Effects of flaxseed oil supplementation to lactating goats diet on milk production, composition and fatty acids profiles

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ABSTRACT

Milk goats is of particular nutritional and economic importance in many parts of the world. This study aimed to define the effect of quaffing dairy goats with linseed oil (10, 20 and 30 mL/head/day) on milk production composition and fatty acids profile. Twenty-four lactating Zaraibi goats at the last weeks of gestation were used. Experimental animals were randomly divided into four equal groups. Result obtained revealed that flaxseed oil supplementation increased milk yield by a mean value of 19.79% as compared with control treatment. Milk fat percentage was higher for goats received 30 mL flaxseed oil than other treatments, while no remarkable effect of flaxseed oil supplementation on milk protein, lactose and ash contents was detected. Addition of flaxseed oil to goats’ diet resulted in reducing saturated fatty acids by a mean value of 13.72% as compared with control sample; however, these decreases may be influenced partially by lactation progress. In contrast, the concentration of unsaturated fatty acids increased with a mean value of 28.32%, with pronounced increases in oleic, linoleic and linolenic acids concentration as compared with control. Moreover, results obtained revealed that α-linolenic acid (ALA) concentrations achieved greatly affect by flaxseed oil supplementation, where their concentrations varied from 0.2-3.04%. In conclusion, feeding flaxseed to lactating goats can be used as a nutritional strategy to reduce concentrations of short-chain and saturated fatty acids and to increasing long-chain and polyunsaturated fatty acids in milk, as well as to improve milk yield. Consequently, such strategy has a significant effect for human's nutrition and health.

Keywords: Goats; Flaxseed; Saturated fatty acids; Unsaturated fatty acids.

INTRODUCTION

Goats are reared worldwide for its performance, durability and excellent ability to adapt to demanding conditions. Their milk has an extra special dietary and sensory properties, for which it is prized in many countries. Goats milk was the first animal milk used in human nutrition where still plays an important role (Vejcik and Kral, 1998). It is very valuable and desired food for their unique composition and high digestibility.

Milk goats is of particular nutritional and economic importance in many parts of the world. It is primarily used for the production of traditional cheeses, yoghurt and ice cream. The composition of milk is one of major factor determining its value in the market. The nutritive value and technological properties of milk are largely influenced by its composition (Morand-Fehr et al., 2007).

Protein of goat milk are more digestible, and their basic amino acids are absorbed easily in comparison to cow milk (Ceballos et al., 2009), also goat milk contains six out of ten essential amino acids in higher amounts (Haenlein, 2004). In addition, goat milk contain casein only in small amount and for this reason is suitable for people suffering for casein allergy (Raynal-Ljutovac et al., 2008).

Generally, milk fat has been criticized for its high content of saturated fatty acids, which contribute to development of hypercholesterinemia, atherosclerosis and other cardiovascular health problems (Noakes et al., 1996). However, the high fat content in goat milk might limit the demand for milk and milk product by health-conscious consumers. Ruminant milk contains relatively higher amount of saturated fats than most oils of plant origin. The consumption of saturated fats is often associated with health disorders in man, such as coronary heart disease (Pfeuffer, 2001). Therefore, efforts have been directed to manipulate fatty acid (FA) composition of ruminant milk. In this regard, the influence of changes in diet composition in milk FA profile of goats has been extensively studied (Nudda et al., 2003; Chilard and Feraly, 2004). Numerous
studies using dietary modification have been conducted to manipulate milk fatty acid composition in order to reduce concentrations of saturated fatty acids and increase the concentrations of polyunsaturated fatty acids (PUFA). Increasing milk concentrations of specific health-promoting fatty acids, such as conjugated linoleic acid (CLA) and linolenic acid, is of particular interest because of their role in prevention of specific human health problems (Parodt, 1999). Feeding oilseeds and vegetable oils is an effective method to manipulate fatty acid composition of goat's milk (Mir et al., 1999) by reducing saturated:unsaturated fatty acid ratio of the milk.

Flaxseed (Linum usitatissimum) is a rich source of α-linolenic acid (ALA), constituting nearly 55% of total oil, this percentage is 5.5 times more than the sources containing the highest ALA (Bloedon and Szapary, 2004). Feeding flaxseed to dairy cows reduced the concentrations of short-chine and saturated fatty acids and increased concentration of long-chine fatty acids and PUFA (Goodridge et al., 2001; Petit, 2002 and Mustafa et al., 2003). Few data are available on performance of lacting goats fed on flaxseed oil rich in PUFA.

Therefore, the objective of the present study was to determine the effects of feeding different levels of flaxseed to lacting goats on milk production, composition and fatty acids profile.

**MATERIALS AND METHODS**

**Materials:**

**Flaxseed oil**

Cold pressed Flaxseed oil was obtained from Extract and Press Oil Unit, National Research Center, Dokki, Cairo, Egypt.

**Experimental animals**

**Goats**

Twenty-four Zaraibi goats at the last 6th weeks of gestation aged 4-5 years and weighting 38±4 kg. had the third parity of lactation were used in the present study. The goats were obtained from Sakha Experimental Research Station belonging to Animal Production Research Institute (APRI), Ministry of Agriculture, Egypt.

**Basal diet**

Goats basal diet consisted of pelleted concentrate feed mixture (14% CP and 60% TDN) plus 3 kg Egyptian clover (Trifolium Alexanderi) / h/ day and bean straw ad lib.

The concentrates consisted of 25% undecorticated cotton seed meal, 35% wheat bran, 30% corn, 3% rice bran 3% molasses, 2% limestone, 1% urea and 1% salt (NaCl).

**Methods**

**Feeding experiment of goats**

Twenty-four lactating Zaraibi goats were randomly divided into four equal groups, according to live body weight, age and parity of lactation.

- Group (1) served as control, nil flaxseed oil supplements.
- Group (2) administrated 10 mL flaxseed oil/head/day.
- Group (3) administrated 20 mL flaxseed oil/head/day.
- Group (4) administrated 30 mL flaxseed oil/head/day.

Diets offered at two times, 9.00 am and 3.00 pm daily, requirements during pregnancy and lactation, according to (NRC recommendations, 2001), while fresh drinking water was freely available all over the day time.

**Milk yields and samples**

The technique of hand milking was used to stimulate milk yield. Goats have been milked twice daily every week by milking one teat, while the kid suckles the other one. Total milk yield/goat = (Total milk yield in one teat x 2 in the morning) + (Total milk yield in one teat x 2 in the afternoon).

A composite sample (10% of total daily milk yield) was immediately collected for chemical analysis.

**Chemical analysis**

**Milk fat and Protein contents**

Fat and total nitrogen contents were determined as described by (Ling, 1963).

**Total solids (TS) and ash contents**

Total solids and ash contents were determined according to (A.O.A.C, 2012).
Lactose content

Lactose content was calculated by the difference between total solids and (fat, protein and ash contents).

Determination of fatty acids profile

The fatty acids profile of flaxseed oil and milk samples were determined as methyl ester by gas liquid chromatography according to the A.O.A.C. (2011).

RESULTS AND DISCUSSION

The present study was carried out with twenty-four lactating Zaraibi goats at the last 6th weeks of gestation until 90 days after parturition, due to time of weaning their kids. Experimental animals were randomly divided into four equal groups, according to live body weight, age and parity of lactation.

However, this study aimed to define the effect of flaxseed oil supplementation (10, 20 and 30 mL flaxseed oil/head/day + basal diet) on milk production, milk composition and fatty acids profile.

Table 1. Effect of flaxseed oil supplementation on milk composition and average of daily milk yield (g/head/day).

<table>
<thead>
<tr>
<th>Stage Overall means of:</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cont.</td>
</tr>
<tr>
<td>Total solids%</td>
<td>13.29</td>
</tr>
<tr>
<td>Fat%</td>
<td>3.30</td>
</tr>
<tr>
<td>Protein%</td>
<td>3.51</td>
</tr>
<tr>
<td>Lactose%</td>
<td>5.72</td>
</tr>
<tr>
<td>Ash%</td>
<td>0.76</td>
</tr>
<tr>
<td>Average of daily milk yield (g/head/day)</td>
<td>960</td>
</tr>
</tbody>
</table>

Cont.: plain goat’s milk, G1: milk from goats received 10 mL flaxseed oil/day. G2: milk from goats received 20 mL flaxseed oil/day, G3: milk from goats received 30 mL flaxseed oil/day

Results of chemical composition of goat’s milk as affected by flaxseed oil supplementation are illustrated in Table 1. Data obtained revealed that no pronounced effect of feeding flaxseed oil on TS% of resultant milk in different treatments as compared with the control. Our results in agreement with those of Morsy et al. (2015).

Furthermore, milk fat percentage was higher for goats fed 30 mL flaxseed oil/day (G3) than those fed on 10 mL and 20 mL flaxseed oil or the control diet. Our results are consistent with other reports where milk fed percentage increased for goats fed supplemental fats (Mir et al., 1999; Zhang et al., 2006 and Morsy et al., 2015).

The higher milk fat levels in different treatments could related to more VFAs produced in rumen of goats as compared to control groups. Actually, milk fat synthesis known to involve the coordinated activity of several lipogenic enzymes, but PUFAs nutrition may regulate mammary lipoprotein lipase, acetyl-CoA carboxylase, fatty acid synthase and stearoyl-CoA desaturase,
which considered a key to produce greater milk fat (Bernard et al., 2009).

In addition, milk protein percentage showed no remarkable effect by dietary treatments (Table 1), which is in agreement with other reports (Kitessa et al., 2003; Zang et al., 2006; Hassan et al., 2012 and Kholif et al., 2015). Our results, however, are different from Rotunno et al. (1998) and Casals et al. (1999) where a negative effect was found on milk protein percentage of goats. While, Morsy et al. (2015) defined no effects of sunflower oil addition to lactating Damascus goats’ diets (control group). However, Wu and Huber (1994) mentioned that this statement may be attributed to a lack of increase in amino acids available to the mammary gland for protein synthesis as milk yield increase during fat supplementation.

Moreover, as shown from Table 1, there were no noticeable effect of flaxseed oil on milk lactose and ash contents in the treatment groups compared with control, where, the control group possessed the highest values, being 5.72% and 0.76% for lactose and ash contents respectively. The same trend of results was previously reported by Abdelhamid et al. (2013) for lactose content and Morsy et al. (2015) for ash content. In contrast, Morsy et al. (2015) reported that linseed oil supplementation caused significant and positive correlation coefficient between lactose production and oil addition to goat diets.

On the other hand, fatty acids profile of flaxseed oil was carried out and results obtained are listed in Table 2.

Table 2. Fatty acids profile of flaxseed oil.

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>%</th>
<th>Fatty acid</th>
<th>%</th>
<th>Fatty acid</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C16:0</td>
<td>5.00</td>
<td>C18:1ω7</td>
<td>1.00</td>
<td>C18:3ω4</td>
<td>0.14</td>
</tr>
<tr>
<td>C18:0</td>
<td>3.90</td>
<td>C18:1ω9</td>
<td>18.91</td>
<td>C20:1ω11</td>
<td>0.10</td>
</tr>
<tr>
<td>C20:0</td>
<td>0.12</td>
<td>C18:2ω6</td>
<td>14.83</td>
<td>TUFAs</td>
<td>90.91</td>
</tr>
<tr>
<td>TSFAs</td>
<td>9.09</td>
<td>C18:3ω3</td>
<td>55.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From these results it could be noticed that, out of nine fatty acids detected, three SFAs and six UFAs. However, flaxseed oil had a high TUFAs content, being 90.91%, while TSFAs possessed only 9.09% of the total fatty acids.

In addition, the two fatty acids (C16:0 and C18:0) were the highest SFAs 5.00 and 3.90%, respectively, while for UFAs the highest values of 55.93, 18.91 and 14.83% were recorded for C18:3ω3 ALA, C18:1ω9 and C18:2ω6 CLA, respectively. Similar finding was previously reported by Oomah (2001), Daun et al. (2003) and Wee-Sim et al. (2007).

Furthermore, the overview of analysed fatty acids from goats’ milk at different sampling periods are presented in Tables 3 and 4.

From Table 3, it could be seen that the most abundant saturated fatty acids (SFAs) was palmitic acid (C16:0) followed by stearic acid (C18:0). Throughout lactation period, palmitic acid percentage for control treatment attained the highest level of SFAs in goats’ milk samples varied from 25.97% to 34.38% of SFAs, with a mean value of 31.54%, which represent 46.82% of TSFAs. In contrast, palmitic acid concentration was sharply reduced in all treatments supplemented with flaxseed oil and possessed lower values with an average of 22.02%, this figure represent about 37.89% of TSFAs. However, these results were consist with those found by Gómez-cortes et al. (2009), Mele et al. (2011) and Gassi et al. (2012).

Contrarily to palmitic acid concentration, stearic acid values achieved an opposite trend, in which their mean value in control treatment was reduced to about 12.56% of SFAs, while flaxseed oil treatments had the highest average figure, actually 14.89% of SFAs throughout lactation period. These results were comparable to those reported by Gassi et al. (2012).
Table 3. Effect of different treatments on milk saturated fatty acids profile (%).

<table>
<thead>
<tr>
<th>Items</th>
<th>1st month</th>
<th>2nd month</th>
<th>3rd month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cont</td>
<td>G1</td>
<td>G2</td>
</tr>
<tr>
<td>C14:0</td>
<td>0.75</td>
<td>0.91</td>
<td>0.90</td>
</tr>
<tr>
<td>C16:0</td>
<td>1.81</td>
<td>1.61</td>
<td>1.23</td>
</tr>
<tr>
<td>C18:0</td>
<td>2.08</td>
<td>1.73</td>
<td>1.33</td>
</tr>
<tr>
<td>C18:1</td>
<td>6.27</td>
<td>5.05</td>
<td>4.28</td>
</tr>
<tr>
<td>C12:0</td>
<td>2.39</td>
<td>2.03</td>
<td>3.89</td>
</tr>
<tr>
<td>C16:0</td>
<td>7.66</td>
<td>6.41</td>
<td>7.26</td>
</tr>
<tr>
<td>C15:0</td>
<td>1.34</td>
<td>1.03</td>
<td>1.55</td>
</tr>
<tr>
<td>C17:0</td>
<td>1.95</td>
<td>1.89</td>
<td>1.94</td>
</tr>
<tr>
<td>C20:0</td>
<td>0.29</td>
<td>0.25</td>
<td>0.24</td>
</tr>
<tr>
<td>TSFAs</td>
<td>67.67</td>
<td>57.66</td>
<td>58.40</td>
</tr>
</tbody>
</table>

Cont.: control goat’s milk, G1: milk from goats received 10 mL flaxseed oil /day, G2: milk from goats received 20 mL flaxseed oil /day, TSFAs: total saturated fatty acids, G3: milk from goats received 30 mL flaxseed oil /day

From the previous results, it could be stated that the concentration of saturated fatty acids was reduced by flaxseed oil supplementation, where the mean value of the decreases attained 13.72%, these decreases may be also influenced partially by lactation progress, where the mean value of SFA concentrations reduced from 59.39% in the first month of lactation to 57.77% at third month, in flaxseed oil treatments.

On the other hand, results presented in Table 4 and Figures 1-3 declared that flaxseed oil treatments showed pronounced increased effect on goats milk oleic, linoleic, and ALA acids as compared to control. The same finding was previously reported by Luna et al. (2008), Atasoglu et al. (2009), Gassi et al. (2012), and Smiddy et al. (2012).

In addition, it was clear from the data obtained that the concentration of total unsaturated fatty acids (TUFAs) in flaxseed oil treatments were increased as compared with control treatment, where the increases % ranged from 19.21% to 34.1% with a mean value of 28.32%. Also, from the same table it was obvious that the major unsaturated fatty acids were oleic acid (C18:1ω9), it accounted about 24.82% of the TUFAs of goats milk in all samples throughout lactation period. Continuously, samples of treat. G3 ranked the highest levels of oleic acid in the third month of lactation actually 27.91%, while control samples had the lowest value, being 22.49% in the second month of lactation. In this respect, Dhiman et al. (2000), and Loor and Herbein (2003) stated that linseed is rich in C18:1 and C18:3 fatty acids, which can contribute to increase C18:1 concentration in milk. C18:1 fatty acid is derived from the partial hydrogenation of the C18:2 and C18:3 fatty acids that occurs in the rumen, by desaturation of stearic acid, which occurs in mammary gland due to the action of the enzyme 9-desaturase.

Furthermore, it was evident from the data presented in Table 4 and Figure 2 that flaxseed oil treatments recorded noticeable increased effect on goats milk linoleic acid (C18:2 n6) concentration as compared with control treatment. However, it could be gathered from the same table and Figure 3 that α-linolenic acid (ALA) concentrations achieved greatly affect by flaxseed oil supplementation. ALA concentrations were varied from 0.20-3.04% in different tested goat milk samples, while kompan and komprej (2012) gave a narrow range, actually from 0.5 to 1.0%. Moreover, the obtained data declared that, in the second month of lactation period, G3 treat. had the highest value of ALA, being 3.04%, while control treat. ranked the lowest figure, actually 0.20%. These results could be due to the fact that goats can successfully build linolemic fatty acid into milk fat when their diets supplemented with flaxseed oil which contain high amount of ALA (55.93%) as shown in Table 2. However, similar results have been previously reported by Luna et al. (2008), Zhang et al. (2006), and Gassi et al. (2012).
The most pronounced impact was noted at the highest level of MCFAs throughout lactation period "three months" were 10.1 and 51.5 in the first month, while in the third month were 4.95 and 67.2. The same trend of result was previously reported by Zhang et al. (2006).

Also, it was evident from the same table that control group possessed the highest level of MCFAs throughout lactation period with a mean value of 50.1%, while flaxseed oil supplementation reduced this figure to about 35.22%. In this respect, Bauman and Grinari (2003) stated that this reduction is likely the results of the negative effect of fat supplementation on de novo synthesis of milk fat.

Furthermore, an opposite trend was recorded for LCFAs concentrations, however, flaxseed oil supplementation leads to a noticeable increase in LCFAs.
concentrations, these increases could be also influenced partially by progress of lactation, where the mean value of LCFAs increased from 53.83% in the first month to about 58.67% in the third month of lactation, while the increases values varied from 13.33 to 47.04% in flaxseed oil treatments as compared to control. In this connection, Zhang et al. (2006) reported that flaxseed oil is rich source of C18:0, C18:1 and C18:3 fatty acids which likely accounted for the increased concentrations of LCFAs in the milk of goats fed on the flaxseed oil diet.

However, our results are in agreement with those reported by Caroprese et al. (2010) and Ingovortova et al. (2013).

Furthermore, the average value of fatty acids content in goat milk are listed in Table 6, and Figures (4-7). Results of saturated (SFA), mono-unsaturated (MUFA), poly-unsaturated (PUFA) and unsaturated (UFA) fatty acids between experimental and control group are compared.

It was obvious from data obtained that the concentration of saturated fatty acids was reduced by flaxseed oil supplementation. The decrease of SFA content could be also influenced partially by progress of lactation. The same relationship was also recorded by Strzalkowska et al. (2009 and 2010).

As seen from Table 6 and Figure 4, total SFAs in goat milk fat varied from 48.68 to 67.67%, where control group had the highest value of total SFAs, being 67.67% in the first month of lactation period, while G3 group ranked the least figure, actually 48.68% in the third month of lactation.

Contrarily to SFAs, unsaturated fatty acids (UFAs) achieved an opposite trend, in which their values were markedly increased throughout lactation period and possessed the highest mean value of 35.51% in the third month of lactation as compared with control (Figure 5).

Table 6. Effect of different treatments on fatty acids content in milk fat.

<table>
<thead>
<tr>
<th>Items</th>
<th>1st month</th>
<th>2nd month</th>
<th>3rd month</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFAs</td>
<td>67.67</td>
<td>57.66</td>
<td>58.4</td>
</tr>
<tr>
<td>MUFAs</td>
<td>26.99</td>
<td>30.58</td>
<td>32.84</td>
</tr>
<tr>
<td>PUFA</td>
<td>5.34</td>
<td>11.76</td>
<td>8.76</td>
</tr>
<tr>
<td>UFAs</td>
<td>32.33</td>
<td>42.34</td>
<td>41.6</td>
</tr>
</tbody>
</table>

Cont.: control goat’s milk, G1: milk from goats received 10 mL flaxseed oil /day. G2: milk from goats received 20 mL flaxseed oil /day, G3: milk from goats received 30 mL flaxseed oil /day, SFAs: saturated fatty acids, MUFAs: mono unsaturated fatty acids PUFAs: poly unsaturated fatty acids.

Moreover, it was of interest to notice that flaxseed oil supplementation increased the concentration of either MUFAs or PUFAs in resultant milk (Figures 6 and 7) and increase was more pronounced in G3 group in the third month of lactation, where the mean value of increase attained 42.53 and 73.3% for MUFAs and PUFAs, respectively relative to control.

In addition, obtained data revealed that control group ranked the lowest levels of total UFAs throughout lactation period varied from 32.33 to 32.95% with a mean value of 32.64%. However, finding are in complete agreement with previous reports of Ward et al. (2002); Petit et al. (2004); Zhang et al. (2006) and Kral (2010).

Generally, from the foregoing results, it could be pointed out that addition of flaxseed oil to goats’ diet increased milk yield by, as well as reducing saturated fatty acids (SFAs) and increasing of unsaturated fatty acids (UFAs) content in milk. Also, a noticeable increase in CLA and ALA content in milk can also be achieved by flaxseed oil supplementation to goats’ diet. Thus, increasing PUFAs content have a favorable effect on human health, however, a proper ratio of n-3/n-6 acid group showed be maintained, with the maximum value being 1/5 (Samkova et al., 2012), and this lead to reduce the risk of cardiovascular diseases.
Slow growth and fat deposition in dairy cows


Kholif, A.E., Khattab, H.M., El-Shewy, A.A., Salem, A.Z.M., Kholif, A.M., El-


Figure 1. Effect of supplementation by flaxseed oil on C18:1 n9 goat milk fat content.
Figure 2. Effect of supplementation by flaxseed oil on C18:2n6 goat milk fat content.

Figure 3. Effect of supplementation by flaxseed oil on ALA goat milk fat content.

Figure 4. Effect of supplementation by flaxseed oil on SFAs in milk fat content.
Figure 5. Effect of supplementation by flaxseed oil on UFAs in milk fat content.

Figure 6. Effect of supplementation by flaxseed oil on MUFAs in milk fat content.

Figure 7. Effect of supplementation by flaxseed oil on PUFAs in milk fat content.
تأثر إضافة زيت بذرة الكتان إلى طبقة الماعز الحنطة على إنتاجية اللبن. تركيب الكياوي ومحاربة من الإحماض الهدهية

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الملخص:
mاعز الحنطة له أهمية طبية واقتصادية خاصة في أجزاء كثيرة من العالم. يهدف هذا البحث إلى دراسة تأثير إضافة زيت بذرة الكتان بنسبة مختلفة (20, 30 و40 مل/رأس/يوم) على إنتاجية الماعز اللبني وتركيبه الكيماوي. استخدمت هذه الدراسة عدد 24 رأس من الماعز الحنطة خلال الفترة الأخيرة من الحمل (ستة أسابيع) إلى نهاية موسم الحمل (90 يوم بعد الولادة) حتى وقت فتح الشعير. وتم قسم الماعز إلى أربع جماعات متساوية. أظهرت النتائج زيادة إنتاجية زيت بذرة الكتان لدى الماعز allotted ساعيًا المهيئة. كما تزايدت نسبة الدهون في الجيل من الماعز المقدما بإضافة زيت بذرة الكتان خلال الشهر الأول من فترة الحمل مقترنة بتغيرات في تركيبات البروتين، الأكوز والبروتينيات وزباديتيت المعاملات المحيدة. وبناء على النتائج المقدمة، فإن إضافة زيت بذرة الكتان يمكن أن يرفع تركيز إنتاجية زيت بذرة الكتان إلى 72.35% ونسبة نسبة رفع نسب زيت بذرة الكتان بنسبة تراوح ما بين 0.2% و3.04%. كما أظهرت زيادة تركيز الكوا من الإجمالي للكوا في المنتج نتيجة لزيادة تركيز زيت بذرة الكتان. نتسلم من هذا إن إضافة زيت بذرة الكتان يمكن أن تؤثر على تركيب الإنتاج الحياتي في الذين الماعز مصرفًا، مما يمكن أن يساهم في تحقيق أهداف التغذية الصحية وصحة الإنسان.

الكلمات المفتاحية: ماعز، بذور الكتان، الإحماء الهدهية المحمولة، الإحماض الهدهية غير المحمولة.