# PHYSICOCHEMICAL PROPERTIES, ANTIOXIDANT STATUS AND LIPID PROFILE OF *LONGISSIMUS LUMBORUM* MUSCLE IN GOATS FED BLEND OF CANOLA OIL AND PALM OIL

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**Abstract –the physicochemical properties, lipids and antioxidant profile of *Longissimus lumborum* (LL) muscle were examined in goats fed graded level of blend of 80% canola oil and 20% palm oil (BCPO). Over a fourteen-week feeding trial, twenty four bucks were randomly assigned to diets containing 0, 4 or 8% BCPO, harvested and the LL was subjected to 7 d postmortem ageing. Neither diet nor *postmortem* ageing influenced glutathione peroxidase, superoxide dismutase and catalase activities, lightness, yellowness, cooking loss and δ-tocopherol. Goats fed 4 and 8% BCPO had higher C18:1 *trans*-11 Vaccenic, C18:3n-3, C22:6n-3 and C22:5n-3, total carotenoids, α and γ-tocopherol and redness than did control goats. Dietary BCPO lowered drip loss and lipid oxidation. Increased postmortem ageing decreased oxidative stability and drip loss. It can be concluded that dietary BCPO enhanced muscle unsaturated fatty acids and quality attributes of LL muscle in goats.**

**Key Words – Drip loss, color, lipid oxidation**.

## I. INTRODUCTION

The high proportion of saturated fatty acids in ruminant meat has been implicated in the incidence of chronic diseases [1]. This justifies the need to modify its fatty acid (FA) composition to support the delivery of healthier and functional ruminant meat that responds to consumer dietary needs. Dietary supplementation of oils has been accentuated as an effective means of modifying the FA of ruminant meat. However, dietary unsaturated fats could predispose the meat to lipid oxidation which can affect the eating and keeping qualities and nutritive value of such meat [2, 3]. In addition, consumption of peroxidised lipids has been implicated in the incidence of various chronic diseases [4]. Synthetic antioxidants are effective in curbing lipid oxidation [5] but there are concerns about their safety in animals and humans [6]. Besides, synthetic antioxidants are expensive and scarce especially in low income countries [7]. Thus, the use of natural antioxidants could be a feasible alternative. Dietary supplementation of vegetable oils rich in unsaturated fatty acids and antioxidants could be utilized to manipulate the fatty acid profile of ruminant meat, prevent lipid oxidation and provide dietary antioxidants to human [8]. Given the established antioxidant contents of red palm oil [9] and PUFA and antioxidants contents of canola oil [10], we hypothetised that a blend of red palm oil and canola oil will enhance beneficial FA in ruminant meat and stabilize such meat against oxidative damage. The objective of this study was to examine the effect of dietary blend of canola oil (80%) and red palm oil (20%) on fatty acid composition, cholesterol, antioxidant vitamins and enzymes, physicochemical properties and oxidative stability of *Longissimus lumborum* muscle in goats.

## II. MATERIALS AND METHODS

Twenty four Boer goats (4-5 months old, initial body weight=20.54±0.47 kg) were randomly assigned to diets containing blend of 80% canola oil and 20% palm oil (BCPO) at 0, 4, 8% DM of diet (Table 1) and fed for 14 weeks following 2 weeks of adaptation. The animals were slaughtered in a commercial abattoir. All analyses were conducted on *Longissimus lumborum* (LL) muscle. Muscle fatty acid was determined by the method of Folch *et al.* [11]. Physicochemical properties of LL muscle were determined as described by Sabow *et al.* [12]. Tocopherol and carotenoids were determined by the method of Kamal-eldin *et al.* [13] and Okonkwo [14] respectively. The experiment followed a completely randomized design. Data obtained for

fatty acids were analyzed by GLM procedure of SAS. Data obtained for physicochemical properties, antioxidants and lipid oxidation was subjected to repeated measure analysis of variance. Means were separated using Tukey HSD test at significant level of $p<0.05$.

Table 1 Chemical composition (% DM), fatty acid composition and antioxidant content of dietary treatments

| | Levels of BCPO[1](% ) | | |
|---|---|---|---|
| Parameter | 0 | 4 | 8 |
| Dry matter, | 67.70 | 67.90 | 68.07 |
| Crude Protein | 14.27 | 14.37 | 14.39 |
| Ether extract | 2.30 | 6.35 | 11.11 |
| Organic matter | 93.16 | 93.42 | 93.55 |
| Nitrogen free extract | 16.56 | 13.97 | 12.45 |
| ADF | 35.04 | 33.28 | 32.52 |
| NDF | 63.52 | 62.67 | 62.06 |
| Metabolizable energy, MJ/Kg | 11.59 | 11.61 | 11.62 |
| Ca | 1.02 | 1.05 | 1.04 |
| P | 0.52 | 0.54 | 0.54 |
| *FA (g/kg DM)* | | | |
| C12:0 | 0.01 | 0.03 | 0.04 |
| C14:0 | 0.53 | 0.51 | 0.51 |
| C16:0 | 2.79 | 5.98 | 7.78 |
| C16:1 | 0.08 | 0.11 | 0.15 |
| C18:0 | 0.56 | 1.12 | 1.43 |
| C18:1n-9 | 3.82 | 14.87 | 26.32 |
| C18:2ω-6 | 7.05 | 11.87 | 12.06 |
| C18:3ω-3 | 1.06 | 2.61 | 4.13 |
| n6/n3 | 6.65 | 4.55 | 2.92 |
| Total FA | 15.83 | 37.09 | 52.27 |
| *Antioxidants (mg/kg)* | | | |
| carotenoid | 14.8 | 16.7 | 19.9 |
| α-tocopherol | 101.1 | 112.5 | 123.2 |
| γ-tocopherol | 10.2 | 34.6 | 49.2 |
| δ-tocopherol | 1.2 | 3.5 | 5.9 |

[1]Blend of canola seed oil (80%) and red palm fruit oil (20%)

## III. RESULTS AND DISCUSSION

The LL muscle did not exhibit differences in the proportion of all saturated fatty acids (SFA) among the diets (Table 2). This finding is consistent with those of Jerónimo *et al.* [15] which showed that various blends of soybean and linseed oils did not alter the short and medium chain FA in the polar, neutral and total lipids of LL muscle of lambs. The LL muscle of goats fed 4 and 8% BCPO had higher ($p<0.05$) C18:1 *trans*-11 Vaccenic, C18:3n-3, C22:5n-3 and C22:5n-3 and lower ($p< 0.05$) n6/n3 ratio. The C18:1 *trans*-11 Vaccenic is a mutual intermediate biohydrogenation product of C18:1n-9, C18:2n-6 and C18:3n-3. Thus, the increase in the concentration of C18:1 *trans*-11 Vaccenic in LL of goats fed 4 and 8% BCPO could be due to higher total unsaturated fatty acids in the diets compared to that of control goats (Table 1). This finding justifies increased intakes of C18:1n-9, C18:2n-6 and C18:3n-3 observed during the feeding trial [16]. The increase in C18:3n-3 in LL muscle of goats fed 4 and 8% compared to that of control goats reflects the dietary concentration of this FA in the diet. It also indicates that some C18:3n-3 escaped rumen biohydrogenation. Feeding high amount of unprotected PUFA-rich oils could lower the rate of rumen biohydrogenation of unsaturated fatty acids thus making such unsaturated fats as well as their biohydrogenation intermediates available for absorption [17]. The increase in the concentration of C18:3n-3 in LL muscle of goats fed 4 and 8% was accompanied by an increase in the concentration of C22:5n-3 and C22:6n-3 suggesting *in vivo* elongation of C18:3n-3. Similar increase in C18:3n-3 and its long chain derivatives following dietary supplementation of vegetable oil blends have been reported [15, 17].

**Table 2** Effect of diet on fatty acid composition (% of total FA) in LL muscle in goats

| | Level of BCPO[1] (%) | | |
|---|---|---|---|
| Parameter | 0 | 4 | 8 |
| C16:0 | 23.3 | 21.7 | 23.4 |
| C16:1n-7 | 2.5 | 2.6 | 2.0 |
| C18:0 | 20.9 | 20.8 | 20.1 |
| C18:1n-9 | 23.7 | 23.4 | 22.9 |
| C18:1*trans*-11Vaccenic | $1.2^{b}$ | $2.4^{a}$ | $3.2^{a}$ |
| CLA cis-9 *trans*-11 | 1.0 | 0.9 | 1.2 |
| CLA cis-12 *trans*-10 | 0.9 | 1.0 | 1.3 |
| C18:2ω-6 | 12.3 | 12.4 | 13.4 |
| C18:3ω-3 | $0.7^{b}$ | $1.0^{a}$ | $1.3^{a}$ |
| C20:4ω-6 | 7.3 | 7.0 | 6.4 |
| C20:5ω-3 | 1.7 | 1.9 | 1.9 |
| C22:5ω-3 | $1.8^{b}$ | $2.0^{a}$ | $2.2^{a}$ |
| C22:6ω-3, | $1.0^{b}$ | $1.3^{a}$ | $1.5^{a}$ |
| ∑SFA | 46.3 | 44.6 | 45.3 |

| | | | |
|---|---|---|---|
| ∑MUFA | 27.4 | 28.4 | 28.0 |
| ∑PUFA | 26.7 | 27.6 | 29.2 |
| ∑ω-3 | 5.1 | 6.3 | 6.9 |
| ∑ω-6 | 19.6 | 19.4 | 19.8 |
| ω-6:ω-3 | 4.1[a] | 3.1[b] | 2.9[b] |
| UFA:SFA | 1.2 | 1.3 | 1.2 |
| PUFA:SFA | 0.6[a] | 0.6[a] | 0.6 |
| Total FA (mg/g) | 2.9 | 3.2 | 3.2 |
| Cholesterol (mg/100g) | 54.3 | 50.9 | 47.7 |

[a,b,c] means having different superscript along the same row are significantly different ($p<0.05$). [1]Blend of 80% canola oil and 20% palm oil.

The increase in the concentration of total carotenoid, α and δ-tocopherol in LL muscle of goats fed 4 and 8% BCPO (Table 3) mirrored dietary antioxidant contents (Table 1). The increase might have been facilitated by the increased fat contents of the diet. Both carotenoid and tocopherol are fat soluble vitamins thus the presence of fat would enhance their digestion, absorption and deposition. This finding is consistent with those of Soler-Velasquez *et al.* [18]. The lack of significant effect of dietary BCPO on superoxide dismutase, catalase and glutathione peroxidase might be related to the level of antioxidant vitamins in the muscle. Increase in antioxidant enzyme (AOE) activities was observed in response to oxidative stress caused by high concentrations of dietary unsaturated fatty acids [19]. Thus, the higher vitamin E and carotenoid contents in the LL muscle of goats fed 4 and 8% BCPO substantiates their inability to invoke increase in AOE activities despite the increase in the n-3 PUFA.

**Table 3** Effect of diet and postmortem aging on antioxidant status of LL muscle in goats

| | Level of BCPO[1] (%) | | | Storage days | |
|---|---|---|---|---|---|
| Parameter | 0 | 4 | 8 | 1 | 7 |
| TBARS | 0.2[c] | 0.1[b] | 0.06[a] | 0.26[b] | 0.55[a] |
| carotenoid | 0.12[c] | 0.23[b] | 0.40[a] | 0.23[a] | 0.12[b] |
| α-tocopherol | 2.29[c] | 3.45[b] | 4.43[a] | 3.57[a] | 2.62[b] |
| γ-tocopherol | 0.66[c] | 0.75[b] | 1.02[a] | 0.75[a] | 0.67[b] |
| δ-tocopherol | 0.06 | 0.07 | 0.09 | 0.08 | 0.05 |
| GPX[2] | 90.52 | 81.50 | 72.64 | 84.71 | 75.22 |
| SOD[3] | 2.29 | 2.63 | 2.83 | 2.62 | 2.14 |
| CAT[4] | 1772.1 | 1700.6 | 1680.4 | 1987.7 | 1801.9 |

[a,b,c] means having different superscript along the same row for each factor are significantly different ($p<0.05$). [1] = blend of 80% canola oil and 20% red palm oil. [2]GPx activity is expressed as nmoles NADPH oxidized /min/mg protein. [3]SOD activity is expressed as Units 50% mg protein. [4]Catalase activity is expressed as nmol. $H_2O_2$/min/mg protein.

Dietary BCPO did not affect cooking loss, tenderness, yellowness and lightness of LL muscle (Table 4). However, the LL muscle of goats fed 4 and 8% BCPO had higher ($p<0.05$) redness and lower drip loss compared to the control goats. The drip loss decreased ($p<0.05$) as *postmortem* storage progressed. *Postmortem* storage did not affect cooking loss, lightness and yellowness of the LL muscle. The higher redness and lower drip loss observed in LL muscle of goats fed 4 and 8% BCPO could be due to higher antioxidant content in their muscle which enhanced oxidative stability of lipid and proteins.

**Table 4** Effect of diet and postmortem aging on physicochemical properties of LL muscle in goats

| | Level of BCPO[1] (%) | | | Storage days | |
|---|---|---|---|---|---|
| Parameter | 0 | 4 | 8 | 1 | 7 |
| CL | 32.1 | 29.4 | 32.6 | 30.9 | 33.3 |
| DL | 7.0[a] | 5.6[b] | 5.1[b] | 5.9[a] | 1.5[b] |
| SF | 1.0[a] | 1.1[a] | 0.9[a] | 1.1[a] | 0.8[c] |
| L* | 32.3 | 33.1 | 31.8 | 32.2 | 34.4 |
| a* | 12.9[b] | 14.3[a] | 15.5[a] | 12.6[a] | 11.0[b] |
| b* | 13.2 | 12.9 | 12.4 | 12.3 | 14.0 |

[a,b,c] means having different superscript along the same row for each factor are significantly different ($p<0.05$). [1]Blend of 80% canola oil and 20% palm oil. CL=cooking loss. DL=drip loss. SF=shear force. L=lightness. a*=redness. b*=Yellowness.

## CONCLUSION

This study demonstrated that dietary blend of 80% canola seed oil and 20% palm oil (BCPO) enhanced the n-3 FA of LL muscle in goats. The oil blend also improved redness and oxidative stability and reduced drip loss of the LL muscle.

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