Effects of lipid supplementation, method of preservation and cooking on nutritional and sensorial qualities of minced beef

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Abstract— **The purpose of this study was to investigate the effects of lipid supplementation, preservation and cooking on nutritional and sensory beef qualities. During 100 days, 24 Normand cull cows divided into 3 groups were fed with one of the 3 following lipid supplementations: no supplementation (control) / extruded linseed / extruded linseed + rapeseed. Minced beef patties (15% fat content) were produced from briskets of these cows. The patties were then stored for 4 days in a tray under air packaging or for 6 days under modified atmosphere packaging (70:30, O2/CO2). After storage, the patties were fried on a steel griddle until an internal temperature of 58°C (medium rare cooking). Linseed or linseed + rapeseed supplementation increased respectively by 3 and 2 C18:3 *n*-3 content of minced beef compared to control group and resulted in 110 or 85 mg of C18:3 *n*-3/100 g of minced beef. Preservation and cooking did not alter C18:3 *n*-3 content. However, onset of lipid oxidation measured by TBA-RS was observed during storage, especially for patties enriched in C18:3 *n*-3 (levels higher than 2.5 mg/kg). No difference in flavor intensity was observed between groups but a greater fishy taste has been observed in the linseed group.**

Keywords— **Minced beef, preservation, fatty acid**

I. INTRODUCTION

Beef, particularly minced beef, is frequently denounced for its significant amounts of saturated fats. Lipids, therefore, have a key role in the beef nutritional image and in the consumer's acceptability of the product. The quantity introduced, their composition of fatty acids and their stability in relation to peroxidation are significant determiners of the nutritional and sensory qualities of beef [1-4]. It seemed, therefore, necessary to improve and secure these qualities through the animals' diet and the technological treatment applied to beef.

The aim of this study was, therefore, to measure the impact of lipid supplementation of dairy cull cows, on the fatty acid (FA) composition of minced beef (15% fat) obtained from these animals, taking into account the effects of the nature of lipid supplementation, the method of preservation and cooking the products.

II. MATERIALS AND METHODS

A. Experimental design

24 Normand dry and not pregnant cull cows were fattened for about 100 days at the experimental station of Mauron (Brittany). They were selected for their live weight, age and visual and manual estimation of body fat score. Animals were assigned at random to 3 groups. Each group was fed a ration consisting of corn silage, soybean meal and an experimental concentrate containing one of the following 3 lipid supplements:

- No supplement, control diet (C group);
- Extruded linseed, a diet rich in *n*-3 polyunsaturated fatty acids (*n*-3 PUFA – L group);
- Extruded rapeseed (⅔) + linseed (⅓), a diet rich in *cis*-monounsaturated fatty acids and secondarily in *n*-3 PUFA (RL group).

The composition of the experimental concentrates is shown in Table 1. The rations (8.5 kg DM of corn silage + 0.4 kg DM of soybean meal + 3.1 kg DM of experimental concentrate) were calculated to enable a theoretical growth of 1100 g/d. The objective of obtaining a body fat score at slaughter of 3 to 3.5 was reached by rationing the quantity of corn silage to 5 kg

Table 1 Experimental concentrate composition

Experimental concentrate	Control	Linseed	Linseed + rapeseed
Ingredients (% as fed basis)			
Wheat	9.7	2.3	2.0
Corn	48.9		
Sunflower meal		8.2	15.0
Rapeseed meal		15.0	15.0
Soybean meal	41.4	3.5	5.3
Extruded linseed		50.0	16.0
Extruded rapeseed			29.0
Wheat bran		20.0	16.7
Vitamin mineral premix	1.0	1.0	1.0
Fatty acid composition (% total fatty acids)			
C16:0	14.5	7.0	6.5
C18:0	2.7	4.2	2.7
C18:1 *n*-9	21.7	23.4	41.0
C18:2 *n*-6	49.7	19.0	22.0
C18:3 *n*-3	9.3	44.7	25.2

DM for the animals with a body fat score above or equal to 2.5 after 42 days of fattening. The quantities of concentrate remained identical throughout the experiment. Therefore, approximately 700 g of lipids were consumed by the animals daily via the L and RL supplements, representing 5.8% of the dry matter ingested by the non-rationed animals and 8.2% by the rationed animals.

B. Measurements, sampling procedures and analytical methods

The brisket (*M. pectoralis profundus* – 5% fat content; *M. serratus ventralis thoracis* and *M. intercostales* – 25-30% fat content) of each animal were removed 48 h after slaughter, vacuum packaged and stored at 0-2°C for 24 h for the preparation of minced beef patties with 15% fat. For each animal, about fifty patties, weighing 90 g each, were produced. The patties were then divided between 2 storage circuits, typically found for this type of product:

- In air packaged trays. The samples were kept at 0-2°C for 3 days, alternated with 12 hours of artificial light and 12 hours of darkness then in the dark at 6-8°C for 1 day;
- Under modified atmosphere packaging (70:30, O_2:CO_2). The samples were kept at 0-2°C for 4 days, alternated with 12 hours of artificial light and 12 hours of darkness, then in the dark at 6-8°C for 2 days.

After the preservation period, the beef patties were cooked on a steel griddle (Thirode) at 250°C, for about 2 minutes each side, until an internal temperature of 58°C was reached (medium rare cooking).

The fat content of the patties was determined by extraction with hot petroleum ether after hydrochloric acid hydrolysis (NF V 04 402 – January 1968). The FA were extracted and transesterified to boron trifluoride, in cold methanol, according to the method of Rule [5], then analysed by gas chromatography (NF EN ISO 5508 – June 1995 / NF EN ISO – June 2000). The lipid oxidation of the patties was assessed by measuring thiobarbituric acid reactive substances (TBA-RS). These analyses were carried out on 2 patties per animal at different points in the process: during the production of the patties (day 0), at the end of preservation and after cooking. The overall intensity and specific descriptors (rancid, fishy...) of the flavour of the cooked patties were evaluated by a panel of 12 experts, on a continuous, unstructured scale from 0 (zero intensity) to 100 (maximum intensity), by sequential monadic tasting tests.

III. RESULTS AND DISCUSSION

A. Minced beef fatty acid composition

The FA composition of beef patties at day 0 is shown in Table 2. The addition of linseed in the diet multiplied the C18:3 *n*-3 content in the patties by 3: 0.25% of the total FA in the C group *vs*. 0.86% in the L group. The RL mixture did not have the same effect. The content of C18:3 *n*-3 was only multiplied by just over 2 (0.58% of the total FA). In addition, the L or RL supplements were able to reduce the C18:2 *n*-6 / C18:3 *n*3 ratio in accordance with nutritionist recommendations, with a ratio of 6.0 in the C group, 2.3 in the L group and 3.0 in the RL group. From a quantitative point of view, the L supplement in the cows' ration produced an average content of 111 mg of C18:3 *n*-3 for 100 g of minced beef, over 34 mg/100 g for the C group ($P < 0.01$) and 86 mg for the RL group ($P < 0.05$). Normand *et al*. [2] reported levels of C18:3 *n*-3 at 0.86 to 1.87% in the *M. longissimus dorsi*

Table 2 Lipids content (g/100 g meat) and fatty acid composition (% total fatty acids) of minced beef at day 0 (means ± standard deviation)

Group	Control	Linseed	Linseed + rapeseed
Lipids (g/100 g)	17.0 ± 1.5	15.3 ± 1.9	15.8 ± 3.7
Saturated FA (% TFA)	49.1 ± 2.8	47.7 ± 1.4	49.7 ± 4.6
Monounsaturated FA	47.1 ± 2.7	46.8 ± 1.3	45.7 ± 4.5
Polyunsaturated FA	3.0 ± 0.3	4.6 ± 0.4	3.8 ± 0.6
C16:0	25.8 ± 1.2	23.0 ± 1.4	23.7 ± 1.6
C18:0	17.1 ± 2.9	18.7 ± 2.0	19.7 ± 4.2
C18:1 *n*-9	42.2 ± 2.3	42.7 ± 1.1	41.6 ± 3.6
C18:2 *n*-6	1.5 ± 0.2	1.9 ± 0.1	1.7 ± 0.3
C18:3 *n*-3	0.3 ± 0.1	0.9 ± 0.1	0.6 ± 0.1
Σ *n*-6 PUFA	2.0 ± 0.2	2.8 ± 0.2	2.4 ± 0.3
Σ *n*-3 PUFA	0.4 ± 0.1	1.1 ± 0.3	0.8 ± 0.2
CLA	0.5 ± 0.2	0.4 ± 0.1	0.4 ± 0.1
Σ C18:1 *trans*	3.0 ± 0.4	3.9 ± 0.3	3.5 ± 0.5
C18:2 *n*-6 / C18:3 *n*-3	6.0 ± 1.0	2.3 ± 0.4	3.0 ± 0.3

Table 3 C18:3 *n*-3 content (mg/100 g meat) of minced beef after preservation and cooking (means ± standard deviation)

Group	Control	Linseed	Linseed + rapeseed
Production (day 0)	34 ± 9	111 ± 9	86 ± 25
Air pack. (4d) – Raw	39 ± 10	115 ± 13	85 ± 25
Air pack. (4d) – Cooked	33 ± 9	109 ± 16	76 ± 23
MAP (6d) – Raw	39 ± 10	115 ± 17	88 ± 24
MAP (6d) – Cooked	36 ± 8	90 ± 28	69 ± 19

MAP : modified atmosphere packaging

(2-5% lipids), or 16 to 45 mg/100 g of muscle, for meat animals that received 750 g/day of extruded linseed. These levels are higher or lower than those observed in this case, in accordance with the weight of the meat as it was recorded (33 *vs*. 111 mg/100 g) or with the total FA (1.31 *vs*. 0.86%). The origin of the differences observed in the two cases may lie with the quantity of linseed consumed (0.75 *vs*. 1.75 kg/day), the lipid content of the meat (3.1 *vs*. 15%) and the type of muscle.

Preservation and cooking did not have a significant effect on the levels of C18:3 *n*-3 in relation to the total FA. From a quantitative point of view, there was no significant difference observed in the level of C18:3 *n*-3 between production and the end of preservation (Table 3). The cooking process led to a decrease in the quantity of C18:3 *n*-3 which was only significant for the patties in the L and RL groups, stored for 6 days under modified atmosphere ($P < 0.01$). This decrease is only partly explained by the 2% loss of fat observed during cooking.

B. Lipid oxidation

During production, the average content of TBA-RS in the 3 groups of patties was not significantly different (0.3 mg/kg of the raw product). Logically, those stored under air packaging or under modified atmosphere induced lipid oxidation, with the TBA-RS content at the end of preservation multiplied by 5 and 7 respectively and significantly higher ($P < 0.01$) than during production. In both cases, oxidation was higher in the L group, but the difference was not significant (Fig. 1). In relation to air packaging, modified atmosphere packaging led to considerably higher levels of TBA-RS for the L and RL groups: 2.7 *vs*. 1.8 and 2.2 *vs*. 1.5 mg/kg respectively.

On the other hand, regardless of the group and the preservation method, the cooking process did not produce any significant effect on the levels of TBA-RS in the patties. This is undoubtedly linked to the less aggressive method of cooking utilised in this study.

C. Minced beef flavour

The flavour intensity was not significantly different between the 3 groups for the two packaging methods studied. However, the "fishy" taste, despite having a relatively weak intensity, was significantly ($P < 0.01$) higher in the L group than in the other groups (6.3 *vs.* 1.4 or 1.6 for the C or RL groups). Scollan et al. [3] had already observed a fishy taste in steer meat, which was fed with linseed treated with formaldehyde. Campo et al. [6] showed that there was a link between the increase in the content of TBA-RS and the appearance of flavour defects. They set the threshold at which consumers detected these defects at 2.3 mg of TBA-RS/kg. It is therefore likely that the flavour problems found in the minced beef patties in the "linseed" group were linked to the oxidation of PUFA.

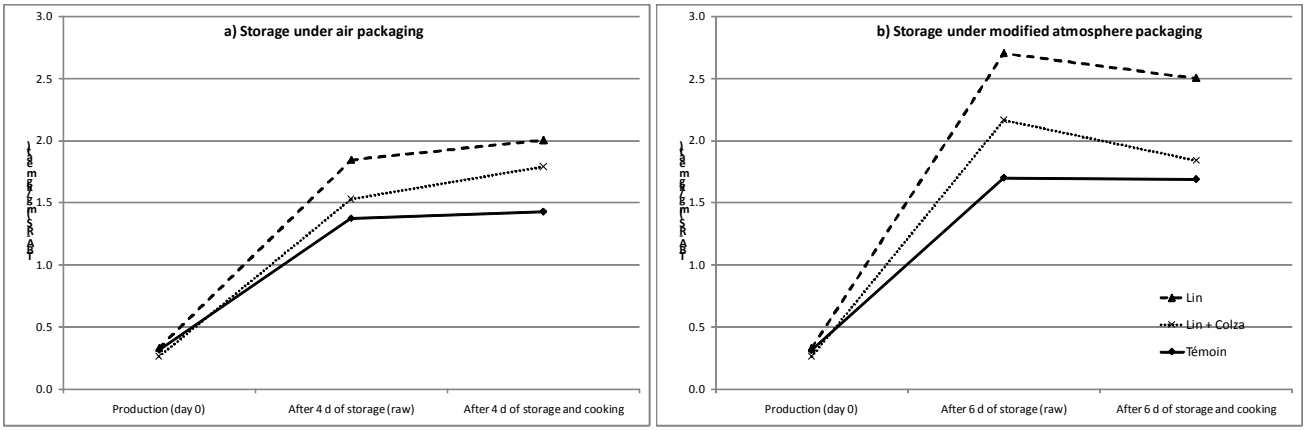

Fig. 1 Lipid oxidation of minced beef after storage under a) air packaging b) modified atmosphere packaging and cooking

IV. CONCLUSIONS

The intake of 1.75 kg/day of extruded linseed for 100 days multiplied the content of C18:3 *n*-3 in the minced beef patties (15% fat) by 3. Quantitatively, this resulted in a C18:3 *n*-3 content of approximately 110 mg/100g. This is relatively high compared to the content measured in the *M. longissimus dorsi*, in relation to the difference in the lipid content of the two products. Nevertheless, it is still too weak to be able to benefit from the nutritional claim "source of omega 3" (in France, an intake of 300 mg/100 g would be required). The intake of the extruded linseed + rapeseed mix did not have the same effect. The C18:3 *n*-3 content was only multiplied by just over 2. The value, therefore, of such a mixture, is uncertain. In addition, the preservation of the meat and, to a lesser extent, cooking process had no major effect on their PUFA content. On the other hand, the beginning of lipid oxidation was observed during preservation. Oxidation was particularly significant in the meats enriched with PUFA and preserved in a modified atmosphere. In the end, this oxidation resulted in the appearance of a characteristically fishy taste in the products. Under certain conditions (relatively fatty products, oxidising preservation conditions), the intake of antioxidants in addition to PUFA supplementation could be an interesting alternative to test in order to limit these phenomena.

ACKNOWLEDGMENT

Funds for this research were provided by FranceAgriMer.

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