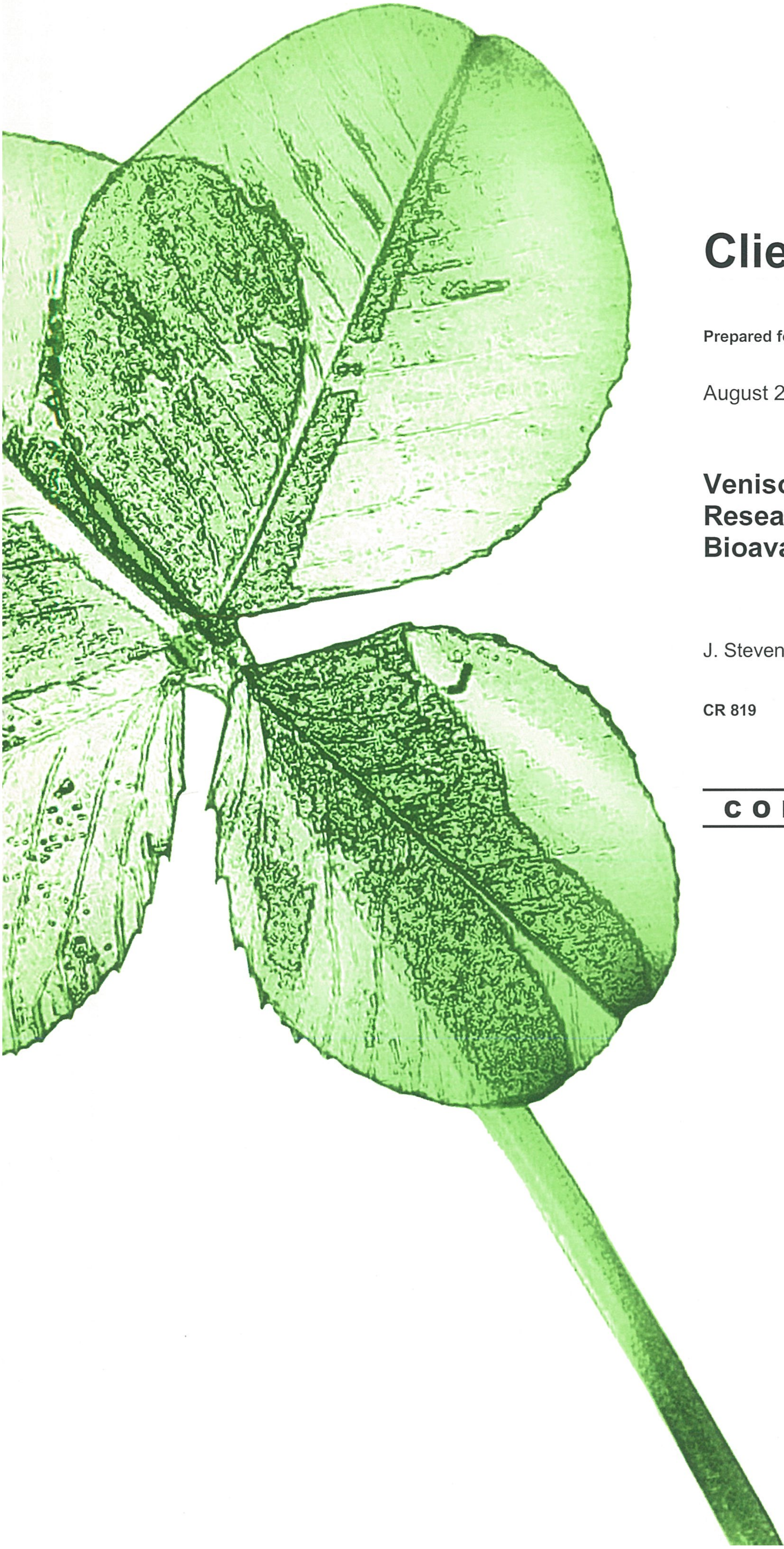

# Client Report

Prepared for New Zealand Game Industry Board

August 2001

## Venison Health-related Research: Iron Bioavailability and CLA's

J. Stevenson-Barry

CR 819

**CONFIDENTIAL**

## Client Report



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# Venison Health-related Research: Iron Bioavailability and CLA's

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# Contents

# 1 Background

Iron bio-availability and conjugated linoleic acid (CLA) content are considered to be two of the hottest topics in health-related meat work in NZ. To our knowledge, CLA or iron bioavailabilty have not been measured for venison. Previous research at Invermay (non-GIB funded work) has shown that the total iron content of venison is approximately triple that of lamb and double that of beef (Drew & Seman, 1987; Stevenson-Barry *et al.*, 1999). However, iron is present in meat in a number of different forms and the proportion in each form is believed to dramatically effect bioavailability. The level of iron absorption for humans is appreciably greater when iron is in the haem form, and is little affected by other components of the diet. Analysis of the iron fractions in venison is much less expensive than conducting actual absorption trials and will give a very good indication as to whether venison is likely to differ in bioavailability compared to other species (particularly beef and lamb).

CLA content in venison is of particular interest since the US Dietetic Association has included red meat in a recently released list of functional foods (Meat New Zealand Meat Matters, October 21, 2000). CLA's have been shown to be anti-carcinogenic, and the functional foods designation of red meat is because it is a good source of CLAs.

VENISON NOT A GOOD SOURCE OF CLA's

# 2 Objective

Determine the amount of soluble and insoluble haem and non-haem iron fractions in twelve venison samples and the fatty acid profiles for twelve venison samples.

# 3 Project Outline

Samples were collected from 1-2 year old animals at a commercial deer slaughter plant following standard slaughter and carcass handling procedures. Animals of known age, sex and genotype were used in this study. Samples were collected at boning time (approximately 24 hours after slaughter) and stored frozen at -80°C prior to analysis. Iron analyses were carried out at Massey University and CLA assays were carried out at the MIRINZ Centre, AgResearch, Ruakura, using the same protocol previously applied to analyses of beef and lamb (details in Appendix 1).

# 4 Results

## 4.1 Iron Analyses

The average iron concentrations of the venison samples, together with some comparative sheep and beef data (Roger Purchas, Massey University, unpublished data, *Pers. Comm.*), are shown in Table 1. Raw data is provided in Appendix 2. While the results show considerable variations between animals, on average, iron concentrations were significantly higher in venison than in the equivalent muscles in beef or sheep. These differences is particularly evident in the heam component of the total iron content of the muscle, and indicate that venison may be a superior source of bioavailable iron than beef or sheepmeat.

Table needs a title and units

**Table 1.**

| Species | **Venison** | Sheep meat sample (rams and hoggets) | | | Heifer samples | | |
|---|---|---|---|---|---|---|---|
| Muscle | **Loin** | Loin | Leg | Shoulder | Loin | Leg | Shoulder |
| Soluble haem | 18.5 | 9.53 | 5.67 | 8.14 | 11.69 | 9.78 | 13.59 |
| Insoluble Haem | 3.6 | 3.83 | 1.69 | 2.83 | 1.91 | 1.98 | 2.4 |
| Total haem | 22.1 | 13.36 | 10.52 | 15.84 | 13.6 | 11.77 | 15.99 |
| Soluble nonhaem | 1.8 | 1.38 | 1.06 | 1.52 | 1.31 | 1.36 | 1.35 |
| Insoluble nonhaem | 5.1 | 2.76 | 2.35 | 2.73 | 1.36 | 1.49 | 1.93 |
| Total nonhaem | 6.9 | 4.14 | 3.4 | 4.25 | 2.67 | 2.85 | 3.28 |
| Total Iron | 27.5 | 17.5 | 13.92 | 20.09 | 16.27 | 14.61 | 19.28 |

Loin = *Longissimus dorsi*, Leg = *Semitendinosus* (pale muscle in leg), Shoulder = *Triceps brachii*

## 4.2 Fatty Acid Analyses

Total fatty acid analyses for each animal is provided in Appendix 2. As a percent of total FA's the CLA and *trans* vaccenic fatty acid (CLA precursor) values were 0.2 and 1.2% respectively. Similar values for lean heifers (n=50) were 0.35% CLA and 1.34% *trans* vaccenic (Terry Knight, AgResearch Grasslands, unpublished data, *Pers. comm.*).

Also, venison generally has lower concentrations of fatty acids than beef. The present samples had, on average, 5.1g lipid per 100g dry matter, which calculates to approximately 1.3 g lipid on a raw meat basis (assuming dry matter is 26% of meat). This value is normal for venison from 1-2 year old animals (Stevenson et al., 1989; Stevenson-Barry et al., 1999), but is significantly lower than other meats, especially beef. The CLA and *trans* vaccenic content per 100 mg of raw venison calculates to approximately 2 and 18 mg respectively (8 and 68.9 mg per 100 g dry matter respectively x 0.26) with maximum levels of each approximately double and triple the average, respectively 3.6 and 56 mg.

A 22% reduction in mammary cancers in mice has been found when feeding a mixed CLA at 0.05% of diet. This value equates to 750 mg per day of the c-9 t-11 CLA, which is the active anticancer CLA (Terry Knight, AgResearch Grasslands, *Pers. comm.*). Average CLA values for lean beef (2% fat content) were found to be approximately 4 mg/100 g raw beef but the maximum was 27 mg/100 g raw meat (Terry Knight, AgResearch Grasslands, *Pers. comm.*). Therefore, in the best case, beef can provide 3.6% of daily requirement, assuming a need of 750 mg/day, and as much as 34% of daily requirement if CLAs are combined with the highest values for vaccenic acid concentrations. In contrast, 1-2 year old deer provide 2.5 % of daily requirement, even when CLA and vaccenic acid are combined. Since the beef study found that CLA and vaccenic acid concentrations increase in proportion to the fat content of the meat, increasing the fat content of venison could provide a strategy for increasing its CLA-related health benefits. Older deer (5-13 years old) have been found to have double to triple the lipid concentration of 1-3 year old animals (Stevenson et al., 1989; Stevenson-Barry et al., 1999), but fat contents vary seasonally (Stevenson et al., 1992; Manley & Forss, 1979; Drew, 1985) and even higher concentrations (3.3-10.9 g/100g) have been reported for very well grown 1-3 year old red deer stags (carcass weights of 41kg at 12 months and 76 kg at 27 months; Drew and Seman; 1997). Therefore, it may be possible to select animals with higher concentrations than found here. Clearly, this strategy would need to be weighed up against the advantages of venison's low-fat associations.

Fat ↑, CLA ↑.

# 5 Conclusions

Venison has high concentrations of haem iron indicating that venison would be a good source of bioavailable iron, moreso even than beef. However, CLAs contribute less to total fatty acids in version than in beef and, since venison also has lower fat concentrations,

Venison is not a good source of CLA.

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# Appendix 1. Methods

Note: The assays are done on raw meat, since this is the procedure previously used for beef and lamb. Cooking does affect the concentrations of some of the components but the magnitude of the effect depends on the cooking temperature. Major changes do not occur until temperatures exceed 100°C which is very well done (medium rare is about 65°C).

**Iron Analyses**

Haem iron was measured by the method of Hornsey (1956). Haem was extracted with acidified acetone and the absorbance of the extract read a 640 nm. All samples were assayed in duplicate.

For non-haem iron, the ferrozine reaction procedure is used as described by Ahn, Wolfe and Sim (1993). The sample is suspended in 0.1M citrate-phosphate buffer, ascorbic acid added to reduce all iron to the ferrous form. Protein is then precipitated with and the sample neutralised with ammonium acetate. The ferroin colour reagent is then added and absorbance read at 562 nm. All samples were assayed in duplicate.

For total iron analysis, samples are wet ashed using concentrated nitric acid followed by hydrogen peroxide, the ash dissolved in 2M HCl, and read against standards on an atomic absorption spectrophotometer. This method is an adaptation of the wet ashing method described by Clark, Mahoney and Carpenter (1997). All samples were assayed in triplicate.

**CLA Analyses**

The total lipids were extracted from freeze dried meat with chloroform /methanol (Folch *et al* 1957). An aliquot was used to determine the lipid content gravimetrically, another evaporated to dryness, and the lipids converted to methyl esters (Slover & Lanza 1979). Separation was using a HP 6890 GC with FID detection and a SGS BPX70 capillary column, quantitation was by way of an internal standard and a external reference standard mixture.

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# Appendix 2. Data

**Table A1**

Iron Analyses (ppm)

| Animal | 1 | 4 | 5 | 6 | 8 | 9 | 12 | 14 | 18 | 19 | 20 | 22 | 2 | 3 | 11 | 23 | Av. | sd | Range | Min. | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soluble haem | 12.3 | 20.5 | 19.1 | 18.9 | 19.9 | 14.7 | 17.6 | 26.6 | 17.2 | 22.4 | 18.6 | 24.1 | 16.5 | 15.5 | 15.9 | 16.2 | 18.5 | 3.6 | 14.3 | 12.3 | 26.6 |
| Insoluble Haem | 3.9 | 6.3 | 5.7 | 5.1 | 4.4 | 4.1 | 2.6 | 1.9 | 2.4 | 5.0 | 2.5 | 2.4 | 3.3 | 2.4 | 3.9 | 2.3 | 3.6 | 1.4 | 4.4 | 1.9 | 6.3 |
| Total haem | 16.2 | 26.8 | 24.7 | 24.0 | 24.2 | 18.8 | 20.2 | 28.4 | 19.6 | 27.3 | 21.1 | 26.5 | 19.8 | 18.0 | 19.8 | 18.5 | 22.1 | 3.8 | 12.3 | 16.2 | 28.4 |
| Soluble nonhaem | 2.3 | 2.4 | 2.3 | 1.6 | 2.2 | 1.7 | 1.9 | 2.3 | 2.0 | 1.5 | 2.5 | 1.7 | 1.1 | 1.3 | 1.1 | 1.0 | 1.8 | 0.5 | 1.5 | 1.0 | 2.5 |
| Insoluble nonhaem | 5.7 | 5.5 | 6.4 | 4.2 | 3.9 | 4.9 | 3.9 | 3.6 | 4.6 | 6.0 | 7.8 | 5.3 | 5.6 | 5.5 | 4.4 | 5.0 | 5.1 | 1.1 | 4.2 | 3.6 | 7.8 |
| Total nonhaem | 7.9 | 7.9 | 8.7 | 5.8 | 6.1 | 6.6 | 5.8 | 5.9 | 6.6 | 7.6 | 10.3 | 6.9 | 6.8 | 6.8 | 5.4 | 6.0 | 6.9 | 1.3 | 4.8 | 5.4 | 10.3 |
| Haem + Nonhaem (H+NH) | 24.1 | 34.7 | 33.4 | 29.8 | 30.4 | 25.3 | 26.0 | 34.3 | 26.2 | 34.9 | 31.4 | 33.4 | 26.5 | 24.8 | 25.2 | 24.4 | 29.1 | 4.1 | 10.9 | 24.1 | 34.9 |
| Assayed total iron | 25.0 | 27.3 | 35.4 | 28.7 | 31.7 | 27.2 | 24.7 | 30.2 | 23.7 | 29.5 | 25.2 | 29.6 | 24.6 | 26.5 | 26.0 | 24.5 | 27.5 | 3.2 | 11.6 | 23.7 | 35.4 |
| % H+NH / asayed total | 96% | 127% | 95% | 104% | 96% | 93% | 105% | 114% | 110% | 118% | 125% | 113% | 108% | 93% | 97% | 100% | 106% | 11% | 34% | 93% | 127% |

**Table A2.**

Fatty Acid Analyses

| ID | Results as % Fatty acid | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C12:0 | C14 | C15 | unknown | C16 | C16:1 | C17 | unknown | C18 | *Trans* Vaccenic | C18:1 | *Cis* Vaccenic | C18 2 | C18:3 | CLA | C20:3 | C20:4 | C20:5 | C22:5 | C22:6 |
| Hind 1 | 0.2 | 5.1 | 0.8 | 3.1 | 26.1 | 7.6 | 0.7 | 0.7 | 17.9 | 1.3 | 13.8 | 2.7 | 5.0 | 3.2 | 0.100 | 0.2 | 1.8 | 1.5 | 1.5 | 0.4 |
| | 0.2 | 5.1 | 0.8 | 3.3 | 26.1 | 7.4 | 0.7 | 0.8 | 17.9 | 1.3 | 13.6 | 2.7 | 5.0 | 3.2 | 0.070 | 0.2 | 1.9 | 1.6 | 1.5 | 0.4 |
| Hind 2 | 0.2 | 3.1 | 0.6 | 6.1 | 23.5 | 7.1 | 0.5 | 1.7 | 12.7 | 1.2 | 13.8 | 3.4 | 8.0 | 4.8 | 0.180 | 0.4 | 3.2 | 2.4 | 2.6 | 0.6 |
| | 0.1 | 3.1 | 0.6 | 6.2 | 23.3 | 6.5 | 0.5 | 1.7 | 12.7 | 1.4 | 13.5 | 3.4 | 8.0 | 4.8 | 0.175 | 0.4 | 3.2 | 2.4 | 2.6 | 0.6 |
| Hind 3 | 0.2 | 3.5 | 0.5 | 6.7 | 22.1 | 7.3 | 0.5 | 1.3 | 12.9 | 0.6 | 14.9 | 3.4 | 7.9 | 4.2 | 0.144 | 0.4 | 3.1 | 2.6 | 2.5 | 0.8 |
| | 0.2 | 3.9 | 0.5 | 5.7 | 23.3 | 7.9 | 0.5 | 1.1 | 13.0 | 0.6 | 15.7 | 3.5 | 6.8 | 3.7 | 0.103 | 0.3 | 2.7 | 2.3 | 2.2 | 0.7 |
| Hind 4 | 0.1 | 2.5 | 0.4 | 7.7 | 19.2 | 4.3 | 0.5 | 1.2 | 14.8 | 1.4 | 13.4 | 3.0 | 9.9 | 5.0 | 0.200 | 0.6 | 4.3 | 3.3 | 3.2 | 1.3 |
| | 0.1 | 2.1 | 0.4 | 8.8 | 17.9 | 4.1 | 0.4 | 1.4 | 14.7 | 1.2 | 12.5 | 2.7 | 10.8 | 5.4 | 0.150 | 0.6 | 4.9 | 3.8 | 3.6 | 1.5 |
| Hind 5 | 0.2 | 4.2 | 0.4 | 5.1 | 28.7 | 7.3 | 0.5 | 0.9 | 11.9 | 0.7 | 14.9 | 3.3 | 7.0 | 3.4 | 0.130 | 0.4 | 2.7 | 2.0 | 2.1 | 0.5 |
| | 0.2 | 4.0 | 0.4 | 5.3 | 28.0 | 7.0 | 0.5 | 1.1 | 12.2 | 0.7 | 14.6 | 3.1 | 7.2 | 3.6 | 0.075 | 0.4 | 2.8 | 2.1 | 2.2 | 0.5 |
| Hind 6 | 0.2 | 5.0 | 0.6 | 5.0 | 26.8 | 7.4 | 0.5 | 1.2 | 13.4 | 0.7 | 14.9 | 2.8 | 5.7 | 3.4 | 0.090 | 0.3 | 2.7 | 1.8 | 1.8 | 0.7 |
| | 0.2 | 5.1 | 0.6 | 4.7 | 27.2 | 8.0 | 0.5 | 1.1 | 12.6 | 0.8 | 14.8 | 2.9 | 5.6 | 3.4 | 0.095 | 0.3 | 2.6 | 1.7 | 1.7 | 0.7 |
| Hind 7 | 0.2 | 4.3 | 0.5 | 5.5 | 25.4 | 7.8 | 0.5 | 1.4 | 11.6 | 0.8 | 14.2 | 3.4 | 7.7 | 4.8 | 0.160 | 0.3 | 2.1 | 1.9 | 1.9 | 0.7 |
| | 0.2 | 4.5 | 0.5 | 5.1 | 26.0 | 8.0 | 0.5 | 1.3 | 11.6 | 0.8 | 14.4 | 3.5 | 7.3 | 4.5 | 0.126 | 0.3 | 2.0 | 1.8 | 1.8 | 0.6 |
| Hind 8 | 0.2 | 3.4 | 0.7 | 5.3 | 21.7 | 6.0 | 0.6 | 1.0 | 17.0 | 2.4 | 13.2 | 3.2 | 7.6 | 4.3 | 0.196 | 0.4 | 2.6 | 2.3 | 2.4 | 0.4 |
| | 0.2 | 3.6 | 0.7 | 5.2 | 22.3 | 7.0 | 0.6 | 1.0 | 15.8 | 1.9 | 13.4 | 3.4 | 7.4 | 4.2 | 0.137 | 0.3 | 2.5 | 2.2 | 2.4 | 0.4 |

**Table A2.**

Fatty Acid Analyses

| ID | Results as % Fatty acid | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C12:0 | C14 | C15 | unknown | C16 | C16:1 | C17 | unknown | C18 | *Trans* Vaccenic | C18:1 | *Cis* Vaccenic | C18 2 | C18:3 | CLA | C20:3 | C20:4 | C20:5 | C22:5 | C22:6 |
| Hind 9 | 0.1 | 2.9 | 0.5 | 7.3 | 19.9 | 5.7 | 0.5 | 1.6 | 13.1 | 1.0 | 13.9 | 3.2 | 9.6 | 5.2 | 0.217 | 0.5 | 4.1 | 3.0 | 2.6 | 1.1 |
| | 0.1 | 2.9 | 0.5 | 7.1 | 20.0 | 5.9 | 0.5 | 1.6 | 13.0 | 1.0 | 13.9 | 3.2 | 9.3 | 5.1 | 0.179 | 0.5 | 3.9 | 2.9 | 2.5 | 1.1 |
| Hind 10 | 0.1 | 3.4 | 0.6 | 5.7 | 22.0 | 7.9 | 0.5 | 1.5 | 12.4 | 1.8 | 14.3 | 3.5 | 8.5 | 4.8 | 0.420 | 0.3 | 2.5 | 2.2 | 2.1 | 0.6 |
| | 0.1 | 3.4 | 0.6 | 5.6 | 21.9 | 7.9 | 0.5 | 1.7 | 12.2 | 2.1 | 14.5 | 3.6 | 8.2 | 4.6 | 0.241 | 0.3 | 2.4 | 2.1 | 2.1 | 0.6 |
| Hind 11 | 0.2 | 3.8 | 0.5 | 6.8 | 23.6 | 6.8 | 0.5 | 1.2 | 13.6 | 0.7 | 15.5 | 3.2 | 6.7 | 3.8 | 0.156 | 0.4 | 3.0 | 2.6 | 2.5 | 0.8 |
| | 0.2 | 3.8 | 0.5 | 6.4 | 23.3 | 6.8 | 0.5 | 1.2 | 13.0 | 0.8 | 15.4 | 3.1 | 6.3 | 3.6 | 0.102 | 0.4 | 2.8 | 2.5 | 2.3 | 0.7 |
| Hind 12 | 0.1 | 3.2 | 0.7 | 5.6 | 24.2 | 6.4 | 0.6 | 1.5 | 14.7 | 2.0 | 14.5 | 3.1 | 6.3 | 3.9 | 0.356 | 0.3 | 2.7 | 2.1 | 2.2 | 0.5 |
| | 0.1 | 3.3 | 0.7 | 5.5 | 24.9 | 6.3 | 0.7 | 1.5 | 15.4 | 2.0 | 14.2 | 2.9 | 6.2 | 3.9 | 0.193 | 0.3 | 2.7 | 2.1 | 2.1 | 0.5 |
| Average | 0.2 | 3.7 | 0.6 | 5.8 | 23.6 | 6.8 | 0.5 | 1.3 | 13.8 | 1.2 | 14.3 | 3.2 | 7.4 | 4.2 | 0.166 | 0.4 | 2.9 | 2.3 | 2.3 | 0.7 |
| | | | | | | | | | | | | | | | | | | | | |
| Animal 1 | 0.22 | 5.1 | 0.8 | 3.2 | 26.1 | 7.5 | 0.7 | 0.7 | 17.9 | 1.3 | 13.7 | 2.7 | 5.0 | 3.2 | 0.085 | 0.2 | 1.9 | 1.5 | 1.5 | 0.4 |
| Animal 2 | 0.15 | 3.1 | 0.6 | 6.2 | 23.4 | 6.8 | 0.5 | 1.7 | 12.7 | 1.3 | 13.7 | 3.4 | 8.0 | 4.8 | 0.178 | 0.4 | 3.2 | 2.4 | 2.6 | 0.6 |
| Animal 3 | 0.16 | 3.7 | 0.5 | 6.2 | 22.7 | 7.6 | 0.5 | 1.2 | 12.9 | 0.6 | 15.3 | 3.5 | 7.4 | 4.0 | 0.124 | 0.4 | 2.9 | 2.5 | 2.4 | 0.7 |
| Animal 4 | 0.10 | 2.3 | 0.4 | 8.2 | 18.6 | 4.2 | 0.5 | 1.3 | 14.8 | 1.3 | 13.0 | 2.9 | 10.4 | 5.2 | 0.175 | 0.6 | 4.6 | 3.5 | 3.4 | 1.4 |
| Animal 5 | 0.18 | 4.1 | 0.4 | 5.2 | 28.4 | 7.2 | 0.5 | 1.0 | 12.1 | 0.7 | 14.8 | 3.2 | 7.1 | 3.5 | 0.102 | 0.4 | 2.8 | 2.1 | 2.2 | 0.5 |
| Animal 6 | 0.19 | 5.1 | 0.6 | 4.9 | 27.0 | 7.7 | 0.5 | 1.1 | 13.0 | 0.7 | 14.9 | 2.8 | 5.7 | 3.4 | 0.093 | 0.3 | 2.6 | 1.8 | 1.8 | 0.7 |
| Animal 7 | 0.18 | 4.4 | 0.5 | 5.3 | 25.7 | 7.9 | 0.5 | 1.3 | 11.6 | 0.8 | 14.3 | 3.5 | 7.5 | 4.7 | 0.143 | 0.3 | 2.0 | 1.9 | 1.8 | 0.7 |

**Table A2.**

Fatty Acid Analyses

| ID | Results as % Fatty acid | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C12:0 | C14 | C15 | unknown | C16 | C16:1 | C17 | unknown | C18 | *Trans* Vaccenic | C18:1 | *Cis* Vaccenic | C18 2 | C18:3 | CLA | C20:3 | C20:4 | C20:5 | C22:5 | C22:6 |
| Animal 8 | 0.15 | 3.5 | 0.7 | 5.3 | 22.0 | 6.5 | 0.6 | 1.0 | 16.4 | 2.1 | 13.3 | 3.3 | 7.5 | 4.3 | 0.167 | 0.4 | 2.5 | 2.2 | 2.4 | 0.4 |
| Animal 9 | 0.12 | 2.9 | 0.5 | 7.2 | 20.0 | 5.8 | 0.5 | 1.6 | 13.1 | 1.0 | 13.9 | 3.2 | 9.5 | 5.2 | 0.198 | 0.5 | 4.0 | 2.9 | 2.5 | 1.1 |
| Animal 10 | 0.14 | 3.4 | 0.6 | 5.7 | 22.0 | 7.9 | 0.5 | 1.6 | 12.3 | 2.0 | 14.4 | 3.6 | 8.3 | 4.7 | 0.331 | 0.3 | 2.5 | 2.2 | 2.1 | 0.6 |
| Animal 11 | 0.16 | 3.8 | 0.5 | 6.6 | 23.4 | 6.8 | 0.5 | 1.2 | 13.3 | 0.7 | 15.5 | 3.2 | 6.5 | 3.7 | 0.129 | 0.4 | 2.9 | 2.6 | 2.4 | 0.8 |
| Animal 12 | 0.15 | 3.3 | 0.7 | 5.6 | 24.6 | 6.3 | 0.6 | 1.5 | 15.1 | 2.0 | 14.4 | 3.0 | 6.2 | 3.9 | 0.275 | 0.3 | 2.7 | 2.1 | 2.2 | 0.5 |
| **Average** | **0.16** | **3.7** | **0.6** | **5.8** | **23.6** | **6.8** | **0.5** | **1.3** | **13.8** | **1.2** | **14.3** | **3.2** | **7.4** | **4.2** | **0.166** | **0.4** | **2.9** | **2.3** | **2.3** | **0.7** |
| Std dev. | 0.03 | 0.8 | 0.1 | 1.3 | 2.9 | 1.1 | 0.1 | 0.3 | 1.9 | 0.6 | 0.8 | 0.3 | 1.5 | 0.7 | 0.074 | 0.1 | 0.8 | 0.5 | 0.5 | 0.3 |
| Minimum | 0.10 | 2.3 | 0.4 | 3.2 | 18.6 | 4.2 | 0.5 | 0.7 | 11.6 | 0.6 | 13.0 | 2.7 | 5.0 | 3.2 | 0.085 | 0.2 | 1.9 | 1.5 | 1.5 | 0.4 |
| Maximum | 0.22 | 5.1 | 0.8 | 8.2 | 28.4 | 7.9 | 0.7 | 1.7 | 17.9 | 2.1 | 15.5 | 3.6 | 10.4 | 5.2 | 0.331 | 0.6 | 4.6 | 3.5 | 3.4 | 1.4 |
| Range | 0.12 | 2.8 | 0.4 | 5.0 | 9.8 | 3.7 | 0.2 | 1.0 | 6.3 | 1.5 | 2.5 | 0.9 | 5.4 | 2.0 | 0.246 | 0.4 | 2.8 | 2.0 | 1.9 | 1.0 |

## Table 3A

Fatty acids as a % of dry matter.

| ID | Lipid % of Dry Matter | grams fatty acid per 100g dry matter | Ratio of fatty acids to Total Lipids | mg Fatty Acid / 100g DM C12 | C14 | C14:1 | C15 | Unknown Branched C16:0 | C15:1 | C16 | C16:1 | C17 | Unknown | C18 | *trans* Vaccenic | C18:1 oleic | *cis* Vaccenic | C18:2 *Trans* | C18:2 | C18:3 | CLA | C20:2 | C20:3 n6 | C20:4 n6 | C20:3 n3 | C20:5 n3 | C22:5 n3 | C22:6 n3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.2 | 7.0 | 68.7% | 15.6 | 388.0 | 7.0 | 60.2 | 237.5 | 16.9 | 1945.6 | 551.1 | 48.0 | 23.5 | 1290.6 | 96.8 | 999.3 | 199.7 | 26.6 | 379.1 | 241.9 | 9.3 | 9.3 | 17.4 | 138.6 | 17.4 | 117.8 | 115.5 | 29.2 |
| 2 | 7.2 | 4.4 | 60.7% | 5.9 | 137.3 | 5.2 | 24.9 | 282.8 | 9.4 | 1075.5 | 310.2 | 22.8 | 12.2 | 564.2 | 70.5 | 618.9 | 159.8 | 12.6 | 370.2 | 224.1 | 8.8 | 8.4 | 19.4 | 146.7 | 19.4 | 114.2 | 119.4 | 26.1 |
| 3 | 8.3 | 5.0 | 60.6% | 7.4 | 193.0 | 6.6 | 25.0 | 324.1 | 8.4 | 1199.7 | 396.7 | 24.1 | 25.3 | 659.4 | 39.0 | 795.2 | 185.7 | 13.2 | 387.4 | 214.1 | 4.9 | 8.5 | 19.6 | 152.0 | 19.6 | 132.5 | 126.1 | 40.1 |
| 4 | 6.7 | 3.7 | 56.1% | 1.6 | 79.8 | 6.5 | 15.4 | 311.2 | 7.6 | 706.9 | 159.7 | 16.7 | 64.0 | 542.0 | 55.0 | 488.4 | 116.3 | 4.7 | 395.5 | 200.8 | 5.9 | 8.8 | 23.1 | 175.0 | 23.1 | 137.2 | 131.8 | 54.2 |
| 5 | 7.5 | 5.1 | 68.0% | 8.6 | 215.8 | 2.5 | 21.6 | 271.6 | 8.2 | 1488.6 | 370.8 | 23.0 | 11.6 | 612.4 | 48.3 | 764.2 | 174.1 | 13.9 | 374.7 | 188.3 | 6.7 | 10.3 | 20.2 | 146.4 | 20.2 | 112.0 | 115.8 | 28.3 |
| 6 | 8.9 | 6.1 | 69.4% | 11.7 | 333.7 | 8.3 | 37.3 | 301.9 | 11.4 | 1747.2 | 493.8 | 30.7 | 21.3 | 810.8 | 56.3 | 942.6 | 186.4 | 11.7 | 366.6 | 224.8 | 6.4 | 12.6 | 17.8 | 169.3 | 17.8 | 117.6 | 116.1 | 45.2 |
| 7 | 8.7 | 5.9 | 68.1% | 10.7 | 277.4 | 7.5 | 28.4 | 330.2 | 10.3 | 1600.6 | 484.7 | 27.1 | 13.6 | 696.6 | 53.0 | 871.6 | 214.8 | 11.2 | 468.2 | 295.7 | 8.4 | 7.9 | 18.5 | 127.0 | 18.5 | 117.8 | 114.2 | 41.7 |
| 8 | 9.3 | 6.1 | 66.3% | 8.8 | 224.6 | 8.4 | 41.9 | 336.4 | 12.5 | 1407.8 | 412.0 | 37.0 | 87.3 | 1013.0 | 141.7 | 831.9 | 212.4 | 19.4 | 485.2 | 279.3 | 9.0 | 3.7 | 22.1 | 162.9 | 22.1 | 146.2 | 154.5 | 26.4 |
| 9 | 6.9 | 4.2 | 62.2% | 4.2 | 116.8 | 6.4 | 21.8 | 305.5 | 8.5 | 853.4 | 246.8 | 19.9 | 89.6 | 539.8 | 56.2 | 589.4 | 144.9 | 8.7 | 405.8 | 226.2 | 8.5 | 10.8 | 22.1 | 171.1 | 22.1 | 129.1 | 110.2 | 48.4 |
| 10 | 7.2 | 4.5 | 62.9% | 5.8 | 155.1 | 2.6 | 26.7 | 268.5 | 11.6 | 1042.2 | 370.4 | 22.5 | 57.8 | 563.0 | 102.1 | 670.9 | 172.0 | 13.7 | 396.3 | 227.1 | 13.9 | 9.9 | 16.2 | 115.7 | 16.2 | 105.6 | 101.5 | 31.0 |
| 11 | 6.8 | 4.5 | 66.1% | 6.5 | 173.6 | 5.6 | 23.4 | 307.2 | 7.9 | 1097.9 | 316.4 | 22.3 | 46.2 | 602.0 | 38.8 | 710.2 | 149.2 | 9.3 | 308.1 | 176.2 | 6.0 | 3.6 | 18.3 | 136.9 | 18.3 | 122.3 | 114.0 | 36.2 |
| 12 | 7.1 | 5.0 | 70.5% | 7.1 | 169.1 | 5.2 | 34.4 | 291.9 | 11.4 | 1293.8 | 330.2 | 32.0 | 13.3 | 765.4 | 103.0 | 743.3 | 163.0 | 12.6 | 328.6 | 211.9 | 12.9 | 6.9 | 17.6 | 142.9 | 17.6 | 112.1 | 115.1 | 25.5 |
| average | 7.9 | 5.1 | 64.5% | 7.9 | 208.7 | 6.0 | 29.7 | 297.9 | 10.2 | 1287.8 | 373.9 | 26.7 | 41.1 | 717.6 | 68.9 | 753.0 | 174.1 | 13.2 | 394.3 | 227.1 | 8.0 | 8.5 | 19.5 | 149.2 | 19.5 | 122.9 | 119.9 | 37.0 |
| Std dev. | 1.1 | 1.0 | 4.4% | 3.7 | 89.8 | 1.9 | 12.0 | 28.6 | 2.6 | 365.8 | 109.2 | 8.6 | 29.3 | 226.5 | 32.0 | 148.4 | 28.9 | 5.5 | 49.8 | 34.2 | 2.7 | 2.7 | 2.2 | 18.3 | 2.2 | 11.9 | 13.3 | 9.8 |
| Minimum | 6.7 | 3.7 | 56.1% | 1.6 | 79.8 | 2.5 | 15.4 | 237.5 | 7.6 | 706.9 | 159.7 | 16.7 | 11.6 | 539.8 | 38.8 | 488.4 | 116.3 | 4.7 | 308.1 | 176.2 | 4.9 | 3.6 | 16.2 | 115.7 | 16.2 | 105.6 | 101.5 | 25.5 |
| Maximum | 10.2 | 7.0 | 70.5% | 15.6 | 388.0 | 8.4 | 60.2 | 336.4 | 16.9 | 1945.6 | 551.1 | 48.0 | 89.6 | 1290.6 | 141.7 | 999.3 | 214.8 | 26.6 | 485.2 | 295.7 | 13.9 | 12.6 | 23.1 | 175.0 | 23.1 | 146.2 | 154.5 | 54.2 |
| Range | 3.5 | 3.3 | 14.4% | 14.0 | 308.2 | 5.9 | 44.8 | 98.8 | 9.3 | 1238.7 | 391.4 | 31.3 | 78.0 | 750.8 | 102.9 | 510.8 | 98.5 | 21.9 | 177.1 | 119.6 | 9.0 | 9.1 | 6.9 | 59.2 | 6.9 | 40.6 | 52.9 | 28.7 |