New Zealand Society of Animal Production online archive

This paper is from the New Zealand Society for Animal Production online archive. NZSAP holds a regular annual conference in June or July each year for the presentation of technical and applied topics in animal production. NZSAP plays an important role as a forum fostering research in all areas of animal production including production systems, nutrition, meat science, animal welfare, wool science, animal breeding and genetics.

An invitation is extended to all those involved in the field of animal production to apply for membership of the New Zealand Society of Animal Production at our website www.nzsap.org.nz

The New Zealand Society of Animal Production in publishing the conference proceedings is engaged in disseminating information, not rendering professional advice or services. The views expressed herein do not necessarily represent the views of the New Zealand Society of Animal Production and the New Zealand Society of Animal Production expressly disclaims any form of liability with respect to anything done or omitted to be done in reliance upon the contents of these proceedings.

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

You are free to:

Share— copy and redistribute the material in any medium or format

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for commercial purposes.

NoDerivatives — If you remix, transform, or build upon the material, you may not distribute the modified material.

http://creativecommons.org.nz/licences/licences-explained/
Conjugated linoleic and trans-vaccenic acids in grass-fed beef and lamb

T. W. KNIGHT, C. A. MORRIS1, R. W. PURCHAS2 AND M. AGNEW1
AgResearch Grasslands, PB 11008, Palmerston North, New Zealand.

ABSTRACT

Cis-9 trans-11 conjugated linoleic acid (CLA) found in ruminant milk and meat has several human health benefits of which the anti-cancer effect is the most prominent. Trans-vaccenic acid (TVA) is a precursor of CLA and can be considered as another dietary source of CLA. This paper uses data from three published papers to compare the CLA and TVA concentrations in the longissimus lumborum muscle (LL) from cattle and lambs, to determine the within-group variation, and to identify factors influencing this variation. The paper discusses the contribution lean beef and lamb can make to the estimated human daily required intake (DRI) for CLA. The CLA and TVA content was measured in the LL from two groups of cattle (n = 15 and n = 100) and two groups of lambs (n = 30 and n = 12). CLA and TVA concentrations in the total fatty acids (TFA) was higher (P<0.001) in lamb than in beef. The coefficients of variation within each group of animals ranged from 23-41% for CLA and 25-68% for TVA, indicating a large variation in the concentration of these fatty acids among animals. A number of factors contributed to these differences but the largest difference was found in lambs, where there was a 41% higher (P<0.01) CLA concentration in the TFA from lambs born to ewes with high CLA concentrations than from lambs born to ewes with low CLA concentrations in their milk fat. A 100g portion of lamb containing 2-4% lipid could contribute 2-5% of the estimated 750mg DRI of CLA for humans. However, if dietary TVA was assumed to be equivalent to CLA, then lamb could contribute 13-15% of the DRI. We conclude that lamb can provide a significant proportion of the DRI for CLA in humans and there is scope for farmers to further increasing the CLA and TVA content of beef and lamb.

Keywords: conjugated linoleic acid; trans-vaccenic acid; beef; lamb.

INTRODUCTION

The cis-9, trans-11 isomer of conjugated linoleic acid (CLA), found in milk and meat from ruminants, has several human health benefits with its anti-cancer effects being the most prominent (Kritchevsky, 2000). Most of the CLA in ruminant tissue arises from desaturation of trans-vaccenic acid (TVA) that escapes the rumen where it forms during biohydrogenation of linoleic and linolenic acids (Kay et al., 2002). Dietary TVA is a precursor of CLA in humans (Turpeinen et al., 2002) and can be considered an additional dietary source of CLA.

In order for New Zealand beef and lamb to be promoted in New Zealand for its CLA content, a 100g portion of raw lean meat would need to contain >20% of the daily required intake (DRI) of CLA (Beef and Lamb Marketing Bureau pers. com.). Unfortunately the DRI for CLA to reduce cancer in humans is unknown. Estimated DRI for CLA to reduce the incidence of cancer was 3 g/d (Ip et al., 1994). This estimate was based on a daily diet containing 0.1% of a mixture of CLA isomers reducing the number of mammary tumours in rats by 36%. However, this mixture of CLA isomers contained only 43% of the c-9 t-11 CLA isomer, which is reported to be the active anti-carcinogenic isomer (Lavillonnière & Bougnoux, 1999), and a daily intake of 0.05% of the CLA mixture reduced the number of tumours by 22% (Ip et al., 1994). Based on these data, and given the aggressive carcinogens used to induce mammary tumours in the rats relative to the slow development of mammary tumours in humans, a DRI of 750 mg c-9 t-11 CLA seems reasonable. There would be further reductions in the number of tumours up to a daily intake of about 3750 mg CLA.

The ease with which New Zealand farmers could increase the CLA and TVA content of beef and lamb to provide >20% of the DRI in 100g lean meat depends on the size of the increase needed, the variation in the content of these fatty acids (FA) among animals, and the factors causing this variation. This paper uses data from three published papers to compare the CLA and TVA concentration in the longissimus lumborum muscle (LL) from cattle and lambs, to determine the within-group variation, and to identify factors influencing this variation. The paper also discusses the contribution beef and lamb makes to the estimated human DRI for CLA and the importance of TVA as a dietary source of CLA.

MATERIALS AND METHODS

Beef-A (n = 15) was from five 30-month-old Hereford-Friesian bulls, five culled Friesian dairy cows older than 4 years, and five 20-month-old Simmental-Hereford heifers that were selected in the yards of a local processing plant in July 2000. Beef-B (n = 100) was from 50 3/4-Jersey 1/4 Limousin (1/4J) and 50 1/4 Limousin 3/4 Jersey (1/4L) cattle born over two years (1996, n = 66 and 1997, n = 34) and sired by one of two bulls (sire A, n = 48; sire B, n = 52). Bull calves were castrated at birth. After weaning, heifer (n = 54) and steer (n = 46) calves from each breed were grazed on similar pastures at the Tokamui Research Station near Hamilton. Heifers and steers were slaughtered in randomly selected groups from August to November at 20-24 months of age. Lamb-A (n = 30) was from lambs born to 15 Romney ewes with high CLA (2.6 g/100g TFA) and 15 ewes with low CLA (1.5 g/100g TFA) concentrations in their milk fat. Seventeen of the lambs were single- and 13 were twin-born, and 18 were ram- and 12 were ewe-lambs. All ewes and lambs were grazed together at Flock House Research Station in the Manawatu
and lambs were weaned at 16 weeks of age and slaughtered at 28 weeks of age. Lamb-B (n = 12) was from ram-lambs sired by Poll Dorset rams and born to six East Friesian and six Romney ewes. All lambs were reared as twins on their mothers until slaughter at 17 weeks of age.

Further details on the animals, management, and selection and preparation of samples can be found in Knight et al. (2003b) for Beef-A and Beef-B, in Knight et al. (2003c) for Lamb-A, and in Knight et al. (2003a) for Lamb-B.

Samples of the LL were taken from the carcasses after they had been chilled for 24-72 hr and vacuum-packed before being stored at -20°C until analysis. The preparation, extraction, saponification, methylation, and analyses of FA in the lean LL were described by Knight et al. (2003b). Cis-9, trans-11 CLA and TVA were the only FA reported in this paper. Lipid content in the meat was measured gravimetrically by evaporating to dryness a sub-sample of the crude chloroform-methanol (2:1; v:v) extract of the meat.

Statistical analyses
All data were analysed by analysis of variance (GenStat, 2000). Details of the analyses for each group are presented in the respective publications. Coefficients of variation (CV) were adjusted for TFA concentration in the LL by calculating residual values for CLA and TVA generated from linear regressions of CLA and TVA with TFA. Each of the CVs, adjusted for TFA concentration in the LL, and the correlation between CLA and TVA in the four groups. Comparisons within a row with different superscripts are significantly different at P<0.05.

Comparison among experiments
There were significant (P<0.01) differences among groups in the concentration of lipid and TFA in the LL, and of CLA and TVA in the TFA (Table 1). Beef-B had higher (P<0.05) lipid concentrations than meat from the other groups. CLA and TVA concentrations were both higher (P<0.05) in Lamb-B than in Lamb-A, and lamb from both groups had at least a 2-fold higher (P<0.05) concentration of these FA in the TFA than the beef. There were significant (P<0.01) correlations between CLA and TVA concentrations in all groups.

Factors influencing within-experiment variation
The CVs, adjusted for TFA concentration in the LL, were high for CLA and TVA in all groups and indicated large variation in the concentrations of these FA among animals (Table 1). Table 2 presents some of the factors that contribute to this variation. CLA concentration was higher in \( \gamma_{4} \) (P<0.001) and progeny born to sire A (P<0.05) than in \( \gamma_{6} \) and progeny born to sire B. TVA concentration was higher for steers (P<0.05), for progeny born to sire A (P<0.05), and for progeny born in 1996 (P<0.001) than for heifers, for progeny born to sire B, and for progeny born in 1997. However, the differences were small. In contrast, in Lamb-A, single-born and lambs born to ewes with high CLA concentrations in their milk had 38-41% higher (P<0.01) concentrations of CLA and TVA in their TFA than twin-born lambs and lambs born to ewes with low CLA concentrations in their milk fat.

Contribution to daily required intake
Table 3 presents the mean content of CLA and TVA in a 100g portion of LL after removal of all external fat, and the proportion of the DRI of 750 mg CLA that a 100g portion of meat would provide. There were no groups that could provide more than 5% of the DRI for CLA from 100g of meat when considering CLA content alone, and no individual animal provided more than 8% of the DRI. However, the content of TVA was 2-7 times higher than the content of CLA in 100g of meat. The combined dietary intake of CLA and TVA from 100g beef would still provide <10% of the DRI even if it was assumed that the dietary TVA was equivalent to CLA. In contrast, a 100g of lamb would provide 13-15% of the DRI from CLA and TVA. All groups now had individual animals that provided >20% of DRI.

---

**RESULTS**

**Comparison among experiments**

There were significant (P<0.01) differences among groups in the concentration of lipid and TFA in the LL, and of CLA and TVA in the TFA (Table 1). Beef-B had higher (P<0.05) lipid concentrations than meat from the other groups. CLA and TVA concentrations were both higher (P<0.05) in Lamb-B than in Lamb-A, and lamb from both groups had at least a 2-fold higher (P<0.05) concentration of these FA in the TFA than the beef. There were significant (P<0.01) correlations between CLA and TVA concentrations in all groups.

**Factors influencing within-experiment variation**

The CVs, adjusted for TFA concentration in the LL, were high for CLA and TVA in all groups and indicated large variation in the concentrations of these FA among animals (Table 1). Table 2 presents some of the factors that contribute to this variation. CLA concentration was higher in \( \gamma_{4} \) (P<0.001) and progeny born to sire A (P<0.05) than in \( \gamma_{6} \) and progeny born to sire B. TVA concentration was higher for steers (P<0.05), for progeny born to sire A (P<0.05), and for progeny born in 1996 (P<0.001) than for heifers, for progeny born to sire B, and for progeny born in 1997. However, the differences were small. In contrast, in Lamb-A, single-born and lambs born to ewes with high CLA concentrations in their milk had 38-41% higher (P<0.01) concentrations of CLA and TVA in their TFA than twin-born lambs and lambs born to ewes with low CLA concentrations in their milk fat.

**Contribution to daily required intake**

Table 3 presents the mean content of CLA and TVA in a 100g portion of LL after removal of all external fat, and the proportion of the DRI of 750 mg CLA that a 100g portion of meat would provide. There were no groups that could provide more than 5% of the DRI for CLA from 100g of meat when considering CLA content alone, and no individual animal provided more than 8% of the DRI. However, the content of TVA was 2-7 times higher than the content of CLA in 100g of meat. The combined dietary intake of CLA and TVA from 100g beef would still provide <10% of the DRI even if it was assumed that the dietary TVA was equivalent to CLA. In contrast, a 100g of lamb would provide 13-15% of the DRI from CLA and TVA. All groups now had individual animals that provided >20% of DRI.

---

**TABLE 1**: Mean lipid and TFA concentrations in the LL (g/100g), CLA and TVA concentrations in TFA (g/100g), adjusted coefficient of variation (CV), and the correlation between CLA and TVA in the four groups. Comparisons within a row with different superscripts are significantly different at P<0.05.

<table>
<thead>
<tr>
<th></th>
<th>Beef-A</th>
<th>Beef-B</th>
<th>Lamb-A</th>
<th>Lamb-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of animals</td>
<td>15</td>
<td>100</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>Lipid (g/100g raw LL)</td>
<td>2.1*</td>
<td>3.6*</td>
<td>2.9*</td>
<td>2.6*</td>
</tr>
<tr>
<td>TFA (g/100g raw LL)</td>
<td>1.6*</td>
<td>3.2*</td>
<td>2.3*</td>
<td>1.8*</td>
</tr>
<tr>
<td>CLA (g/100g TFA)</td>
<td>0.18*</td>
<td>0.34*</td>
<td>0.69*</td>
<td>1.92*</td>
</tr>
<tr>
<td>TVA (g/100g TFA)</td>
<td>1.24*</td>
<td>1.43*</td>
<td>3.54*</td>
<td>4.66*</td>
</tr>
<tr>
<td>CV for CLA (%)</td>
<td>42</td>
<td>27</td>
<td>41</td>
<td>23</td>
</tr>
<tr>
<td>CV for TVA (%)</td>
<td>68</td>
<td>25</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>Correlation</td>
<td>CLA vs. TVA</td>
<td>0.87***</td>
<td>0.54***</td>
<td>0.48**</td>
</tr>
</tbody>
</table>

**TABLE 2**: Factors contributing to the within-group variation in CLA and TVA concentrations are presented. Values in parenthesis are the percentage increase of the larger from the smaller value. n.s. indicates the factor was not significant whereas – indicates the factor was not evaluated.

<table>
<thead>
<tr>
<th>Gender</th>
<th>CLA</th>
<th>n.s.</th>
<th>Beef-B</th>
<th>n.s.</th>
<th>Lamb-A</th>
<th>n.s.</th>
<th>Lamb-B</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>CLA</td>
<td>-</td>
<td>-</td>
<td>0.38 vs. 0.31 (23%)</td>
<td>-</td>
<td>n.s.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TVA</td>
<td>-</td>
<td>-</td>
<td>0.36 vs. 0.32 (13%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sire</td>
<td>CLA</td>
<td>-</td>
<td>-</td>
<td>1.5 vs. 1.3 (15%)</td>
<td>-</td>
<td>n.s.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TVA</td>
<td>-</td>
<td>-</td>
<td>1.5 vs. 1.3 (15%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Year-born</td>
<td>CLA</td>
<td>-</td>
<td>-</td>
<td>0.80 vs. 0.58 (38%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TVA</td>
<td>-</td>
<td>-</td>
<td>0.81 vs. 0.57 (41%)</td>
<td>-</td>
<td>n.s.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Birth rank</td>
<td>CLA</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TVA</td>
<td>-</td>
<td>-</td>
<td>n.s.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
is required. There may also be a direct anti-carcinogenic affect for TVA since the growth of human cancer cells in tissue culture was reduced by TVA (Awad et al., 1995). However, the conversion of TVA to CLA could not be discounted.

Measurements of CLA and TVA content were made on the LL with all external fat removed. Some external fat is usually left on the meat during cooking and could increase CLA and TVA intake. To put this into perspective, the 1.9% of CLA in the TFA in Lamb-B meat was at the upper range of the 1.2-2.2% of CLA found in milk fat from New Zealand dairy cows (Kay et al., 2002). Therefore, an extra 2-3g of lamb fat consumed with a lamb chop could provide a similar increase in CLA intake as eating 2-3g of butter or cheese.

Providing there is a high absorption and bioconversion of TVA to CLA, farmer should be able to increase the content of these FA in beef, and especially lamb, to provide >20% of the estimated DRI of CLA needed to reduce the incidence of cancer in humans. Selecting ewes with high CLA concentrations in their milk fat or manipulating the diet of lactating ewes to increase the CLA in milk fat may result in further increases in the CLA and TVA in the meat from their lambs.

ACKNOWLEDGEMENTS
These projects were conducted under contract to Meat New Zealand and Foundation for Research, Science and Technology.

REFERENCES
Knight, T. W.; Knowles, S.; Death, A. F.; Murr, P. D.; Cumming, T. 2003a: Effects of cooking method on the conjugated linoleic, trans-vaccenic and long chain omega-3 fatty acid content of the m. longissimus from lambs born to East Friesian and Romney ewes. New Zealand journal of agricultural research: In press
Knight, T. W.; Tavendale, M. H.; Death, A. F.; Agnew, M. 2003c: Conjugated linoleic acid (CLA) concentration in the m. longissimus of lambs born to Romney ewes screened for high and low CLA in their milk. New Zealand journal of agricultural research: In press
Advances in conjugated linoleic acid research Champaign, Illinois AOCs Press pp 276-282
