# Fatty acid composition and vitamin E content of lambs fed with different levels of concentrate in a pasture feeding system.

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**Abstract**

The effect of different levels of concentrate in a pasture feeding system on the fatty acid composition and vitamin E content of *Corriedale* male lambs has been studied. The experimental groups were: animals fed on pasture (6% of live weight) composed mainly of *Lotus corniculatus*, animals fed pasture (6% of live weight) and concentrate (0.6% of live weight), animals fed pasture (6% of live weight) and concentrate (1.2% of live weight), and animals fed concentrate *ad libitum* and alfalfa hay (25% of the ration). The proportion of saturated and polyunsaturated fatty acids (SFA and PUFA, respectively) decreased, whereas the proportion of monounsaturated fatty acid (MUFA) increased as concentrate intake increased. The highest PUFA proportion in lambs fed on pasture was mainly due to the higher PUFA *n-3* proportion, especially linolenic acid (C18:3 *n-3*) in the pasture. As a consequence, according to human nutritional requirements, the ratio *n-6*/*n-3* was healthier in lambs fed pasture (with or without concentrate) than in lambs fed only concentrate. With respect to vitamin E content, animals fed pasture (with or without concentrate) had higher concentrations of vitamin E than animals fed only concentrate.

**Introduction**

The proportion of intramuscular fat and the fatty acid composition in the meat of ruminants vary according to different factors like breed, slaughter weight, fatness, and the diet provided. Diet has the greatest effect, especially when the relationship between pasture and concentrate is modified (Marino *et al*., 2006). In general, the consumption of fresh or conserved pasture in the form of hay leads to lower fat deposition than that obtained in animals that receive concentrate as the main component of their diet. These differences could be due to the lower total energy of feed consumed by lambs on pasture than those in drylot. Variations in the quality of the fat deposited are due fundamentally to the difference between the fatty acid composition of the pasture (rich in fatty acids like C18:3 *n-3* and their long-chain derivatives) and the concentrates (rich in linoleic acid and its derivative arachidonic acid (C20:4)). The fatty acid composition can affect the oxidative processes during meat storage, and thus it is important to know not only fatty acid composition, but also the concentration in the meat of anti-oxidants like vitamin E. Anti-oxidant concentration in meat is affected by the consumption of vitamin E in the diet and is found naturally in high concentrations in pasture. This study was carried out to evaluate the differences in the proportions of intramuscular fat, fatty acid composition, and vitamin E in the meat of lambs fed with different levels of concentrate.

**Materials and methods**

One hundred castrated *Corriedale* male lambs with an average live weight (LW) of 28.2 kg were divided into four groups which were fed different diets to an average LW of 40.0 kg. The experimental groups were: animals fed on pasture (6% of live weight) (T1); animals fed pasture (6% of live weight) and concentrate (0.6% of live weight) (T2); animals fed pasture (6% of live weight) and concentrate (1.2% of live weight) (T3); and animals fed concentrate *ad libitum* and alfalfa hay (25% of the ration) (T4). Pasture was composed mainly of birdsfoot trefoil (*Lotus corniculatus)* and the concentrate was a mixture of 72% ground corn and 28% soybean expeller. At 24 h after slaughter, samples of *Longissimus thoracic* muscle were collected from the left side to determine fatty acid composition and vitamin E content. Intramuscular fat was extracted from the muscle samples according to the Bligh & Dyer (1959) method, and methyl esters were formed according to the method described by Morrison & Smith (1964). Chromatographic analysis of

the methyl esters was carried out with a gas chromatograph. Muscle concentration of α-tocopherol was determined as described by Cayuela *et al*. (2003).

**Results and Discussion**

Least square means of intramuscular fat proportion (F), fatty acid proportions, and vitamin E content are shown in table 1. There was an effect of diet on F (P <0.001); this proportion increased as concentrate in diet increased. Fatty acid composition was also affected by diet. SFA proportion decreased as concentrate intake increased, mainly due to stearic acid (C18:0). Conversely, the proportion of MUFA increased as concentrate intake increased, mainly due to oleic acid (C18:1).

**Table 1.** Least square means of intramuscular fat proportion (F), fatty acid proportions, and vitamin E content of lamb fed with different diets

| | T1 | T2 | T3 | T4 | SEM | Sign |
|---|---|---|---|---|---|---|
| **F** | 3.62$^{a}$ | 4.34$^{ab}$ | 4.45$^{b}$ | 5.96$^{c}$ | 1.41 | *** |
| **Fatty acids** | | | | | | |
| **ΣSFA** | 48.62$^{b}$ | 47.50$^{ab}$ | 47.10$^{ab}$ | 46.18$^{a}$ | 2.67 | * |
| **C12:0** | 0.14 | 0.12 | 0.13 | 0.13 | 0.04 | ns |
| **C14:0** | 2.32$^{b}$ | 2.10$^{a}$ | 2.10$^{a}$ | 2.30$^{b}$ | 0.34 | * |
| **C15:0** | 0.49$^{c}$ | 0.36$^{ab}$ | 0.40$^{b}$ | 0.32$^{a}$ | 0.09 | *** |
| **C16:0** | 23.43$^{a}$ | 24.67$^{b}$ | 22.77$^{a}$ | 25.22$^{c}$ | 1.42 | *** |
| **C17:0** | 1.33$^{c}$ | 1.12$^{ab}$ | 1.20$^{b}$ | 1.10$^{a}$ | 0.13 | *** |
| **C18:0** | 20.69$^{b}$ | 19.39$^{b}$ | 20.31$^{b}$ | 16.99$^{a}$ | 2.34 | *** |
| **C20:0** | 0.21$^{b}$ | 0.14$^{a}$ | 0.19$^{b}$ | 0.11$^{a}$ | 0.07 | *** |
| **ΣMUFA** | 36.68$^{a}$ | 39.14$^{b}$ | 39.88$^{b}$ | 42.10$^{c}$ | 2.19 | *** |
| **C14:1** | 0.06$^{ab}$ | 0.06$^{ab}$ | 0.05$^{a}$ | 0.09$^{b}$ | 0.02 | *** |
| **C16:1** | 1.16$^{ab}$ | 0.93$^{a}$ | 1.31$^{b}$ | 1.55$^{c}$ | 0.22 | *** |
| **C17:1** | 0.56$^{ab}$ | 0.50$^{a}$ | 0.60$^{b}$ | 0.53$^{a}$ | 0.10 | ** |
| **C18:1** | 34.90$^{a}$ | 37.64$^{b}$ | 37.97$^{b}$ | 39.93$^{c}$ | 2.13 | *** |
| **ΣPUFA** | 14.68$^{b}$ | 13.36$^{ab}$ | 12.98$^{ab}$ | 11.70$^{a}$ | 3.05 | * |
| **C18:2 *n-6*** | 5.38$^{a}$ | 5.49$^{a}$ | 5.85$^{ab}$ | 6.36$^{b}$ | 1.41 | * |
| **CLA** | 0.99$^{c}$ | 0.81$^{b}$ | 0.95$^{c}$ | 0.70$^{a}$ | 0.17 | *** |
| **C18:3 *n*-3** | 2.46$^{c}$ | 1.61$^{b}$ | 1.72$^{b}$ | 0.77$^{a}$ | 0.49 | *** |
| **C20:3 *n*-6** | 0.27 | 0.28 | 0.24 | 0.24 | 0.07 | ns |
| **C20:4 *n*-6** | 2.24 | 2.40 | 2.02 | 2.33 | 0.73 | ns |
| **C20:5 *n*-3** | 1.57$^{d}$ | 1.20$^{c}$ | 0.92$^{b}$ | 0.44$^{a}$ | 0.40 | *** |
| **C22:5 *n*-3** | 1.39$^{c}$ | 1.25$^{c}$ | 1.03$^{b}$ | 0.70$^{a}$ | 0.32 | *** |
| **C22:6 *n*-3** | 0.37$^{c}$ | 0.31$^{bc}$ | 0.27$^{b}$ | 0.16$^{a}$ | 0.12 | *** |
| **ΣPUFA/ΣSFA** | 0.31 | 0.28 | 0.28 | 0.26 | 0.08 | ns |
| ***n-6*/*n-3*** | 1.37$^{a}$ | 1.86$^{b}$ | 2.20$^{b}$ | 4.66$^{c}$ | 0.79 | *** |
| **Vitamin E** | 6.12$^{c}$ | 5.60$^{bc}$ | 5.17$^{b}$ | 1.77$^{a}$ | 1.33 | *** |

Sign: significance; *P <0.05; ** P <0.01; *** P <0.001; ns: no significant; CLA: C18:2 *cis-9 trans-11*.$^{a,b,c.}$: Least square means in the same row with different superscript letters are different (P <0.05);

With respect to PUFA, their proportion decreased as concentrate intake increased (P<0.05). The highest PUFA proportion in lambs fed on pasture was mainly due to the higher PUFA *n-3* proportion, mostly because of the higher C18:3 *n-3* content of grass. Lambs fed only concentrate had the highest proportion of linoleic acid (C18:2 *n-6*). This fatty acid is present in high concentrations in cereal and oleaginous seeds (Nuernberg *et al*., 2005).

In relation to long chain *n-3* PUFA, EPA (C20:5 *n-3*) and DHA (C22:6 *n-3*) proportions were higher in lambs fed pasture with or without concentrate than lambs fed only concentrate. The high availability of C18:3*n-3* in grass has resulted in an enhanced synthesis of these long chain fatty acids on lambs fed pasture. Therefore, animals grazing on pasture, such as T1, T2, and T3, accumulated a 2 to 3-fold higher concentration of total *n-3* PUFA in their meat (mainly T1) compared to those that were only fed concentrate, like T4, which agrees with Dannenberger *et al*. (2004) and Nuernberg *et al*. (2005).

The lowest proportion of CLA, which are of special interest in the human diet, was found in the muscle of animals fattened exclusively on concentrate. There is clear evidence of an enhanced proportion of

CLA in grass-fed animals compared with concentrate-fed animals, as shown by Díaz *et al*. (2005) in lambs and French *et al.* (2000) in beef.

The *n-6*/*n-3* ratio of lambs fed pasture and pasture with concentrate (T1, T2, and T3) followed the recommendation that it should be less than 4 (Department of Health, 1994). Conversely, animals fed only concentrated (T4) had a value of 4.7. As consequence, according to human nutritional requirements, the *n-6*/*n-3* ratio was healthier in lambs fed pasture (with or without concentrate) than in lambs fed only concentrate.

With respect to vitamin E content, animals fed pasture (with or without concentrate) have higher concentrations of vitamin E than animals fed only concentrate. According to Nuernberg *et al*. (2005), animals kept on pasture have higher concentrations of vitamin E in muscle. Vitamin E increases the oxidative stability of meat (Lauzurica *et al*., 2005).

**Conclusions**

Lambs fed pasture (with or without concentrate) had high proportions of PUFA *n-3* and therefore the lowest *n-6*/*n-3* ratio and high vitamin E content. However, lambs fed concentrate only had high proportions of F, MUFA and C18:2 *n-6*.

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