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RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Effect of different levels of ground flaxseed on *In vitro* and *In vivo* digestibility in Karadi lambs

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Abstract

This study was conducted to determine the effect of different levels of flaxseed (0, 3, 6 or 9%) on *in vitro* and *in vivo* apparent digestibility of dry and organic matter and voluntary feed intake on growth of Karadi lambs. Sixteen Karadi male lambs of eight months and weighing 45.6±0.481 kg were randomly divided into four treatments and individually penned for a period of 84 days. Results revealed that there were no significant differences among treatments in the daily intake of DM, OM, CP, CF, and NFE, ME. Ether extract (EE) was higher ($P<0.05$) in lambs fed 9% flaxseed both *in vitro* and *in vivo* digestibility trials. The *in vivo* apparent and *in vitro* digestibility of dry matter (DM), organic matter (OM), total digestible nutrient (TDN), digestible energy (DE) and metaboilzable energy was not influenced by the addition of flaxseed to the diet. In conclusion, the addition of 6 or 9% flaxseed to the diets does not improve intake and digestibility of nutrients. However, significantly higher digestibility of EE was noticed in lambs fed 9% flaxseed.

Keywords: Flaxseed; digestibility; Karadi lambs

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Introduction

Inclusion of flaxseed into the ruminant diets increases the fat content, which may decrease fibre digestibility in the rumen (Micek et al., 2004). On the other hand, the addition of fat increases the energy concentration of the diet and helps to limit energy losses during fermentation by restricting the number of methane-producing bacteria, which may have a positive effect on the magnitude of microbiological protein synthesis (Machmüller et al., 2000). Supplemental flaxseed, containing fat rich in polyunsaturated fatty acid, may therefore alter the digestibility of dietary nutrients and influence the energy and protein metabolism in the body (Jenkins, 1993). Feeding flaxseed, which is high in linolenic acid, is a viable option to enrich the n-3 fatty acid concentration in livestock diets and subsequent in ruminant products (Soita et al., 2003; Kronberg et al., 2006; Maddock et al., 2006). However, there are limitations on the level of fat that can be added to ruminant diets due to reductions in intake and digestibility (Schauff and Clark, 1992). This is especially true for fats high in polyunsaturated fatty acids (Palmquist and Jenkins, 1980; Jenkins, 1993). Furthermore, flaxseed seems to be unique in this regard as indicated by Zhang et al. (2007) who showed an increase in dry matter digestibility for lactating ewes fed a silage-based diet containing 8% flaxseed compared with 7.3% canola seeds or no oilseeds. In feedlot diets, flaxseed did not influence (Maddock et al., 2006) or increases dietary intake, and an overall improvement in average daily gain was observed with inclusions rate of 5 to 8% flaxseed in the diet (Drouillard et al., 2004).

The aim of this study was to determine the effect of supplementation of flaxseed to the diets on daily feed intake, *in vitro* and *in vivo* digestibility of Karadi male lambs.

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Materials and Methods

This study was carried out at the Animal Farm, Department of Animal Production, Faculty of Agricultural Sciences, University of Sulaimani, Bakrajo, Sulaimani, Kurdistan, Iraq.

Animals

Sixteen Karadi male lambs weighing 45.6±0.083 kg and of eight months old were individually housed and treated against ecto- and endo-parasites. After an adaptation periods of 14 days, lambs were randomly divided into four treatments for a period of 84 days.

Diets

Four rations were used in this experiment each contained 0, 3, 6 or 9% of flaxseed. Formulation and ingredients' of the diets are presented in Table 1.

Lambs of the control group received a basal diet with 0% flaxseed, whereas lambs in T1, T2 and T3 received flaxseed at a rate of 3, 6 or 9% (Table 1). All lambs were fed concentrate at a rate of 3% of their body weight once daily, and the refusal of the diet was collected and weighed before offering the feed in the next morning. Straw was given *ad libitum*. Clean water was available constantly. Lambs were weighed at weekly intervals.

Faeces collection and apparent digestibility

The digestibility trial was determined from the total collection of faeces for 7 days at 11 weeks of feeding trial. Faeces from the individual lambs were collected and weighed every morning by fitting lambs collection bags (Saeed, 2011). The faeces were mixed thoroughly by hand and 10% sub-sample was retained and stored at -15°C. At the end of the collection period, the sample of feed and refusal were dried at 65°C for 48 h and faeces were dried at 65°C until constant weight. The dried samples were ground through 1 mm mash. Aliquots of the samples from each day were pooled and analyzed chemically. The apparent digestibility coefficient of feed nutrients was determined according to McDonald et al. (2002).

Chemical analysis

Proximate chemical analysis of concentrate samples in triplicate per each determination was carried out for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash content according to the A.O.A.C. (1995). The nitrogen free extract (NFE) was calculated by subtracting the summation percentages of CP, EE, CF and ash from one hundred. The *In vitro* digestibility of DM and OM for treatments was determined using the method of Telley and Terry (1963).

Table 1: Formulation and chemical composition of experimental diets

Ingredients (%)	Control	T1	T2	T3
Barley	40	40	40	40
Wheat	27	27	27	27
Yellow Corn	15	15	15	15
Soybean meal	15	12	9	6
Flaxseed	0	3	6	9
Salt	1	1	1	1
Minerals and vitamins	2	2	2	2
Chemical composition%				
Dry matter (DM)	94.5	94.0	94.0	94.0
Organic matter (OM)	93.7	93.6	93.4	93.3
Crude protein (CP)	16.2	16.1	16.1	16.1
Ether extract (EE)	2.3	3.1	4.1	4.7
Total Ash	6.3	6.4	6.6	6.7
Crude fiber (CF)	5.4	4.8	4.2	4.4
Nitrogen free extract (NFE)	69.8	69.6	69.0	68.1
Metabolizable energy ME (MJ/Kg)*	12.7	12.8	13.1	13.1

*ME (MJ/ kg DM) = 0.012 CP +0.031 EE+0.005 CF +0.014 NFE (MAFF, 1977). T1-T3 was fed flaxseed at the rate of 3, 6 and 9%.

Statistical analysis

The obtained data were analyzed according to Addinsoft XLSTAT (2007) for one way analysis of variance. Differences among means were carried out by using Duncan multiple range tests (Duncan, 1955). Data from experiment were analyzed according to the following model:

$$Yij = \mu + t_i + eij$$

Where: Yij = the dependent variable, μ = overall mean, Ti = effect of the treatment (i = control, 3%flaxseed, 6% flaxseed or 9% flaxseed), eij = random residual error.

Results

In vitro dry matter and organic matter digestibility

Data related to the *in vitro* digestibility of dry matter and organic matter is given in Table 2. There was no effects (P>0.05) of different levels of flaxseed on *in vitro* digestibility of DM and OM among treatments.

Total daily nutrient intake during the digestibility trial

Data of daily nutrient intake is given in Table 3. It can be seen from this table that DMD, OMD, CP, CF, Ash, NFE and ME intake are the same for all treatments. The EE intake was significantly (P<0.05) higher in T3 as compared to control group. However, marginally higher DM and OM were observed in T1 followed by T2 and T3.

Numerically, higher ME intake was observed in T2 treatment followed by T1 and T3. However, all treatments were not significant.

Table 2: Effect of different levels of flaxseed on *in vitro* dry matter and organic matter digestibility and daily nutrient intake of lambs during the digestibility trial

Item	Control	T1	T2	T3
Live body weight (kg)	45.3±1.89^a	45.97±1.61^a	46.0±1.67^a	45.1±1.91^a
Metabolic weight ($W^{0.75}$)	17.46±0.41^a	17.65±0.24^a	17.66±0.37^a	17.4±0.49^a
IVDMD	66.3±0.61^a	66.8±0.96^a	66.2±0.51^a	65.7±0.45^a
IVOMD	68.2±0.93^a	68.4±0.27^a	68.9±0.60^a	67.5±0.38^a
DMI (g/day)	1382±1.90^a	1392±1.83^a	1388±1.48^a	1384±2.21^a
DMI (g/ kg $W^{0.75}$)	79.15±0.48^a	78.87±0.74^a	78.56±0.89^a	79.68±0.97^a
OMI (g/day)	1295±2.39^a	1303±2.40^a	1297±2.73^a	1291±2.28^a
OMI (g/ kg $W^{0.75}$)	74.16±0.76^a	73.82±0.70^a	73.36±1.10^a	74.33±1.71^a
CP (g/day)	224.0±1.51^a	224.0±1.93^a	224.0±1.88^a	222.6±1.99^a
CP (g/ kg $W^{0.75}$)	12.82±0.17^a	12.69±0.29^a	12.65±0.52^a	12.8±0.59^a
EE (g/day)	31.8±1.23^c	43.2±1.32^{bc}	57.0±1.42^{ab}	64.7±1.29^a
EE (g/ kg $W^{0.75}$)	1.82±0.19^c	2.43±0.30^{bc}	3.22±0.28^{ab}	3.73±0.33^a
Ash (g/day)	87.0±1.64^a	89.0±1.01^a	91.0±1.56^a	93.0±1.91^a
Ash (g/ kg $W^{0.75}$)	4.98±0.26^a	5.04±0.04^a	5.17±0.15^a	5.33±0.39^a
CF (g/day)	74.6±2.39^a	67.0±2.67^a	58.0±2.00^a	61.0±2.17^a
CF (g/ kg $W^{0.75}$)	4.27±0.46^a	3.78±0.49^a	3.29±0.31^a	3.52±0.33^a
NFE (g/day)	964.6±3.36^a	968.8±4.11^a	958.0±4.80^a	942.7±3.67^a
NFE (g/ kg $W^{0.75}$)	55.25±0.87^a	54.90±0.91^a	54.21±0.97^a	54.27±0.88^a
ME MJ/ kg DM	17.6±0.21^a	17.82±0.10^a	18.2±0.15^a	18.1±0.23^a
ME (g/ kg $W^{0.75}$)	0.727±0.01^a	0.725±0.01^a	0.742±0.01^a	0.755±0.04^a

Means followed by different superscripts within a row are significant (P<0.05); T1-T3 were fed flaxseed at the rate of 3, 6 and 9%. IVDMD= In vitro dry matter digestibility, IVOMD= In vitro organic matter digestibility, DMI= Dry matter intake, OMI= Organic matter intake, CP= Crude Protein, EE= Ether extract, CF=Crude fiber, NFE= Nitrogen free extract, Me= Metabolizable energy

Table 3: Effect of different levels of ground flaxseed on the *in vivo* digestibility of the nutrient (%)

Item	Control	T1	T2	T3
DMD	67.4±0.25^a	67.9±0.28^a	67.3±0.21^a	66.9±0.23^a
OMD	69.7±0.37^a	70.1±0.39^a	69.3±0.30^a	68.6±0.22^a
CPD	69.1±0.29^a	69.5±0.36^a	70.1±0.34^a	68.6±0.20^a
EED	68.4±0.67^c	73.2±0.77^b	79.5±0.87^a	81.3±0.92^a
CFD	44.2±0.19^a	43.6±0.22^a	45.1±0.26^a	43.6±0.20^a
NFED	74.8±0.29^a	75.1±0.17^a	73.6±0.21^a	74.0±0.18^a

Means followed by different superscripts within a row are significant (P<0.05); DMD = Dry matter digestibility, OMD = Organic matter digestibility, CPD = crude protein digestibility, EED = Ether extract digestibility, CFD = Crude fibre digestibility, NFED = Nitrogen free extract digestibility; T1-T3 were fed flaxseed at the rate of 3, 6 and 9%.

In vivo digestibility of the nutrients

The apparent *in vivo* digestibility of all nutrients are presented in Table 3. In the digestibility experiment, the *in vivo* apparentdry matter digestibility (DMD) ranged between 66.9 to 76.9%, and the differences among treatment were not significant (P>0.05). The organic matter digestibility (OMD) was marginally higher in T1 followed by T2 and T3. Moreover, the digestibility of CP was marginally higher in T2 followed by T1 and T3.

Result indicated that the ether extract digestibility (EED) was significantly (P<0.05) higher in T2 and T3 as compared to T1.

Furthermore, the mean value of crude fibre digestibility (CFD) was not significantly (P>0.05) different among treatment. On the other hand, the *in vivo* apparent nitrogen free extract digestibility (NFED) was not significant (P>0.05) among treatments. However, digestibility of NFED was numerically higher in T1 (75.1%) followed by T3 and T2.

The energetic values of diets

The energetic values of the diets such as total digestible nutrient (TDN), digestible energy (DE) and metabolizable energy (ME) are presented in Table 4. In the current work, TDN, DE and ME are almost similar in all treatments (P>0.05).

Discussion

In the present work, it was clear that the use of flaxseed cannot be used as an energy and protein source in animal. Similar result was observed by Macdonald (1994) and Mustafa et al. (2003). Similar results were also reported by Astellini et al. (2004), Petit et al. (2003) and Gonthier et al. (2004). The high percentage of EE in T3 diet is reasonable since linseed contains about 40% oil (Legrand et al., 2010). These results are similar to the results of Micek et al. (2004) who reported higher ether extract intake in contained 10% crushed linseed supplemental, as compared to the control groups.

The higher digestibility of ether extract increased in the current study by the inclusion of dietary flaxseeds. This result was similar to the finding of Alcaldeet al. (2011) who reported that nutrient intake increased in trialon Boer and Saanen goat kids fed on flaxseed, sunflower or canola.

Table 4: Effect of different levels of ground flaxseed on the energetic value of experimental diets

Item	Control	T1	T2	T3
Total digestible nutrient (%DM) TDN [1]	67.39±0.41 a	67.84±0.44 a	67.23±0.40 a	67.19±0.38 a
Digestible energy (Mcal /kg DM) DE [2]	2.971±0.05 a	2.991±0.03 a	2.964±0.06 a	2.962±0.04 a
Metabolizable energy (Mcal / kg DM) ME [3]	2.437±0.04 a	2.453±0.02 a	2.431±0.06 a	2.429±0.03a

Means followed by the same superscripts within a row are not significant (P<0.05); [1] TDN (DM) = DCP+DEE × 2.25+TDC (Sniffen et *al*., 1992); [2]DE = %TDN × 0.04409 (NRC,1996); [3]ME = DE × 0. 82 (NRC, 1996); T1-T3 were fed flaxseed at the rate of 3, 6 and 9%.

No significant difference was found in dry matter in the current study. These findings are in confirmation with the findings of the Micek et al. (2004) and Walkunde and Adangale (2011) who reported non-significant difference in dry matter digestibility among treatments when 50, 100 and 150 g linseed supplementation was done in Osman abadi goat kids and who observed non-significant difference in dry matter digestibility when 3% linseed oil supplementation was done in dairy cows (Ueda et al., 2003). However, Machmüller et al. (2000) evaluated the supplementation with squeezed canola, sunflower or flaxseed in growing lambs fed on corn silage, grass hay and concentrate (5.6% EE vs. 3.1% control) and observed that dietary sunflower seed reduced the digestibility of neutral detergent fibre, acid detergent fibre and organic matter. Diets were formulated to provide similar total digestible nutrients and crude protein contents in order to avoid composition variations and changes in rumen environment. The major variation was observed in the ether extract content, which showed significant change (Table 3). These results were similar to the results of Mustafa et al. (2002), Gonthier et al. (2004) and Alemu et al. (2010) who reported higher CP digestibility in linseed cake supplemented ration than a control ration of Sidama Goat. It may be due to higher solubility of heat treated of linseed protein which might favour higher digestibility. The perusal of the data indicated that linseed protein can be efficiently used by ruminants without affecting overall digestibility of experimental ration. Moreover, EE content of diets with oilseeds (3.1 and 4.7% on average) is not considered at level high enough to damage nutrient digestibility, mainly crude fibre digestibility. In general, these fatty acids show better digestibility than saturated fatty acids and are more harmful to rumen fermentation (Palmquist and Mattos, 2006). The findings of present study envisage that digestibility of various nutrients under different treatments supplemented with different levels of flaxseed were similar and comparable with control indicating no adverse effect on nutrient digestibility. The perusal of data indicates that there was no specific trend in NFE digestibility.

There was no comparable data for energy contents of the flaxseed in the diets. These results are similar to the findings of Alcalde et al. (2011) who reported that an increase of 2.32% in ether extract compared with the control. Chilliard (1993) reported that diets with 3.9% of lipids show higher (9%) energy values than control diets. Among the nutrients, lipids have the highest energetic value (NRC, 2007). Therefore, the highest intake and digestibility for ether extract provided by flaxseeds could alter the energy value of diets, but this was not observed in this experiment. This may be related to levels of inclusion of flaxseed and also to the balancing of the diets which presented similar values of metabolizable energy in their final composition. The increased content of polyunsaturated fatty acid in linseed-based diets may cause a slight decrease in cellulolytic activity in the rumen, which was observed in the present study by the decrease of the VFA content (Micek et al., 2004). They reported that 10% addition of linseed to concentrate caused a decrease in VFA in the rumen fluid. Furthermore, the control diet had higher nitrogen free extract, which probably offset the additional energy contained in flaxseed diets.

Conclusions

Feeding diets with different levels of flaxseed (3, 6 and 9%), have no beneficial effect in Karadi male lambs except improvement in digestibility of ether extract.

References

A.O.A.C. 1995. *Association of Official Analytical Chemists*, Official a methods of analysis, 14th edn. Washington, DC, pp: 1018.

Addinsoft. 2007. XLSTAT. URL http://www.xlstat. com

Alcalde, C.R., Grande, P.A., Lima, L.S., Macedo, F.A.F., Zeoula, L.M. and Paula, M.C. 2011. Oilseeds in feeding for growing and finishing ¾ Boer + ¼ Saanen goat kids. *Revista Brasileira de Zootecnia*, 40: 1753-1757.

Alemu, W., Melaku, S. and Tolera, A. 2010. Supplementation of cottonseed, linseed, and noug seed cakes on feed intake, digestibility, body weight, and carcass parameters of Sidama goats. *Tropical Animal Health Production*, 42: 623-631.

Al-Rubeii, A.M.S. and Zahir, H. Gh. 2012. Effect of Different Levels of Flax Seed Powder as a Source of Omega-3 on the Carcass Characteristics of Karadi Lambs. *Journal of Agricultural Science and Technology*, 2: 1189-1196. ISSN 1939-1250.

Astellini, C., Dal bosco, A.C., Ardinali, R., Mugnai, C. S. and Ciascia, E. 2004. Effect of dietary N-3 fatty acids on the composition of doe's milk and tissues of suckling rabbits. *Meat Science*, 66: 407-413.

Bas, P., Berthelot, V., Pottier, E. and Normand, J. 2007. Effect of level of linseed on fatty acid composition of muscles and adipose tissues of lambs with emphasis on trans fatty acids. *Meat Science*, 77: 678-688.

Borowiec, F., Micek, P., Marcinski, M., Barteczko, J. and Zajac, T. 2004. Linseed-based diet for sheep. 2. Performance and chemical composition of meat and liver. *Journal of Animal and Feed Sciences*, 13: 19-22.

Borys, B., Jarzynowska, A., Janicki, B. and Borys, A. 2005. Effects of different particle size of rapeseed and linseed in fattening lamb diets. *National Research Institute of Animal Production Krakow, Meat and Fat Research Institute, Jubilerska*, 4: 40-190.

Chilliard, Y. 1993. Dietary fat and adipose tissue metabolism in ruminants, pigs, and rodents: A review. *Journal of Dairy Science*, 76: 3897-3931.

Czauderna, M., Kowalczyk, J., Niedźwiedzka, K.M., Wąsowska, I. and Pająk, J.J. 2004. The effect of selenium and linseed oil on growth of sheep and content of selected fatty acids in M. longissimus dorsi. *Journal of Animal and Feed Sciences*, 13: 303-306.

Demirel, G., Wachira, A.M., Sinclair, L.A., Wilkinson, R. G., Wood, J.D. and Enser, M. 2004. Effects of dietary n _ 3 polyunsaturated fatty acids, breed and dietary vitamin E on the fatty acids of lamb muscle, liver and adipose tissue. *British Journal of Nutrition*, 91: 551-565.

Drouillard, J.S., Seyfert, M.A., Good, E.J., Loe, E.R., Depenbusch, B. and Daubert, R. 2004. Flaxseed for finishing beef cattle: Effects on animal performance, carcass quality, and meat composition. Pages 108-117 in Proc. 60th Flax Inst., Fargo, ND. Flax Inst., Dept. Plant Sci., Fargo, ND.

Duncan, D.B. 1955. Multiple ranges and multiple "F" test. Biometrics, 11: 1-12.

Goering, H.K. and Van Soest P.J. 1970. Forage analysis. No.98. 387-598.Agriculture Handbook, U.S. Department of Agriculture.

Gontheir, C., Mustafa, A.F., Berthiaume, R., Petit, H.V., Martineau, R. and Ouellet, D.R. 2004. Effect of feeding micronized and extruded flaxseed on ruminal fermentation and nutrient utilization by Dairy Cows. *Journal of Dairy Science*, 87: 1854-1863.

Jenkins, T.C. 1993. Symposium: Advances in ruminant lipid metabolism. Lipid metabolism in the rumen. *Journal of Dairy Science*, 76: 3851-3863.

Kronberg, S.L., Barceló-Coblijn, G., Shin, J., Lee, K. and Murphy, E.J. 2006. Bovine muscle n-3 fatty acid content is increased with flaxseed feeding. *Lipids*, 41: 1059-1068.

Legrand, P., Schmitt, B., Mourot, J., Catheline, D. and Chesneau, G., Mireaux, M., Kerhoas, N. and Weill, P. 2010. The consumption of food products from linseed-fed animals maintains erythrocyte omega-3 fatty acids in obese humans. *Lipids*, 45: 11-19.

Machmüller, A. Ossowski, D.A. and Kreuzer, M. 2000. Comparative evaluation of coconut oil, oilseeds and crystalline fat on methane release, digestion and energy balance in lambs. *Animal Feed Science and Technology*, 85: 41-60.

Maddock, T.D., Bauer, M.L., Koch, K.B., Anderson, V.L., Maddock, R.J., Barceló-Coblijn, G., Murphy, E.J. and Lardy, G.P. 2006. Effect of processing flax in beef feedlot diets on performance, carcass characteristics, and trained sensory panel ratings. *Journal of Animal Sci*ence, 84: 1544-1551.

MAFF. 1975. Ministry of Agriculture, Fisheries and Food Department of Agriculture and Fisheries for Scotland. Energy allowance and feeding system for ruminants. Technical Bulletin, 33 Her Majesty's Stationery Office London.

McDonald, B.E. 1994. Canola oil nutritional properties. Canola Council of Canada. Winnipeg, MB.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. 2002. Animal Nutrition. 6th Edition. Pearson Prentice Hall. Pp: 33-47,176, 270-271, 281-289.

Micek, P., Borowiec, F. and Marciński, M. 2004. Linseed-based diets for sheep. 1. Nutrient digestibility, N retention and rumen fermentation. *Journal of Animal and Feed Sciences*, 13, Suppl. 2:15-18.

Mustafa, A.F., Gonthier, C., and Ouellet, D.R. 2003. Effects of extrusion of flaxseed on ruminal and postruminal nutrient digestibilities. *Archives of Animal Nutrition*, 57: 455-463.

National Research Council. 1996. Nutrient requirements of beef cattle. 7. rev. ed. Washington, DC: National Academy Press. P: 242.

National Research Council. 2007. Nutrient requirements of small ruminants. Washington, D.C. *National Academy Press*. P:362.

Palmquist, D.L. and Jenkins, T.C. 1980. Review: Fat in lactation rations. *Journal of Dairy Science*, 63:1-14.

Palmquist, D.L. and Mattos, W.R.S. 2006. Metabolismo de lipídeos. In: Berchielli, T.T., Pires, A.V., Oliveira, S.G. (Eds.) Nutrição de ruminantes. Jaboticabal: FUNEP, Pp: 287-310.

Petit, H.V. 2003. Digestion milk production milk composition and blood composition of dairy cow fed formaldehyde treated flaxseed or sunflower seed. *Journal of Dairy Science*, 86: 2637-2646.

Saeed, A.A. 2011. Effect of level and degradability of dietary protein fed with or without yeast (*Saccharomyces cerevisiae*) on Awassi lambs performance. Ph.D. thesis, Dept. of Anim. Res. College of Agric. Univ. of Baghdad. Iraq.

Schauff, D.J. and Clark, J.H. 1992. Effects of feeding diets containing calcium salts of long-chain fatty acids to lactating dairy cows. *Journal of Dairy Science*, 75: 2990-3002.

Soita, H.W., Meier, J.A., Fehr, M., Yu, P., Christensen, D.A., McKinon, J.J. and Mustafa, A.F. 2003. Effects of flaxseed supplementation on milk production, milk fatty acid composition and nutrient utilization by lactating dairy cows. *Archives of Animal Nutrition*, 57: 107-116.

Tilley, J.M. and Terry, R.A. 1963. A two stage technique for *in vitro* digestion of forage crops. *Journal of the British Grassland Society*, 18: 104-111.

Ueda, K., Ferlay, A., Chabrot, J., Loor, J.J., Chilliard, Y. and Doreau, M. 2003. Effect of linseed oil supplementation on ruminal digestion in dairy cows fed diets with different forage: concentrate ratios. *Journal of Dairy Science*, 86: 3999-4007.

Walkunde, T.R. and Adangale, S.B. 2011. Digestibility and energy utilization of diet enriched with whole linseed in osmanabadi goat kids. *International Journal of Food, Agriculture and Veterinary Sciences*, 1:17-20.

Zhang, R.H., Mustafa, A.F. and Zhao, X. 2007. Effects of feeding oilseeds on nutrient utilization by lactating ewes. *Small Ruminant Research*, 67: 307-311.