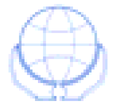

EFFECT OF A LINSEED OIL SUPPLEMENTATION ON TOTAL FATTY ACIDS OF MUSCLES AND ON COLOUR STABILITY AND LIPID OXIDATION OF BOVINE MEAT

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Background

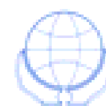
Recent decline of beef consumption in European countries is mainly due to problems with food safety (e.g. BSE) and the health aspect of eating red meat. Enhancing the polyunsaturated fatty acid, especially n-3 PUFA, and decreasing the saturated fatty acid (SFA) content of meat improve the nutritional value and increase the attractiveness of meat to consumers. In beef, it has been previously described that the PUFA/SFA and n-6/n-3 ratio can be modulated by dietary manipulation with oil. For ruminants, pasture, grass silage, whole linseed and linseed oil are the most important sources of n-3 fatty acid but the dietary PUFA must escape biohydrogenation in the rumen (Raes et al., 2004). In bovine, increasing PUFA of the diet can also increase the production of conjugated linoleic acid (CLA) (Enser et al; 1999 ; Bauchart et al; 2002) which may have health benefits to man. If nutritional value of meat can be improved by increasing dietary PUFA level, its sensorial quality must remain acceptable to consumers. It has been established that animal diet can affect beef colour stability and lipid oxidation during display life (Gatellier et al., in press)) and after cooking.

Objectives

The aim of this study was to assess the effect of increasing dietary PUFA level, especially n-3 PUFA, with linseed added to the diet or linseed oil directly infused in the duodenum, on intramuscular total fatty acids composition and on oxidative stability of bovine meat.

Materials and methods

Experiment was carried out with 12 crossbred Charolais x Salers 15 months old steers. Three diets were given for 70 days: a *control (C)* diet consisting in hay (45%) and concentrate feed (55%); a *linseed* (*L*) diet consisting of the same control diet supplemented with 4% of lipids provided by extruded linseed; a *linseed oil* (*O*) diet consisting of the control diet supplemented with 4% of lipids provided by linseed oil continuously infused into the proximal duodenum in the aim to bypass rumen hydrogenation. Animals were slaughtered in the INRA abattoir and, at 24 h *p.m.*, muscle *Semi tendinosous* was removed. Meat portions were placed on a fibre board tray, overwrapped with an oxygen permeable film and exposed in darkness for a maximum of 13 days at 4°C. Total lipids in muscles have been extracted according to the method of Folch et al. (1957). Their fatty acids were converted into methyl esters by transmethylation using borotrifluorure at 14% in methanol according to the method of Sébédio et al; (1999) for their analysis by gas-liquid chromatography using CP Sil 88 glass capillary column. Colour measurement was determined with a spectrophotometer equipped with an integrating sphere (2°-viewing angle, illuminant D65). Colour coordinates were calculated in the CIELAB (1976) system. The results were expressed as lightness (L*), redness (a*) and yellowness (b*). Meat discoloration was determined by difference R_{630}-R_{580} (Renerre, 2000). Lipid oxidation was measured by the TBA-RS method according to Mercier et al. (1998). All values are reported as the mean +/- standard deviation for each animal group. The unpaired Student *t*-test was used to test differences between each group.



Results and discussion

muscle fatty acids							
Treatments	**Diet C**		**Diet L**		**Diet O**		Significance
	LSM	SEM	LSM	SEM	LSM	SEM	(P≤ 0.05)
Fatty acids (%)							
C16:0	**24.7**	2.8	**23.6**	1.6	**24.4**	3.0	0.6754
C18:0	**17.8**	2.1	**16.2**	3.7	**15.0**	4.3	0.2832
C18:1*cis*9	**31.0**[ab]	3.6	**33.8**[a]	4.5	**27.7**[b]	3.7	**0.0198**
C18:2 *n*-6	**6.3**[a]	1.6	**4.8**[a]	1.6	**8.5**[b]	2.1	**0.0019**
C18:3 *n*-3	**1.0**[a]	0.1	**1.5**[a]	0.5	**8.7**[b]	1.5	**0.0001**
CLA *cis9, tr11*	**0.4**[a]	0.1	**0.7**[b]	0.1	**0.4**[a]	0.1	**0.0001**
Sum SFA[a]	**46.7**	4.1	**44.2**	3.3	**43.6**	5.0	0.3260
PUFA n-6/PUFA n-3 ratio	**2.980**[b]	0.579	**2.581**[b]	0.534	**1.035**[a]	0.168	**0.0001**
P/S ratio[b]	**0.270**[a]	0.087	**0.250**[a]	0.070	**0.495**[b]	0.144	**0.0001**

Table1: Effects of diets on total fatty acids % in muscle

As shown in table 1, compared to the control diet (diet C), addition of extruded linseed (diet L) induced a large increase of the content of CLA, especially of the isomer 9c,11t (P<0.0001). No difference was noted in the major SFA (C16:0 and C18: 0) between treatments. However, the impact of the lipid supplement on fatty acids content of muscle was more marked with diet O, leading to a large incorporation of 18:3n-3 (P<0.0001) and to a large increase in the P/S ratio (P<0.0001) up to the recommended value for the health of consumers. Moreover, diet O decreased the ratio of PUFA n-6 /PUFA n-3 (P< 0.0001) but, with diet L compared to diet C, no significant difference was noted in C18:3n-3 such as noted in the literature (Choi et al., 2000) but quantity and nature of extruded linseed are different between experiments.
About colour characteristics measurements, a slight increase of luminosity L* during the 13 days of meat storage was observed (figure not showed) but with no significant differences between treatments. Figure 1 showed a good stability of a* values until 3 days. From 7 to 13 days, the decrease of redness was more important in O group than in C and groups. The decrease of a* was slightly higher in L group compared to C one. At the end of storage, redness was approximatly two fold higher in C and L groups compared to O group with only a significant difference between C and O group. This indicated a greater myoglobin oxidation rate in meat of animals from O group while feeding animals with extruded linseed (L group) gave meat with myoglobin oxidation identical toC group. It was not showed a significant variation of b* during meat storage and no differences were measured between animals groups (not showed). Some authors (Vatansever et al., 2000; Wood et al., 2003) showed that linseed supplementation slightly decreased colour saturation $(a^2 + b^2)^{1/2}$ of bovine meat comparatively to controls.
Variation of meat discoloration (figure 2) during a refrigerated storage, showed that decrease of R_{630}-R_{580} was more important in O group than in two other animal groups. C and L groups showed similar decrease of R_{630}-R_{580} with values slightly higher (NS) in C group. After 9 days of air storage, mean values of R_{630}-R_{580} in O group were below the limit value of 12.5 which corresponds to 50% acceptability for the consumers (Renerre, 2000). This limit was reached after 10 days in L group and only after 13 days in C group. These results showed the highest reduction of retail shelf life of meat from animals receiving PUFA by oil infusion in the duodenum.

Figure 3 showed an important increase of lipid oxidation measured by accumulation of TBA-RS as soon as 3 days storage. This increase was particularly noted in O group. After 7 days, TBARS values were also above 2 mg MDA/Kg meat in C and L groups and largely exceeded this cut off value, at which rancidity may be detected by consumers (Younathan and Watts, 1959). At the end of storage, TBA-RS values in O group were

approximately two fold higher than values measured in the two other groups and were very high (> 8mg MDA/kg meat) After 7, 9 and 10 days storage, *t*-test showed significant differences between O and L groups. Moreover, lipid oxidation was more important in C than in L group but differences were not significant. This paradoxal effect could be attributed to antioxidants present in linseed grain which could offer better protection against lipid oxidation in membranes. In steers, for Vatansever et al. (1998), linseed (+/- fish oil) showed only small increase in TBA-RS when compared with control. In charolais cattle, it was observed lower TBA-RS values in meat from animals fed pasture, even if PUFA content was higher in meat of these animals (Gatellier et al., in press), compared to mixed-diet.

Conclusions

Compared to controls, including extruded linseed in the finishing diet of steers significantly increase the content of CLA, but not the C18:3n-3 content; but extruded linseed don't change significantly colour stability and lipid oxidation in meat after a refrigerated storage. Bypassing rumen hydrogenation by direct infusion of linseed oil in the duodenum had a significant effect on PUFAn-6/PUFAn-3 and P/S ratios; moreover, infusion of linseed oil increase myoglobin and lipid oxidation. Lipid oxidation induced by linseed oil infusion could be decreased by the use of antioxidants. Further investigations on the relation of PUFA increase and nutritional antioxidant status on beef qualities would be of interest as it was done on other animal species such as turkey (Mercier et al., 1998).

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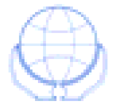

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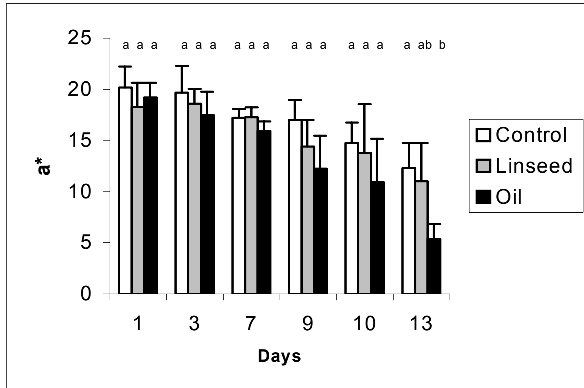

Figure 1: variation of redness a*

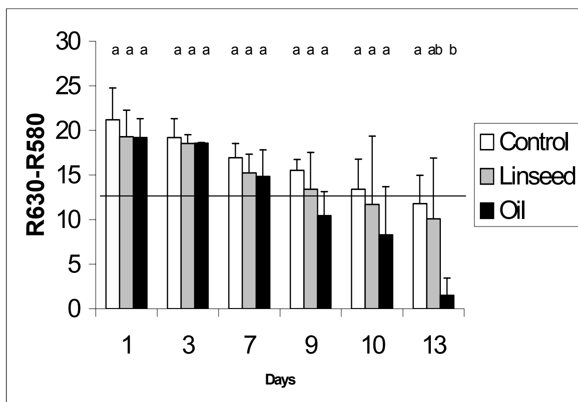

Figure 2: variation of R_{630}-R_{580}

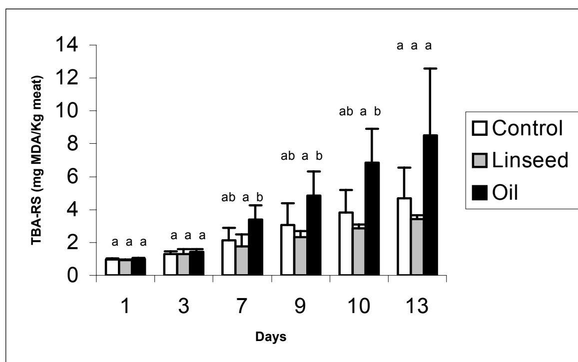

Figure 3: variation of TBARS