactating animals' rations (Boyd *et al.*, 2013 and Carvalho *et al*., 2011).

Addition of fibrolytic enzyme (ALLZYME^{TM}) to glycerol ration (R3) showed to alleviate the negative effect of glycerol on milk fat content compared with control (R1). This result could be explained by the positive effect of fibrolytic enzyme on ruminal pH stabilization and digestion improvement (Arriola *et al.*, 2011 and Kung *et al*., 2000). This result agreed with Khattab *et al*. (2012).

It was observed that milk efficiency as milk yield, g/DMI,g did not significantly ($P<0.05$) differ among treatments. The insignificant differences either in milk yield or DMI among different groups could be the reason. Also, no significant effect in milk efficiency with feeding glycerol was observed by Zymon *et al.* (2012) and Boyd *et al.* (2013).

CONCLUSION

Results indicated that substitution of yellow corn by crude glycerol at 50% might be required the addition of fibrolytic enzymes to alleviate the negative effects of glycerol in ration on digestion and productive performance of lactating Baladi goats.

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تأثير الجليسرول الخام كإحلال من الأذرة مع أو بدون الانزيمات المحللة للألياف على الآداء الإنتاجى للماعز البلدى الحلاب

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تم إجراء هذه التجربة لدراسة تأثير استخدام الجليسرول الخام كبديل للأذرة الصفراء بنسبة 50% مع أو بدون الانزيمات المحللة للألياف على معامل الهضم، القيمة الغذائية، مقاييس سائل الكرش و الدم و الأداء الآنتاجى للماعز البلدى الحلاب. تم استخدام 30 عنزة بلدى حلابة بعد اليوم السابع من الولادة و قسمت لثلاث مجاميع (10 حيوانات بالمجموعة) تبعاً للإنتاج و تم توزيع المجاميع عشوائياً لإختبار واحد من العلائق التالية: العليقة المقارنه (R1) تتكون من 60% مخلوط علف مركز و 40% برسيم مصرى، المعاملة الثانية (R2) و الثالثة (R3) تم إحلال 50% من الأذرة الصفراء بالجلسيرول الخام فقط أو باضافة إنزيمات محللة للألياف (ALLZYME™)، على التوالى. وبالرغم من أنه لوحظ انخفاض فى معامل هضم العناصر الغذائية و مكونات الألياف و القيمة الغذائية فى صورة مركبات غذائية كلية مهضومة (TDN) سواء عند استخدام الجليسرول وحده (R2) أو مع إضافة انزيمات محللة للألياف (R3)، إلا انه لم يكن هناك اختلافات معنوية بين المعاملات والمقارنة فى قيم البروتين الخام المهضوم (DCP)، مقاييس الدم و الكرش، محصول اللبن و تركيبه. إضافة الإنزيمات المحللة للألياف (ALLZYME™) الى العليقة المحتوية على جليسرول (R3) أدت الى زيادة معامل هضم العناصر الغذائية، القيمة الغذائية و محتوى اللبن من الدهن مقارنة بالمعاملة الثانية (R2) المحتوية على الجليسرول فقط. و بهذا تشير النتائج الى إمكانية استخدام الجليسرول الخام بالإضافة الى الإنزيمات المحللة للألياف (ALLZYME™) فى علائق الماعز البلدى الحلاب كبديل جزئى للأذرة دون وجود تأثير سلبى على الآداء الإنتاجى أو صحة الحيوانات.