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# Fatty Acid Profile of Meat from Lambs Fed on Diets Containing Mulberry Hay

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***Abstract*—**The aim of this trial was to evaluate fatty acid profile of meat from lambs fed on diets containing 0, 12.5 and 25.0% mulberry hay as a substitute for the concentrate. Twenty-four feedlot Ile de France lambs (average weight of 15kg and average age of 60 days) were randomized to receive the different diets and slaughtered at 32kg body weight. Increases were observed in the concentrations of the saturated pentadecanoic, heptadecanoic and arachidic fatty acids; of the monounsaturated nervonic fatty acid and of the polyunsaturated α-linolenic, ɣ-linolenic and eicosapentaenoic fatty acids. Increased conjugated linoleic acid (CLA) was also found in the meat of lambs fed on 12.5% mulberry hay. In addition, the omega-3 composition was augmented, while the omega-3/omega-6 ratio was decreased in mulberry hay-fed animals. In conclusion, a more desirable fatty acid profile was observed in lamb meat following the substitution of mulberry hay in the concentrate of fed, resulting in improved nutritional characteristics of the meat.

***Keywords*—**Alternative food, fatty acids, feedlot, sheep meat.

## I. Introduction

CHANGES in the eating habits of the world population have occurred recently in the pursuit of a more healthy diet with healthier and better quality products. Meats with these nutritional characteristics are popular due to their beneficial effects on human health. Some polyunsaturated fatty acids that are recognized as beneficial to human health, such as linoleic (omega-6) and linolenic (omega-3) acid, can be found in the composition of sheep meat at levels of up to 72% of the desirable fatty acids [1]. High concentrations of lipids and saturated fatty acids classify red meat as one of the main factors responsible for increased plasma cholesterol, which may incur cardiovascular diseases and atherosclerosis [2].

Alternatives with decreased levels of saturated fatty acids and increased mono and polyunsaturated fatty acids (particularly the linoleic and linolenic acids and conjugated linoleic acid) levels are desirable and are considered essential. The use of alternative food to modify the lipid compounds of meat should be evaluated in nutritional studies, to assess the possibility of manipulating the fatty acid profile of muscle and improve the quality of meat, in terms of quality. Mulberry (*Morus* sp.) is used as a forage for ruminants due its agrostologic properties of: 25 to 30 t/ha/year mass production, good acceptability, levels of crude protein of 18 to 28%, 75 to 85% of dry matter digestibility and high percentages of omega-3 fatty acids (50.43%), which characterize this plant as an important alternative food.

Reports of the use of alternative foods, such as mulberry hay, in lamb feed and their effects on nutritional aspects of meat are scarce. The intake of a higher nutritional quality lamb meat may provide benefits to human health. Thus, the aim of this trial was to evaluate the fatty acid profile of meat from lambs fed on diets containing mulberry hay.

## II. Material and Methods

If The trial was carried out in the College of Agricultural and Veterinarian Sciences, FCAV, UNESP, Jaboticabal - SP, Brazil. Twenty-four newly-weaned Ile de France lambs with an average age of 60 days and an initial body weight of 15.48 ±0.07kg were allocated to a completely randomized experimental design, with three treatments and eight replicates, in which the animals were housed in individual pens (1m$^2$). Experimental diets were calculated in accordance to the requirements preconized by the NRC [3] for weaned lambs with an average daily gain of 300g/day. A 50:50 forage: concentrate ratio was used in the diets (D), and the following diets were administered; D1: sugarcane + concentrate without mulberry hay; D2: sugarcane + concentrate with 12.5% of mulberry hay and D3: sugarcane + concentrate with 25.0% of mulberry hay. Sugarcane of the IAC 86-2480 forage variety was used; sugarcane was chopped in particles of 1.0cm and provided *in natura*. Feeding was offered at 7h and at 17h, to ensure at least 10% of waste.

The lambs were slaughtered at a body weight of 32.20 ±0.49kg after a fasting period of 16 hours with a solid diet. The animals were stunned by electronarcosis with an electric current of 220V for 2 seconds, and the jugular veins and the carotid arteries were sectioned in accordance to humane slaughter procedures. After slaughter, skinning, evisceration and removal of the head and members, carcasses were stored at 6°C for 24 hours. The carcasses were then divided lengthwise; the left half-carcasses were then divided into five anatomic regions: neck, palette, ribs, loin and leg. The Longissimus lumborum muscles were individually identified, vacuum packed, and stored at -18°C until the beginning of analysis.

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The extraction of total lipids of the meat from the Longissimus lumborum muscle was carried out according to the methodology described by Bligh and Dyer [4]. Afterwards, triacylglycerols were transesterified using the 5509 method from ISO [5], in n-heptane and KOH/methanol solution. The esters of the fatty acids were isolated and analyzed in a Shimadzu 14B gas chromatograph, equipped with a flame ionization detector and a fused silica capillary column (30m length, 0.25mm internal diameter and 0.25μm Omegawax 250). The initial temperature of the flame of the column was 50°C, which was maintained for 2 minutes and raised to 220°C at 4°C/minute for 25 minutes. The methyl esters standards were obtained from Sigma and data were expressed as percentage compositions of each fatty acid.

Results were evaluated by analysis of variance and the Tukey test using the SAS program (Statistical Analysis System, version 9.0), where the significance level obtained by the F-test was defined as 1% or 5%.

## III. Results and Discussion

The inclusion of mulberry hay (12.5 and 25.0%) modified ($P<0.05$) the fatty acid profile of the lamb meat (Table I), and increases ($P<0.05$) were observed in the concentrations of the saturated pentadecanoic, heptadecanoic and arachidic fatty acids; of the monounsaturated nervonic fatty acid and of the polyunsaturated α-linolenic, γ -linolenic and eicosapentaenoic fatty acids. Importantly, there was an increase in CLA content in the meat ($P<0.05$) of 12.5% mulberry hay-fed lambs.

TABLE I
Fatty Acids Profile of the Longissimus Lumborum muscle of Lambs Fed Diets Containing Mulberry Hay

| Fatty acid (%) | | Mulberry hay (%) | | | *P*-value | RSD[1] |
|---|---|---|---|---|---|---|
| | | 0 | 12.5 | 25.0 | | |
| Myristic | C14:0 | 2.33 | 2.39 | 2.37 | 0.980 | 0.82 |
| Pentadecanoic | C15:0 | 0.31a | 0.41b | 0.42b | 0.011 | 0.08 |
| Palmitic | C16:0 | 24.90 | 23.94 | 25.16 | 0.370 | 2.24 |
| Heptadecanoic | C17:0 | 1.15a | 1.49b | 1.62b | 0.001 | 0.27 |
| Stearic | C18:0 | 18.22 | 17.95 | 17.94 | 0.967 | 3.38 |
| Arachidic | C20:0 | 0.12a | 0.12ab | 0.13b | 0.036 | 0.01 |
| Palmitoleic | C16:1 | 1.66 | 1.46 | 1.54 | 0.409 | 0.37 |
| Heptadecenoic | C17:1 | 0.70 | 0.86 | 0.92 | 0.066 | 0.23 |
| Oleic | C18:1ω9 | 40.64 | 40.25 | 39.30 | 0.516 | 3.15 |
| Cis-vaccenic | C18:1ω7 | 2.12 | 2.16 | 2.22 | 0.646 | 0.28 |
| Nervonic | C24:1ω9 | 0.20a | 0.36b | 0.33b | 0.010 | 0.12 |
| Linoleic | C18:2ω6 | 4.28 | 4.75 | 4.35 | 0.591 | 1.22 |
| α-linolenic | C18:3ω3 | 0.18a | 0.44b | 0.57b | <0.001 | 0.15 |
| γ-linolenic | C18:3ω6 | 0.12a | 0.14b | 0.15b | 0.002 | 0.02 |
| CLA | C18:2c9.t11 | 0.50a | 0.59b | 0.50a | 0.049 | 0.09 |
| Eicosapentaenoic | C20:5ω3 | 0.08a | 0.17b | 0.17b | 0.020 | 0.08 |
| Omega-3 | - | 0.31a | 0.69b | 0.80b | <0.001 | 0.22 |
| Omega-6 | - | 6.38 | 6.83 | 6.27 | 0.703 | 1.79 |
| Omega-6:Omega-3[2] | - | 20.99a | 10.07b | 8.06b | <0.001 | 1.41 |

[1]RSD = residual standard deviation; [2]relation.

The increases in the polyunsaturated α-linolenic (ω-3) and γ-linolenic (ω-6) fatty acids are related to their higher concentrations in the mulberry hay, while the augmented level of the CLA and nervonic fatty acid is related to the incomplete biohydrogenation of polyunsaturated fatty acids by bacteria in the feed forage, which normally present high polyunsaturated concentrations [6]. The increases observed in the monounsaturated nervonic acid (C24:1ω9) level, and in the levels of the polyunsaturated α-linolenic (C18:3ω3), γ-linolenic (C18:3ω6) and eicosapentaenoic (C20:5ω3) fatty acids in lamb meat are of great importance, since these are essential for human health, with properties that protect against the development of atherosclerosis and thrombotic disease [7].

An increase ($P<0.001$) in the percentage of fatty acids of the omega-3 series was observed (Table I), mainly due to an increase in the α-linolenic fatty acid in the meat of lambs fed diets containing mulberry hay. The omega-3 fatty acids play a role in augmenting "good" cholesterol, as represented by the high density lipoproteins (HDL). The omega-6:omega-3 ratio was decreased in mulberry hay fed lambs ($P<0.001$), varying from 20.99 (control treatment) to 8.06 (with the inclusion of 25.0% of mulberry hay). Nutritionists have emphasized the importance of keeping the omega-6:omega-3 ratio at lower than 4 to reduce coronary complications, a ratio of 4/1 was associated with a 70% decrease in total mortality [8].

## IV. Conclusion

The inclusion of mulberry hay, at levels of up to 25.0%, in the concentrate of lamb feed improved the fatty acid profile of the meat and its nutritional quality. The results of this trial characterize this forage as an important source for the manipulation of the fatty acid profile and validate its use as an alternative ingredient for providing feedlot lambs with meat of a better nutritional quality.

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