The nutritional quality of meats and liver differed deeply in cereal (indoor) and grass (outdoor) fed fattening lambs

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Abstract

To update data bases on nutritional value of meat, we analysed five meat cuts and liver of lambs from the 2 main French rearing systems (outdoor-fed grass and indoor-fed hay and concentrate). The results showed that outdoor lambs had a meat with a higher protein (20.1% versus 19.7%) and heme iron (0.72 versus 0.60 mg/100g) contents, but lower in selenium (1.8 versus 7.6 µg/100g) and vitamin B_{12} (1.32 versus 2.00 µg/100g) than that of indoor lambs. No significant differences were observed in lipids, zinc, vitamins B_3 and B_6 vitamin contents. Meats from outdoor lambs were higher in saturated fatty acids (49.6 versus 44,4%) and less polyunsaturated fatty acids (PUFA) (7.0 versus 10.4%) than that of indoor lambs. The lower PUFA content of meats in outdoor lambs resulted from a lower proportion of n-6 PUFA (3.8 versus 7.8%), despite their higher proportion of n-3 PUFA (3.2 versus 1.6%). These difference related to rearing systems affect the nutritional value of lamb meats, mainly in selenium, B_{12} vitamin and in PUFA.

Introduction

In France, consumers demand more and more accurate informations on nutritional value of meat. Since more than 20 years, ruminant meat is subjected to serious critics because of it is suspected to favour human diseases such as cardiovascular diseases (Dallongeville et al., 2008) and colorectal cancer (Pierre et al, 2008).This explains why many nutritionists recommend to reduce meat consumption. However, these recommendations are not supported by clear demonstration of causal effect between meat consumption and these diseases. Up to now, nutritional value of meat is estimated through the chemical composition of raw meat and more rarely of cooked meat. Data found in nutritional data bases suffer of numerous lacks i) too old data that do not correspond to the evolution in rearing systems and breed, ii) data that must be revaluated because of recent advances in analytical methods (trans fatty acids, B12 vitamin). This explained why the centre for consumer information on meat (Centre d'Informations des Viandes, CIV, 75000 Paris) decided two years ago to re-evaluated the nutritional characteristics of raw meats from lamb, beef (Bauchart et al, 2008), horse and veal produced and consumed in France to provide more accurate data for nutritional data base update. This paper presents the nutritional characteristics of lamb meats and liver. Analyses were focused on lambs coming from the most widely used rearing systems in France (indoor and outdoor systems) and on the main cuts of the carcass. The nutrients taken into account in this study were those which cover a significant part (at least 15%) of the daily supply recommended for the french population.

Materials and methods

Sixteen lambs of Inra 401 breed were reared in one of Inra experimental unit. One group were reared indoor and given hay and concentrate. The second group was reared outdoor on a natural pasture and given only grass. Animals were slaughtered at a live weight of 34-35 Kg (100-110 day old).

The liver and five of main cuts were dissected out of the carcasses, i.e. rib (dorsal), fillet, saddle, collar and knuckle. In each cut, 3-4 slices of 100-150 g were cut in the middle of each cut. When visible fat was present in the slice, the butcher had removed it with a knife to approach the reality of meat consumption in France where the consumer eliminated a large part of the fat tissue in his plate. Meat and fat were analysed separately.

The following components were determined in each meat cut such as dry matter (AFNOR, NF), total nitrogen (AFNOR, NFV04 407), lipids (Folch and al., 1957), P in total lipid extracts (Bartlett, 1959), total iron and zinc (atomic absorption), heme iron (Hornsey, 1956), selenium (Ducros and Favier, 1992), B3 (Ndaw et al., 2002), B6 (Ndaw et al., 2000) and B12 (Ortigues-Marty et al, 2005) vitamins Fatty acid composition of total lipid extracts were determined according to Sébédio et al. (1997) after transesterification of fatty acids according to Morrison and Smith (1964). A vitamin was determined only in liver (AFNOR, NF EN 12823-1).

Data were analysed using a two-way variance analysis including meat cut (five), rearing conditions (two) and interaction between both factors. Means were compared by a Neuman keuls test.

Results and discussion

Proximate composition

Anatomical location of cuts: Lamb meat contained between 25.0-31.9 g, 18.3-20.8 g, 4.3-13.2 g /100 g fresh meat according to the anatomical local Dry matter was strongly related to lipid content while protein content showed low differences between cuts. Saddle and fillet were the leaner cuts and collar the fattiest one, rib and knuckle having intermediate position. Anatomical location of cuts had no significant effect on total iron and zinc contents which accounted for 1.3-1.4 mg and 4.6-4.8 µg /100 g fresh meat. Small differences were observed in heme iron content within meat cuts (0.61-0.70 mg/100g), this parameter being known to be strongly related to the metabolic type of muscle fibres (Leseigneur-Meynier and Gandemer, 1991). This result suggested that metabolic type of muscles from these cuts were very similar. B vitamin contents strongly depended on cuts. This effect was mainly due to collar that contained smaller B_3 and B_6 vitamin contents compared to other cuts (4.3 versus 6.4-6.9 and 0.15 versus 0.26-0.31 mg/100 g respectively). B_{12} vitamin content varied largely from one muscle to another, the highest values being found in the collar and the knuckle and the lowest in the fillet and the rib. These results agreed with those previously published for European lambs (Badiani et al, 1998).

Table 1. Proximate composition of lamb meats as related to the anatomical location of cuts and lamb rearing conditions ([1] in g, [2] in mg or [3] in µg/100 g fresh raw meat)

	Rib	**Fillet**	**Saddle**	**Collar**	**Knuckle**	**Muscle effect**	**Indoor**	**Outdoor**	**Rearing Effect**
Dry matter[1]	28.4^{b}	26.2^{c}	25.0^{d}	31.9^{a}	26.5^{c}	***	26.9^{b}	28.4^{a}	***
Proteins[1]	20.1^{b}	20.8^{ab}	20.3^{a}	18.3^{c}	19.8^{b}	***	19.7^{b}	20.1^{a}	**
Lipids[1]	7.6^{b}	4.6^{d}	4.3^{d}	13.2^{a}	6.3^{c}	***	6.9	7.5	ns
Phospholipids[1]	0.72^{c}	0.81^{b}	0.94^{a}	0.79^{b}	0.78^{b}	***	0.86^{a}	0.76^{b}	***
Iron									
Total [2]	1.31	1.36	1.31	1.27	1.45	ns	1.29	1.39	ns
Heme Iron[2]	0.61^{b}	0.67^{ab}	0.66^{ab}	0.66^{ab}	0.70^{a}	***	0.60	0.72	**
Heme/total	47.8	50.0	51.0	53.5	49.8	ns	47.5	53.4	ns
Zinc[2]	2.6^{b}	2.7^{b}	3.0^{b}	3.8^{a}	2.9^{b}	***	3.0	3.0	ns
Selenium[3]	4.6	4.8	4.8	4.6	4.7	ns	7.6a	1.8b	***
B vitamins									
B_3[2]	6.7^{ab}	6.9^{a}	6.7^{ab}	4.3^{c}	6.4^{b}	***	6.2	6.2	ns
B_6[2]	0.28^{ab}	0.31^{a}	0.28^{ab}	0.15^{c}	0.26^{b}	***	0.26	0.25	ns
B_{12}[3]	1.49^{cd}	1.21^{d}	1.68^{bc}	2.06^{a}	1.88^{ab}	***	2.00^{a}	1.32^{b}	***

On the same row and for a given factor (muscle or rearing conditions), data with different superscripts differ significantly

Rearing conditions (indoor/outdoor): This factor had a lower influence on meat composition than the anatomical location. Differences in dry matter and protein contents were significant but remained low. No significant differences were observed for lipids, iron, zinc, B_3 and B_6 vitamin contents. The higher in heme iron content of cuts in outdoor lambs than those of indoor lambs would be explained by the higher physical exercise of outdoor lambs than of indoor ones (Cassens and Cooper, 1971) favouring oxidative muscles. The main effect of rearing conditions on meat composition concerned selenium and B_{12} vitamin contents which were lower in outdoor lambs. This probably resulted of the lower content of grass in Se and cobalt (a precursor of B_{12} vitamin) respectively.

Liver: Liver composition showed a dry matter, protein, lipid and zinc contents similar to those of meat cuts. It contained more iron (6-7 versus 1.3-1.5 mg/100g), selenium (10-49 versus 1.8-7.6 µg/100g) and B vitamins (x 3 for B_3, x 2 for B_6, x 30-40 for B_{12}). As for meat cut, liver from outdoor lambs contained less selenium and B_{12} than those from indoor lambs. A similar difference was observed for A vitamin (3755 versus 55 mg/100 g fresh liver).

Fatty acid content

Anatomical location of cuts: Contents in saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids strongly depended on the anatomical location of cuts. Similar variation was observed for trans fatty acids and conjugated linoleic acids (CLA), these two FA being positively correlated to the lipid content of cuts. The higher is the lipid content of cut the higher is its SFA, MUFA, PUFA, CLA and trans contents. Thus, the higher contents in these FA were observed in the collar and the lower contents in the fillet and the saddle. In contrast, contents in long chain PUFA (LC PUFA) of both n-6 and n-3 series were not related to cuts. Indeed, the lack of differences in LC PUFA of cuts would be explained by the fact these FA are located only in phospholipids (Gandemer, 1990) of which the content did not deeply vary between cuts.

Table 2. Fatty acid content of lamb meat as related to the anatomical location of cuts and rearing conditions of lambs (in mg/100 g fresh meat)

	Rib	**Fillet**	**Saddle**	**Collar**	**Knuckle**	Muscle effect	**Indoor**	**Outdoor**	Rearing effect
Lipids	**7600^{b}**	**4600^{d}**	**4300^{d}**	**13200^{a}**	**6300^{c}**	*******	**6900**	**7500**	**ns**
Fatty acids (FA)									
Saturated FA	3287^{b}	1888^{d}	1664^{d}	5799^{a}	2585^{c}	***	2770^{b}	3319^{a}	*
Linear	3169^{b}	1822^{d}	1605^{d}	5582^{a}	2493^{c}	***	2656^{b}	3212^{a}	**
Branched chain	118^{b}	66^{d}	59^{d}	218^{a}	91^{c}	***	113^{b}	107^{a}	*
Monounsaturated FA	**2786^{b}**	**1627^{c}**	**1481^{c}**	**4927^{a}**	**2316^{b}**	*******	**2552**	**2703**	**ns**
cis MUFA	2453^{b}	1440^{c}	1321^{c}	4325^{a}	2072^{b}	***	2223	2422	ns
Polyunsaturated	**432^{b}**	**360^{c}**	**360^{c}**	**763^{a}**	**457^{b}**	*******	**553^{a}**	**419^{b}**	*******
Total n-6 PUFA	325^{b}	241^{c}	236^{c}	510^{a}	296^{b}	***	411^{a}	232^{b}	***
cis n-6 PUFA	270^{b}	212^{c}	208^{c}	413^{a}	253^{b}	***	362^{a}	180^{b}	***
cis n-3 PUFA	140^{b}	108^{c}	102^{c}	192^{a}	138^{b}	***	85^{b}	187^{a}	***
n-6 cis LC PUFA	30	30	28	33	30	ns	60^{a}	traces^{b}	***
n-3 cis LC PUFA	62	58	67	62	71	ns	37^{b}	90^{a}	***
n-3+n-6 LC PUFA	98	91	90	102	92	*	99^{a}	91^{b}	**
CLA	29^{b}	17^{b}	16^{b}	61^{a}	21^{b}	***	57^{b}	traces^{a}	***
Trans FA	388^{b}	216^{c}	187^{c}	698^{a}	286^{c}	***	377^{a}	313^{b}	*
trans MUFA	333^{b}	187^{c}	159^{c}	601^{a}	243^{c}	***	328^{a}	281^{b}	*
trans n-6 PUFA	55^{b}	29^{c}	28^{c}	97^{a}	43^{b}	***	49	52	ns
PUFA/SFA	0.16^{c}	0.20^{b}	0.23^{a}	0.13^{c}	0.19^{b}	***	0.76	0.70	ns
18:2 n-6/18:3 n-3	4.4	5.3	5.3	3.9	4.8	ns	12.0^{a}	3.2^{b}	***

On the same row and for a given factor (muscle or rearing conditions), data with different superscripts differ significantly. LC means long chain and CLA means Conjugated linoleic Acids

Rearing conditions (indoor/outdoor): Compared to the anatomical location of cuts, rearing conditions had a general low effect on fatty acid content of meat because rearing conditions had a non significant effect on lipid content of cuts excepted for PUFA contents in n-3 and n-6 series which were strongly related to rearing conditions. Meats from lambs reared outdoors on pasture showed a higher content in n-3 PUFA and a lower content in n-6 PUFA. This was a direct consequence of the high content in 18:3 n-3 of grass compared to cereals rich in 18:2 n-6. The balance in both PUFA series was marked for LC PUFA. Thus, outdoor lambs had their meats higher in LC PUFA of n-3 series while their content in LC n-6 PUFA was very low. In contrast, meat from indoor lambs were richer in LC PUFA of n-6 series than in LC PUFA of n-3 series. Such specificities would explain the similar PUFA/SFA ratio in both lamb groups while the n-6/n-3 ratio was far higher in indoor lambs than in outdoor lambs. If trans FA contents were similar in meats

of both lamb groups, meats from outdoor lambs were poor in CLA compared to that from indoor lambs having a significant CLA content.

Nutritional value of lamb meats: Nutritional interest of lamb meat was evaluated by comparing the amount of a given nutrient provided by a portion of 100g meat and the recommended daily requirement (RDR) for this nutrient for a given group of French population. According to the RDR of adult men and women, a portion of 100g of meat lamb covered 10 to 20% of RDR for iron, zinc, selenium and B_6 vitamin. It largely contributed to RDR for B_3 (40%) and was a source of B_{12} (100 to 200% RDR) and A vitamin (liver only). Lamb meat was an interesting source of LC PUFA of both n-6 and n-3 series. To this respect, meat from outdoor lambs offered a better equilibrium between n-6 and n-3 PUFA than meat from indoor lambs. Interestingly, lamb meat as the other meats was a good source of proteins very digestible and well equilibrated in amino acids for human needs and not a fatty food if you take care to remove visible fat from your meat portion.

Conclusions

Meat from lambs is a source of proteins, B_{12} vitamin and long chain PUFA. It supplies a significant amount of iron, selenium, zinc and B_3 and B_6 vitamins. Its nutritional value depends on rearing systems. Lambs reared outdoor on pasture has a meat with a higher LC PUFA of n-3 series and a lower contents in selenium and B_{12} vitamins than that of lambs reared indoor fed with hay and cereals.

References

Association Française de Normalisation (AFNOR) Recueil des normes françaises.
Bartlett G.R. 1959. Journal of Biological Chemistry, 234, 466-468.
Badiani A., Nanni N., Gatta P.P., Tolomelli B., Manfredini M. 1998. Food Chemistry, 61, 89-100.
Bauchart D., Chantelot F., Gandemer G. 2008. Cahiers Nutrition Diététique, 43, 1S29-1S39.
Cassens B, and Cooper C.C. 1971. Advances in Food Research, 19, 1-74.
Dallongeville J., Gruson E., Dauchet L., 2008. Cahiers Nutrition Diététique, 2008. 43, 1S52-1S57.
Ducros V. Favier A. 1992. Journal of Chromatography, 583, 35-44.
Folch J., Lees M., Sloane-Standley G. H. 1957. Journal of Biological Chemistry, 226, 497-509.
Gandemer G. 1990. Revue Française des Corps Gras, 37, 75-81.
Hornsey C. 1956. Journal of Food Science and Agriculture, 7, 534-540.
Leseigneur-Meynier C., Gandemer G. 1991. Meat Science, 29, 229-241.
Morrison W. R., Smith L. M. (1964). Journal Lipid Research, 5, 600-608.
Ndaw S, Bergaentzlé M., Aoute-Werner D., Hasselmann C. 2000. Food Chemistry, 71, 129-138.
Ndaw S, Bergaentzlé M., Aoute-Werner D., Hasselmann C. 2002. Food Chemistry, 78, 129-134.
Ortigues-Marty I., Micol D., Prache S., Dozias D., Girard C.L. 2005. Reproduction Nutrition Development 45, 453-467.
Pierre F., Santarelli R., Corpet, D. 2008. Cahiers Nutrition Diététique, 43, 1S61-1S65.
Sébédio J.L., Juaneda P., Dobson G., Ramilison J., Martin J.D., Chardigny J.M., Christie W.W. 1997. Biochimica, Biophysica Acta, 1345, 5-10.