Egyptian J. Anim. Prod., Vol. 31, Supplement Issue, Nov.(1994):59-73.

EFFECT OF DIETARY FAT AND CALCIUM SUPPLEMENTS ON IN VIVO DIGESTIBILITY, RUMEN FERMENTATION AND SOME BLOOD CONSTITUENTS OF SHEEP

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SUMMARY

Twenty-four metabolism trails were carried out to study the effect of fat supplement and calcium addition on nutrient utilization of berseem hay. Twelve Rrahmanay rams (3 years old and 40 Kg Body weight) three animals in each trail were used to evaluate the three sources of fat without calcium addition. Fat sources of sunflower oil, hydrogenated vegetable oil (HVO) and tallow were compared with the control (no fat supplement). Accordingly, fat sources were evaluated with calcium addition using the same animals. Fats were supplemented at the rate of 5% and calcium was added at the rate of 1% (2.5% calcium carbonate) to the control ration composed of berseem hay.

Vegetable oil either hydrogenated or not had severe adverse effect on DM, OM, CP and CF digestibilities while tallow supplement caused only a decrease in CP digestibility. Digestibility of EE significantly increased by any fat supplement.

Calcium addition did improved the digestibility of EE of oil supplemented hay but not affect or decrease the digestibility of HVO or tallow supplemented hay. Cellulose was found to be the most negatively affected constituent in crude fiber by fat supplement.

Fat supplement decreased ruminal pH but had no significant effect on VFA's molar proportions of animals fed fat supplemented rations either with or without calcium addition. Ruminal ammonia-N and total VFA's concentrations significantly decreased by oil or tallow supplement but not by HVO supplement.

Blood plasma Ca, Mg and P were not affected by the treatments. However, plasma total lipids (TL), triglycerides (TG) and cholesterol increased by feeding fat supplemented hay. Calcium addition had no significant effect on plasma lipids.

Keywords: Fat supplement, calcium addition, digestibility, rumen fermentation, plasma lipids, sheep

INTRODUCTION

Increasing energy intake by feeding high concentrate rations to ruminants is limited by the development of some disorders in digestion and metabolism of ruminants such as acidosis, low fiber utilization and bloat (Jenkins and Palmquist 1984). Therefore, fats are added to ruminant rations to increase their energy density. However, the digestible energy intake is not often increased because of the depression in fiber digestion. Calcium was reported to have a positive effect on nutrient digestibilities of fat supplemented rations. Lucerne ash was earlier reported to reverse the inhibition of in vitro cellulosedigestion caused by added oil (Brooks et al., 1954). Meanwhile, White et al, (1958) showed that lucerne ash could be replaced by calcium salts.

The objective of the study was to evaluate the effect of feeding vegetable oil, hydrogenated vegetable oil or tallow with or without calcium addition on digestibility, rumen fermentation and lipid metabolites in blood plasma of sheep.

MATERIALS AND METHODS

Twenty-four metabolism trails were conducted using four rations which consisted of unsupplemented berseem hay or supplemented with vegetable oil (O), hydrogenated vegetable oil (HVO) or tallow (T) fed to twelve Rahmany rams (3 years old and 40 Kg body weight) without calcium addition in an experiment and with calcium addition in another (three animals in each treatment). Fat from each source replaced 5% and calcium carbonate replaced 2.5% of berseem dry matter in berseem hay rations. Chemical composition of the experimental rations is shown in Table 1.

Table 1. Chemical composition of the experimental rations

Item	Without calcium				with calcium			
	Control	Oil	HVO	Tallow	Control	Oil	HVO	Tallow
Proximate analysis, %								
DM	90.2	90.90	91.00	89.4	90.5	89.5	89.7	89.3
Dry matter composition								
OM	85.4	86.6	86.4	83.4	82.6	85.9	83.5	84.2
CP	18.4	17.5	17.8	17.7	18.9	17.4	16.9	18.6
CF	33.5	29.0	26.1	31.9	31.9	31.2	30.4	30.8
EE	2.8	7.6	8.4	8.4	2.1	8.0	7.9	8.5
NFE	30.7	32.5	34.1	25.4	29.7	29.3	28.3	26.3
Ash	14.6	13.4	13.6	16.6	17.4	14.1	16.5	15.8
Cell wall constituents,%								
NDF	58.0	57.6	55.7	57.6	59.9	55.3	57.0	54.0
ADF	37.5	37.3	35.3	36.6	36.6	35.6	37.0	37.4
ADL	7.9	7.2	7.0	7.5	7.4	7.0	6.7	7.1
Cell.	29.6	30.1	28.3	29.1	29.2	28.6	30.3	30.3
Hemi.	20.5	20.3	20.4	21.0	23.3	19.7	20.0	16.6

Cell. = Cellulose, Hemi. = hemicellulose

HVO = Hydrogenated vegetable oil

Animals were housed in metabolic cages for 14 days preliminary followed by 7 day collection period and were fed at a constant rate of 3% DM of body weight. Fresh water was offered ad libitum once a day. Feces and urine were collected at 8.00 am during the collection period and representative samples of one tenth of the total were taken for laboratory analyses. Chemical composition of feeds and feces were determined according to A.O.A.C (1975) and Goering and Van Soest(1970). Rumen fluid was sampled using stomach tube before feeding, 2, 4 and 8 hr after feeding from all animals for two consecutive days at the end of each metabolism trial. Rumen pH was measured immediately using pH-meter, ammonia nitrogen (Conway, 1962), total volatile fatty acid concentrations (Kromann et al., 1967) and molar proportions of volatile fatty acids (Erwin et al., 1961) were determined.

Blood samples were withdrawn from the jugular vein before and 4 h. post feeding. Plasma total lipids

(Boehringer Mannheim GmbH Diagnostica), Cholesterol (Pointe Scientific Inc.) and triglycerides (BioMerieux Laboratory Reagents and Instruments) were determined using photometry method. Plasma phosphorus (Egyptian-American Co. for Laboratory Services) were colorimetery measured. Calcium and magnesium were determined using atomic absorption spectroscopy.

Data were analyzed using general linear model (GLM) by ANOVA procedures of SAS (1982). Means were separated using Duncan's multiple range test at alpha = 0.05 when the main effects were significant.

RESULTS AND DISCUSSION

Nutrient digestibilities

Nutrient digestibilities are shown in Table 2 (a & b). Fat supplement, in general, increased the digestibility of EE in comparison with the control value because of the high digestibility of supplementary lipids (Jenkins and Jenny, 1992). Digestibility of EE of supplementary fat was calculated to be 84.29, 93.03 and 91.29 % for oil, HVO and tallow without calcium addition, respectively. The corresponding values with calcium addition were 94.66, 93.99 and 93.35%.

Table 2a. Effect of dietary fat source and calcium addition on nutrient digestibilities of berseem hay fed to sheep

Treatment	DM	OM	CP	EE	CF	NFE
Without calcium						
Control	62.50^{a}	62.41^{a}	63.48^{a}	57.63^{d}	55.31^{a}	68.68^{a}
Oil	57.13^{bc}	57.40^{bc}	59.84^{bc}	76.84^{bc}	41.29^{c}	64.00^{abc}
HVO	59.92^{ab}	60.31^{ab}	62.76^{abc}	80.50^{ab}	53.08^{ab}	60.74^{c}
Tallow	62.30^{a}	62.92^{a}	54.56^{d}	79.95^{ab}	55.15^{a}	68.50^{a}
With calcium						
Control	60.39^{ab}	61.71^{a}	62.86^{ab}	46.06^{e}	55.53^{a}	66.96^{ab}
Oil	61.48^{a}	62.56^{a}	59.69^{c}	76.23^{c}	56.36^{a}	66.02^{ab}
HVO	59.54^{ab}	59.98^{ab}	60.46^{abc}	79.78^{abc}	51.51^{ab}	62.58^{bc}
Tallow	56.07^{c}	56.70^{c}	61.65^{abc}	80.80^{a}	49.37^{b}	55.36^{d}
SE	1.06	0.97	0.93	1.15	1.59	1.43

a,b,c,d,e Means on the same column having unlike superscripts differ (P<.05)

Digestibilities of CP, CF and NFE of fat supplemented rations were slightly lower than those of the control ration. Dry matter and organic matter digestibilities were not affected by fat supplement. Calcium addition, in general, decreased the digestibility of EE and NFE without significant effect on the digestibilities of other nutrients (Table 2b).

Table 2b. Mean effect and probability of fat source and calcium addition on nutrient digestibilities

Item	Fat source				Prob.	Calcium		Prob.
	Control	Oil	HVO	Tallow		0%	1%	
DM	61.5	59.3	59.7	59.2	.162	60.5	59.4	.163
OM	62.1	60.0	60.2	59.8	.113	60.8	60.2	.900
CP	63.2	59.8	61.6	58.1	.001	60.2	61.2	.146
EE	51.9	76.5	80.1	80.3	.000	73.3	70.7	.001
CF	55.4	48.8	52.1	52.3	.007	51.2	53.1	.112
NFE	67.8	65.0	61.7	61.9	.001	65.5	62.7	.015

Without calcium addition, oil supplement decreased ($P<0.05$) the digestibilities of DM, OM, CP and CF but had no significant effect on NFE digestibility. However, HVO decreased only NFE digestibility and tallow decreased CP digestibility with no significant effect on the other nutrients. The adverse effect of oil on nutrient digestibility had been extensively discussed in the in vitro study (Allam et al., 1994) that oil contains high proportion of polyunsaturated fatty acids which have greater inhibition effect on microbial growth and cellulolytic activity than the saturated fatty acid in HVO or tallow.

Calcium addition had no significant effect on the nutrient digestibilities of the basal ration (control) except its negative effect ($P<.05$) on EE digestibility. The effect of calcium addition on nutrient digestibilities of fat supplemented rations was variable depending on the source of fat. Calcium addition alleviated ($P<0.05$) the negative effect of oil supplement on the DM, OM and CF digestibilities. However, it decreased ($P<0.05$) the digestibility of DM, OM, CF and NFE but improved ($P<0.05$) the CP digestib-ility of tallow supplemented rations. No significant effect on the digestibility of HVO supplemented ration of calcium addition was detected (Table 2a).

The dependant role of calcium addition on fat source seemed to be a result of its readily reaction with fatty acids to form insoluble soap (Jenkins and Palmquist 1984). Moreover, calcium addition with fat supplement could change the site of digestion (Weakley et al., 1990).

Cell wall digestibility

Data of cell wall digestibilities are shown in Table 3 (a and b). Digestibility of cell wall fibers were determined to recognize the most affected constituent of cell wall by fat supplement. No effect on NDF but significant decrease (P<.05) in ADF and cellulose digestibilities of oil supplemented hay was found. Calcium addition improved the digestibility of ADF and cellulose except in case of tallow supplement.

Table 3a. Effect of dietary fat source and calcium addition on digestibilities of cell wall constituents by sheep

Treatment	NDF	ADF	Cellulose	Hemicell.
Without calcium				
Control	54.00[ab]	46.60[a]	57.00[ab]	67.80[b]
Oil	51.80[b]	38.50[b]	46.20[d]	76.10[a]
HVO	55.10[a]	44.80[a]	50.60[cd]	73.10[ab]
Tallow	55.80[a]	49.60[a]	62.00[a]	66.30[b]
With calcium				
Control	56.00[a]	45.90[a]	53.50[bc]	71.80[ab]
Oil	56.30[a]	49.40[a]	59.70[a]	71.90[ab]
HVO	55.20[a]	47.50[a]	53.50[bc]	72.40[ab]
Tallow	53.10[ab]	39.80[b]	48.40[cd]	73.00[ab]
SE	1.00	1.71	1.71	2.06

[a,b,c,d] Means on the same column having unlike superscripts differ (P<.05).

Hemicellulose digestibility was not affected by either fat supplement or calcium addition. Cellulose was the most affected fiber fraction by fat supplement. Differences between the in vivo and in vitro nutrient digestibility values of the same feeds (Allam et al.,

1994) were noticeable. This perhaps is due to that fat supplement shifts the site of digestion from rumen to hind gut and calcium addition reacts to variable extent with the different fatty acids (Jenkins and Fotouhi, 1990).

Table 3b. Mean effect and probability of fat source and calcium addition on digestibilities of cell wall constituents

Item	Fat source					Calcium		
	Control	Oil	HVO	Tallow	Prob.	0%	1%	Prob.
NDF	55.0	54.0	55.1	54.4	NS	54.1	55.2	.167
ADF	46.3	43.9	46.2	44.0	.408	44.9	45.5	NS
Cell.	55.3	53.0	52.0	55.2	.192	53.9	53.8	.146
Hemi.	69.7	74.0	72.8	69.6	.119	70.8	72.3	.330

Cell. cellulose ; Hemi. hemicellulose

Effect of dietary fat source, calcium addition and sampling time on ruminal pH, ammonia-N and total volatile fatty acid's concentrations by sheep is shown in Table 4.

Ruminal pH

Feeding oil or HVO supplemented hay without calcium addition decreased ruminal pH at all sampling time. However, ruminal pH of sheep fed tallow supplemented hay showed comparable values to the control except for the zero time (before-feeding). Calcium addition had no significant effect on ruminal pH of sheep fed oil or HVO supplements but decreased ruminal pH of sheep fed tallow supplement. Fat supplement was reported to have almost similar effect on ruminal pH like in case of high concentrate feeding (El-Bedawy, 1989; Henderson 1973). The variable response to tallow in comparison with vegetable oil supplement again might be due to the ready reaction of its fatty acids with cations in the rumen. Ruminal pH decreased two hours post-feeding and showed almost constant lower pattern than after till eight hr. post feeding.

Table 4. Effect of dietary fat source, calcium addition and sampling time on ruminal pH, ammonia-N and total VFA's concentration by sheep

Sampling time	Control 0%	Control 1%	Oil 0%	Oil 1%	HVO 0%	HVO 1%	Tallow 0%	Tallow 1%
pH (SE= 0.42)								
Before feeding	7.05^{a}	6.96^{ab}	6.59^{cd}	6.23^{e}	6.56^{cd}	6.46^{cde}	6.71^{cd}	6.31^{de}
2 hr post-feeding	6.43^{a}	6.14^{abc}	5.74^{d}	6.07^{bc}	5.73^{d}	5.97^{cd}	6.31^{ab}	5.86^{cd}
4 hr post-feeding	6.02^{ab}	6.08^{a}	5.60^{c}	5.78^{abc}	5.72^{bc}	5.67^{c}	6.01^{ab}	5.78^{abc}
8 hr post-feeding	5.94^{a}	5.99^{a}	5.63^{b}	5.54^{b}	5.46^{b}	5.48^{b}	5.97^{a}	5.42^{b}
Ammonia-N, mg/100 ml(SE =0.18)								
Before feeding	3.09	3.46	2.70	3.84	2.78	3.78	2.97	3.16
2 hr post-feeding	5.12^{ab}	4.22^{b}	5.01^{ab}	5.74^{a}	5.03^{ab}	5.86^{a}	5.26^{ab}	4.74^{ab}
4 hr post-feeding	6.17^{a}	5.44^{ab}	5.65^{ab}	4.58^{b}	5.97^{a}	5.02^{ab}	5.95^{a}	5.15^{ab}
8 hr post-feeding	7.40^{a}	6.24^{bc}	4.89^{d}	5.18^{cd}	6.10^{bc}	6.57^{ab}	5.31^{cd}	5.84^{bcd}
VFA's,m.eq./100 ml (SE=2.14)								
Before feeding	18.1	17.0	19.8	18.0	20.2	21.7	15.8	18.0
2 hr post-feeding	20.3^{abc}	26.1^{a}	23.8^{ab}	18.2^{c}	24.4^{ab}	26.3^{a}	27.9^{a}	19.1^{bc}
4 hr post-feeding	22.9^{a}	26.3^{a}	21 9^{a}	14.4^{c}	24.1^{a}	21.0^{ab}	22.0^{a}	16.2^{bc}
8 hr post-feeding	15.7^{bc}	14.8^{bc}	17.8^{ab}	11.6^{c}	21.9^{a}	15.5^{bc}	15.7^{bc}	12.5^{bc}

^{a,b,c,d} Means on the same row within each trait having unlike superscripts differ (P<.05).

Ruminal VFA's concentration

Lower (P=.031) ruminal VFA's concentrations were associated with feeding oil or tallow supplemented hay. Calcium addition had no significant effect on ruminal VFA's concentrations (P=.090). The VFA's concentrations increased (P=.0001) after feeding. The peak values were observed at two hr after feeding. The reduction in VFA's by feeding oil or calcium added tallow supplemented rations might be due to the low cellulose digestibility (Doreau et al., 1991 and El-Meddah et al., 1991).

Ammonia-N

Oil and tallow supplement decreased (P=.0001) ruminal ammonia-N concentrations which were also decreased (P=.0001) by calcium addition. Ruminal ammonia-N increased by increasing sampling time reaching its peak value at two hrs post-feeding and declined thereafter. Calcium addition decreased the ammonia-N with oil and tallow supplement but not with the control ration or the HVO supplement. The decrease in ammonia-N by fat supplement could be explained by 1) the decrease in proteolytic activity (El-Meddah et al., 1991) or 2) the increase in ammonia absorption by rumen epithelium at high pH (Smith 1975) but the present results referred to the contrary since lower ruminal pH was associated with feeding fat or 3) the increase in the efficiency of microbial protein synthesis, perhaps due to the partial defaunation in the rumen. However, inconsistent data were reported in the literature. Sutton et al., 1983 reported that the last trend seems to be more acceptable.

Molar proportions of VFA

Neither fat supplement nor calcium addition had significant effect on molar proportions of volatile fatty acids (Table 5). Similar results were found by Bock et al, (1991) and Jenkins and Jenny (1992). The peak values were observed at 4 to 8 hr after feeding for acetate and at 2 hr for propionate. Therefore, the lowest values of acetate: propionate ratio were observed at 2 hr post-feeding. The molar proportions of butyrate, iso-butyrate and iso-valerate decreased from time before feeding to 2 hr post-feeding and leveled off afterwards.

Plasma constituents

Blood plasma levels of Ca, Mg and P or plasma lipid metabolites were not affected by sampling time (before or 4 hr post feeding). Therefore data were pooled for sampling time in Table 6. Fat source, and calcium addition had no significant effect on Ca, Mg and P in plasma. Bock et al. (1991) found that feeding tallow or soybean oil soapstock with two levels of calcium did not affect serum calcium. Most of hypocalcemia and hypomagnesemia cases were developed by high lactating cows fed fat supplements (Steele 1984).

Although feeding fat supplemented hay significantly increased TL, TG and Cholesterol in plasma yet calcium addition had no effect the increase was more evident by oil or HVO supplement than that by tallow supplement.

The increase in plasma lipids might be due to the depression in lipogenic enzyme activities by liver and adipose tissue associated with feeding supplementary fat (Storry 1981). Feeding long chain fatty acids was reported to induce shifting in the balance from active protomeric to inactive polymeric forms of acetyl Co A carboxylase in bovine adipose tissue (Bauman and Davis 1975).

Table 5. Effect of dietary fat source, calcium addition and sampling time on molar proportions of ruminal volatile fatty acids of sheep

Diet	Control		Oil		HVO		Tallow	
Item Ca,%	0	1	0	1	0	1	0	1
Acetate (SE= 5.12)								
0 hr	54.41	53.54	52.23	54.44	48.29	54.34	54.34	53.00
2 hr	54.67	56.22	54.88	56.22	53.06	55.74	56.45	55.05
4 hr	58.09	52.57	58.86	59.01	58.16	57.35	58.24	52.45
8 hr	62.97	60.15	61.11	60.23	61.90	59.70	62.81	59.54
Propionate (SE= 2.32)								
0 hr	22.35	21.55	22.82	24.43	23.98	23.13	22.19	23.15
2 hr	28.08	27.79	30.68	27.03	30.96	28.02	26.63	29.23
4 hr	27.32	26.05	27.13	26.23	27.90	26.88	26.47	27.55
8 hr	24.57	24.20	25.27	25.70	24.84	24.94	24.47	25.84
Butyrate (SE=0.98)								
0 hr	9.49	11.48	13.55	11.02	12.82	11.30	11.49	11.98
2 hr	10.50	10.60	10.03	9.68	10.98	9.94	11.31	8.90
4 hr	10.07	9.82	10.12	9.48	9.63	9.48	10.11	8.71
8 hr	9.30	11.36	10.92	10.85	10.49	11.03	10.05	11.37
Iso-butyrate (SE= 0.08)								
0 hr	3.23	4.74	3.82	3.15	4.27	3.83	4.05	4.07
2 hr	2.19	1.47	1.12	1.50	1.31	1.61	1.51	1.49
4 hr	1.80	1.25	0.63	1.13	0.78	1.26	1.17	1.02
8 hr	0.48	0.70	0.35	0.67	0.43	0.92	0.69	0.54
Iso-valerate (SE=0.13)								
0 hr	4.44	7.30	6.36	5.26	6.27	5.91	5.97	5.94
2 hr	2.91	1.95	1.46	2.11	1.63	2.36	2.05	2.03
4 hr	1.08	1.19	0.53	1.21	0.55	1.22	1.11	0.90
8 hr	0.27	0.51	0.13	0.53	0.22	0.88	0.42	0.25
Valerate (SE=0.21)								
0 hr	1.08	1.49	1.39	1.70	1.37	1.49	1.99	1.76
2 hr	1.64	1.97	1.82	3.17	2.06	2.70	1.99	3.31
4 hr	1.64	3.11	2.59	2.93	2.98	3.81	2.90	3.36
8 hr	2.41	2.09	2.17	2.03	2.11	2.45	1.56	2.45
Acetate:propionate ratio (SE=0.16)								
0 hr	2.66	2.49	2.29	2.24	2.06	2.35	2.46	2.29
2 hr	1.95	2.02	1.79	2.10	1.74	1.99	2.12	1.90
4 hr	2.13	2.25	2.18	2.25	2.11	2.14	2.20	2.13
8 hr	2.58	2.49	2.42	2.35	2.50	2.39	2.57	2.30

Table 6. Effect of dietary fat source and calcium addition on plasma cations and lipids (mg/dl) of sheep

diet	Control		Oil		HVO		Tallow		
Item Ca,%	0	1	0	1	0	1	0	1	SE
Plasma cations									
Ca	8.91^{c}	9.41^{ab}	9.23^{b}	9.94^{a}	9.30^{b}	9.27^{b}	9.17^{bc}	9.69^{a}	0.46
Mg	1.83^{b}	1.66^{c}	1.90^{a}	1.85^{b}	1.72^{bc}	1.82^{b}	2.04^{a}	1.71^{bc}	0.14
P	5.73^{b}	6.10^{a}	6.20^{a}	5.71^{b}	6.06^{a}	6.08^{a}	6.07^{a}	5.78^{ab}	0.32
Plasma lipids									
TL	169^{d}	195^{cd}	325^{ab}	337^{ab}	313^{ab}	351^{a}	269^{abc}	281^{abc}	32
TG	35.3^{d}	43.9^{bcd}	50.2^{ab}	53.3 [illegible]	44.0^{bcd}	56.1^{a}	47.1^{abc}	51.2^{ab}	3.9
Ch	41.2^{d}	47.0^{cd}	63.6^{b}	91.2^{a}	58.2^{b}	71.1^{ab}	59.8^{b}	61.1^{b}	9.3

a,b,c,d Means on the same row within each trait having different superscripts differ (P<.05).
TL total lipids, TG triglycerides, Ch cholesterol

The higher plasma total cholesterol associated with fat feeding especially oil or HVO than that by tallow, despite that vegetable oils are cholesterolree free agreed with the findings of Schauff et al. (1992). It might be related to that dietary poly- unsaturated long chain fatty acids in vegetable oil may stimulate the de novo cholesterol synthesis in rats compared with poly-saturated fatty acids (Kritchevsky and Tepper 1965). Moreover, Mayes (1991) found an increase in endogenous cholesterol when the cholesterol intake was low.

It could be concluded that vegetable oils had adverse effect on digestibility more than tallow. The simple way of calcium addition was effective to reverse the inhibition effect of vegetable oils but not with tallow. Perhaps, more complicated calcium supplement as calcium soap could be beneficial with tallow. No adverse effects on rumen fermentation or animal health associated with fat supplement were observed.

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تأثير إضافة الدهن والكالسيوم على معاملات الهضم وتخمرات الكرش وبعض مكونات الدم فى الأغنام.

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أجريت أربع وعشرون تجربة هضم على ١٢ كبش رحمانى متوسط عمرها ٣ سنوات ووزنها ٤٠كجم لدراسة تأثير إضافة الدهن والكالسيوم على الإستفادة من المركبات الغذائية لدريس البرسيم، قيمت من خلال هذه التجارب ثلاثة مصادر من الدهن مع أو بدون إضافة كالسيوم. كانت المصادر الثلاثة عبارة عن زيت نباتى (عباد الشمس)، زيت نباتى مهدرج وشحم حيوانى مقارنة مع المنترول (بدون إضافة دهن) . أضيفت الدهون بمعدل ٥٪ والكالسيوم بمعدل ١٪ (٢,٥٪ كربونات كالسيوم) كإحلال من المادة الجافة.

أوضحت النتائج أن الزيت النباتى سواء مهدرج أو غير مهدرج له تأثير سلبى على معاملات هضم المادة الجافة و العضوية والبروتين الخام والألياف الخام بينما لم يلاحظ مثل هذا التأثير فى حالة الشحم الحيوانى إلا على معامل هضم البروتين الخام فقط. ووجد أن معامل هضم مستخلص الإثير يزيد مع إضافة أى مصدر من الدهن.

ادت إضافة الكالسيوم الى تحسن فى معاملات الهضم التى أنخفضت بتأثير إضافة الزيت ولم تؤد الى نفس التأثير مع المصدرين الأخرين (الزيت النباتى المهدرج و الشحم الحيوانى).وضح من الدراسة أيضا أن السيليلوز أكثرمكونات الجدار الخلوى تأثرا سلبيا بإضافة الدهن.

لم تؤد إضافة الدهن الى تغير معنوى فى نسب الأحماض الدهنية الطيارة المنفردة بينما أنخفضت درجة حموضة الكرش للأغنام المغذاه على العلائق المضاف اليها دهن سواء مع إضافة الكالسيوم أوبدون إضافته، وأدت إضافة الزيت والشحم الحيوانى الى إنخفاض تركيزات الأمونيا و الأحماض الطيارة الكلية معنويا و لم يلاحظ مثل هذا التأثير عند إضافة الزيت النباتى المهدرج.

لم يتأثر كالسيوم وماغنسيوم وفوسفور بلازما الدم بينما زادت تركيزات الليبيدات الكلية والجلسريدات الثلاثية و الكوليستيرول بالتغذية على دريس البرسيم المضاف اليه دهن. ولم يكن هناك تأثير لإضافة الكالسيوم على ليبيدات سيرم الدم.