Animal Science Papers and Reports vol. 23 (2005) no. 4, 261-267
Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Presented at the Conference
„Improving the quality of meat for the consumer"
held at the „ANIMBIOGEN" Centre of Excellence
in Genomics and Biotechnology Improving Functional
Traits in Farm Animals and Quality of their Products,
11 April 2005, Jastrzębiec, Poland

Factors affecting fatty acid composition and dietetic value of beef*

L. Bartoň, V. Kudrna, D. Bureš, M. Krejčová, R. Zahrádková

Research Institute of Animal Production in Prague-Uhříněves, Czech Republic

Charolaise bulls and heifers showed higher SFA and lower MUFA content of *longissimus thoracis* muscle (MLT) than did the Aberdeen-Angus, Simmental and Hereford cattle, with no reference to feeding. It can be assumed that this difference is due to the reduced activity of Δ^9 desaturase in Charolaises. Fatty acid composition of MLT was significantly modified by feeding diets rich in n-3 and n-6 PUFAs. Both linseed and sunflower supplementation increased the proportion of CLA. In addition, inclusion of linseed enhanced the proportion of long chain PUFA n-3 (EPA, DPA, DHA) and reduced PUFA n-6 to PUFA n-3 ratio, important for human health.

KEY WORDS: beef / cattle / dietetic value / fatty acids / *longissimus thoracis* / muscle

Since 1990 the *per capita* consumption of red meat and poultry meat in the Czech Republic (CR) has declined by 16% (96.5 kg in 1990 *vs* 80.6 kg in 2003). However, since 1995 the consumption remains stable and amounts to about 80 kg meat *per capita* per year [Czech Statistical Office 2004]. Simultaneously, the share of poultry meat

*Supported by the project MZE 0002701403.

Fig. 1. Type of meat consumed in the Czech Republic in 1990 and 2003.

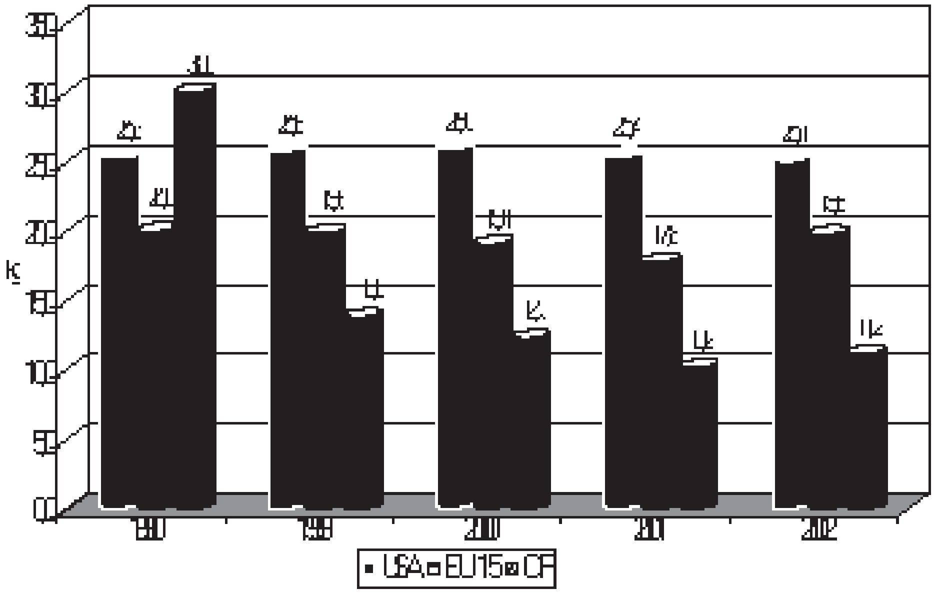

Fig. 2. The *per capita* beef consumption in the Czech Republic compared to that in the United States and EU-15 in the period from 1990 to 2002.

consumed increased, while that of beef decreased (Fig. 1).

Figure 2 illustrates the *per capita* beef consumption in CR compared to that in the US and EU-15. While in 1990 the beef consumption in the CR was approximately 30 kg/year, in 2002 it was only about 11 kg which is a significant reduction. No such tendency could be observed in the US and EU-15. In 2001 there was a temporary impact of the BSE crisis on beef consumption both in EU-15 and CR.

What are the reasons of such a considerable drop in beef consumption in the CR? Firstly, it is a strong competition coming from white meats – mostly from chicken and partially turkey meat. Both are cheaper than beef and are believed to be healthier. This is the area in which cattle will probably never be able to compete with chicken. The second reason might be the variable sensory properties of the marketed beef. From the sensory point of view, consumers' preferences for meat are affected by its appearance, tenderness, flavour, and juiciness [Resurreccion 2003]. However, eating quality of beef in the CR could not always be guaranteed. Lastly this has improved significantly and the buyers are through the labelling system obligatorily providing basic information about the meat they purchase. There still is a space for further education of consumers. For instance, very few of them are aware of the ageing processes of beef. In the CR as well as in other countries, the media have given a lot of publicity to BSE, foot and mouth disease, chemical residues recorded in meat and other similar events. It has inevitably resulted in a reduced confidence of consumers in safety of beef and meat in general and also contributed to a decreased consumption.

Beef is sometimes negatively perceived by consumers because of factors given below and related to human health.

1. Beef is a source of fat. Fat is generally rich in energy and the excessive intake of energy is one of main factors causing obesity, which nowadays represents a serious problem for human population. On the other hand, fat content of beef muscle is rather low, mostly well below 5%, and beef muscle can be classified as low-fat food. Of course, some intermuscular and subcutaneous fat is also consumed, but both are usually very closely trimmed from muscle before cooking. Beef is estimated to supply only about 5% of the total fat intake [Demeyer and Doreau 1999].
2. Beef is a source of saturated fat. Saturated fatty acids (SFAs), and particularly myristic and palmitic acids and *trans* fatty acids are known to increase blood cholesterol and contribute to the increased risk of coronary heart disease. That is why only about 10% of dietary energy originating from SFAs is recommended for humans. The content of SFAs of beef and lamb meat is quite high (almost 50% of total FAs), as compared to pork, rabbit and chicken meat. Therefore, many scientists all over the world, search for methods enabling to alter, at least partially, the composition of fatty acids in beef, particularly in favour of omega-3 polyunsaturated fatty acids (PUFAs) and simultaneous reduction in the content of SFAs.
3. Increased fat intake and meat consumption are often considered as related to cancer and particularly colon cancer. This association is quite important in the case of CR as in a number of regions of this country (and also in Hungary) the colon cancer mortality is reported to be twice as high as the mean given for EU-25 [Statistical Office of the European Communities 2004]. On the other hand, recent studies revealed no strong evidence of the association between fat and meat consumption and cancer [Baghurst 2004]. It is more likely that another factors like methods of meat cooking, alcohol consumption, smoking, *etc*., are responsible for colon cancer incidence. On the contrary, the meat of ruminants

> contains conjugated linoleic acid (CLA) which is frequently associated with a number of beneficial effects on health, e.g. prevention and inhibition of carcinogenesis, protection against atherosclerosis, *etc*.

As already mentioned, the importance of fatty acid (FA) composition of meat is growing due to the increasing awareness of consumers of the association between fat intake and the incidence of various health problems. Meat FA composition is affected by a number of genetic and environmental factors like species, breed, age, sex, anatomic location of muscle, content of intramuscular fat, feeding, *etc*. The objective of the present study was to determine breed and dietary effects on FA composition of *M. longissimus thoracis* (MLT) in cattle.

Material and methods

Three experiments were conducted. In experiment 1 (EXP 1) compared were four beef breeds – Aberdeen Angus (AA), Charolaise (Ch), Simmental (S) and Hereford (H). A total of 44 bulls were included, all fed a common diet throughout the trial. Only breed effects were estimated.

In experiment 2 (EXP 2) used were 46 purebred Ch and Limousine (L) heifers fed two different diets with similar protein and energy content. The experimental diet was supplemented with linseed as a source of linolenic acid. Breed and diet effects were thus estimated simultaneously.

In experiment 3 (EXP 3) the FA composition was determined in MLT from 46 Ch and S bulls fed two isonitrogenous and isocaloric diets with different sources of dietary fat – whole sunflower seed as a source of polyunsaturated linoleic acid and Megalac rich in saturated palmitic acid.

To determine the FA composition standard procedures were used (detailed description is available from the authors). Results are presented as fatty acid profile, *i.e*. per cent share of a particular FA in a total FAs in triacylglycerol and phospholipid fractions together. All the important FAs were determined. Calculated were totals of SFAs, MUFAs, PUFAs and separately the sum of PUFA n-6 and PUFA n-3.

For statistical evaluation linear models were used with breed or breed and diet as fixed effects. Since for main FAs interactions breed × diet were not found significant, they were not included in the final model. Intramuscular fat content was included in the model as a covariate in EXP1. In remaining two experiments the intramuscular fat content was found similar in groups and therefore no linear regression was calculated. Statistical evaluations were performed using the GLM procedure of SAS [2001].

Results and discussion

Here only most important results are presented and discussed. In all three experiments some consistent differences were found between Ch cattle and cattle of remaining breeds, with no reference to diet and sex (Tab. 1). The sum of SFAs (myristic, palmitic and stearic acids) of MLT was always highest in Ch. In EXP 2 the difference between Ch and L heifers reached 5 per cent units. Clear differences between Ch and other cattle appeared also for the sum of myristoleic, palmitoleic and oleic acids (MUFAs) which appeared always lowest in Ch. It seems that there is a difference between Ch and the other breeds in the activity of Δ^9-desaturase (16, 18) converting palmitic and stearic acids to their corresponding MUFA n-9. Differences in FA composition of intramuscular fat between early and late maturing cattle breeds were also reported by Siebert *et al*. [1996], while Laborde *et al*. [2001] found that the activity of Δ^9-desaturase in the conversion of palmitic to palmitoleic acid was greater in total lipids from Simmental than from Red Angus cattle.

The results of EXP 2 in which linseed supplement was used are summarized in Table 2. Feeding of both experimental and control diet lasted 245 days. No significant

Table 1. Fatty acid composition of *m. longissimus thoracis* (MLT) in cattle of different breeds

Acids	EXP 1 – bulls					EXP 2 – heifers			EXP 3 – bulls		
	AA	Ch	S	H	P	L	Ch	P	S	Ch	P
SFAs	51.4^{a}	53.3^{a}	48.9^{b}	50.7^{a}	***	46.5	51.0	***	49.9	52.8	***
MUFAs	38.7^{ab}	35.7^{a}	40.0^{b}	39.8^{b}	**	43.8	40.5	***	38.7	36.1	***
PUFAs	7.4	83	8.7	7.2	ns	6.8	5.6	*	91	8.7	ns
PUFAs-n6	6.0	7.4	7.7	6.1	ns	5.2	4.0	**	7.7	73	ns
PUFAs-n3	1.4^{a}	1.0^{ab}	11^{ab}	1.1^{b}	**	13	1.2	NS	1.1	11	ns

*P<0.05; **P<0.01; ***P<0.001; ns – not significant.
^{ab}Within rows means bearing different superscripts differ significantly at P<0.05.
AA – Aberdeen Angus.
Ch – Charolaise.
S – Simmental.
H – Hereford.

differences in live weight gain, feed efficiency and carcass composition were identified between the two feeding groups. Also similar was intramuscular fat content in linseed and control group (24 *vs* 28 g/kg muscle, respectively). As expected, feeding linseed as a rich source of linolenic acid (LNA) significantly (P<0.001) increased the deposition of the acid in MLT. It is evident that some part of dietary LNA escaped the process of biohydrogenation in the rumen of heifers and was deposited in tissues. However, the differences were considerably smaller than those observed in experiments with dietary linseed protected against the rumen biohydrogenation [Scollan *et al*. 2003]. A clear relationship was also found between feeding linseed and the proportion of conjugated linoleic acid (CLA) as a sum of its different isomers. CLA was significantly (P<0.001) increased in MLT of the linseed-fed heifers partially due to its ruminal production during the process of biohydrogenation, but there is a strong evidence that the substantial part of CLA is also produced endogenously in adipose tissue by desaturation of *trans* vaccenic acid (Raes *et al*. 2004). Recently, increasing attention is paid to the long-chain n-3 polyunsaturated fatty acids – EPA, DPA and DHA - which show a wide range of

Table 2. Fatty acid composition (%) of *m. longissimus thoracis* (MLT) as affected by different diets

Acids	EXP 2 – heifers			EXP3 – bulls		
	linseed	control	P	sunflower	control	P
LA	3.59	3.25	ns	6.73	5.47	**
LNA	0.79	0.38	***	0.51	0.55	ns
EPA	0.22	0.14	***	0.15	0.14	ns
DPA	0.47	0.35	*	0.35	0.38	ns
DHA	0.047	0.035	*	0.025	0.026	ns
CLA	0.49	0.38	***	0.323	0.243	**
SFAs	48.5	49.1	ns	50.7	51.9	ns
MUFAs	42.0	42.3	ns	37.4	37.5	ns
PUFAs	6.7	5.7	ns	9.6	8.2	*
PUFAs-n6	4.7	4.5	ns	8.2	6.8	*
PUFAs-n3	1.5	0.9	***	1.0	1.1	*

*P≤0.05; **P≤0.01; ***P≤0.001; ns – not significant.
LA – linoleic acid (C18:2n-6).
LNA – linolenic acid (C18:3n-3).
EPA – eicosapentaenoic acid (C20:5n-3).
DPA – docosapentaenoic acid (C22:5n-3).
DHA – docosahexaenoic acid (C22:6n-3).
CLA – conjugated linoleic acid (EXP 2: sum of isomers, EXP 3-c9t11 CLA).
SFAs – C14:0 + C16:0 + C18:0.
MUFAs – C14:1 + C16:1 + C18:1.
PUFAs n-6 – C18:2n-6 + C18:3n-6 + C20:2n-6 + C20:3n-6 + C20:4n-6.
PUFAs n-3 – C18:3n3 + C20:5n3 + C22:5n3 + C22:6n3.

beneficial effects on human health. Feeding linseed resulted in increasing proportions of all the three acids mentioned. It is rather surprising that in another trial [Scollan *et al*. 2001] dietary linseed failed to increase DHA levels.. The ratio of PUFA n-6 to PUFA n-3 is often used to indicate the relative atherosclerotic activity of fatty acids. In this study the sum of PUFA n-3 was significantly increased in the linseed group and this resulted in a decreased PUFA n-6 to PUFA n-3 ratio.

In EXP 3 the experimental diet was supplemented with whole sunflower as a source of linoleic acid (LA). Feeding sunflower increased the proportion of LA in MLT of bulls (Tab. 2). It can be assumed that the high LA concentration in the rumen inhibited partially its biohydrogentation and resulted in its higher deposition in muscle. The proportion of c9t11 CLA was also increased by the sunflower-supplemented diet corroborating the results of Noci *et al*. [2005] who concluded that high proportion of dietary LA is effective for CLA enhancement in intramuscular fat.

REFERENCES

1. BAGHURST K., 2004 – Dietary fats, marbling and human health. ***Australian Journal of Experimental Agriculture*** 44, 635-644.

2. Czech Statistical Office, 2004 – Available: http://www.czso.cz/csu/edicniplan.nsf/publ/3004-04-v_roce_2003
3. DEMEYER D., DOREAU M., 1999 – Targets and procedures for altering ruminant meat and milk lipids. ***Proceedings of the Nutrition Society*** 58, 593-607.
4. LABORDE F.L., MANDELL I.B., TOSH J.J., WILTON J.W., BUCHANAN-SMITH J.G., 2001 – Breed effects on growth performance, carcass characteristics, fatty acid composition, and palatability attributes in finishing fteers. ***Journal of Animal Science*** 79, 355-365.
5. NOCI F., O'KIELY P., MONAHAN F. J., STANTON C., MOLONEY A.P., 2005 – Conjugated linoleic acid concentration in M. Longissimus dorsi from heifers offered sunflower oil-based concentrates and conserved forages. ***Meat Science*** 69, 509-518.
6. RAES K., FIEVEZ V., CHOW T.T., ANSORENA D., DEMEYER D., DE SMET S., 2004 – Effect of diet and dietary fatty acids on the transformation and incorporation of C18 fatty acids in double-muscled Belgian Blue young bulls. ***Journal of Agricultural and Food Chemistry*** 52, 6035-6041.
7. RESURRECCION A.V.A., 2004 – Sensory aspects of consumer choices for meat and meat products. ***Meat Science*** 66, 11-20.
8. SAS Institute Inc., 2001 – Release 8.2 (TS2MO) of the SAS System for Microsoft Windows. SAS Institute Inc, Cary, NC, USA.
9. SCOLLAN N.D., ENSER M., GULATI S. K., RICHARDSON I., WOOD J.D., 2003 – Effects of including a ruminally protected lipid supplement in the diet on the fatty acid composition of beef muscle***. British Journal of Nutrition*** 90, 709-716.
10. Statistical Office of the European Communities, Eurostat yearbook 2004 – Available: http://epp.eurostat.cec.eu.int/portal/page?_pageid=1334,1457106,1334_1457111&_dad=portal&_ schema=PORTAL.
11. SIEBERT B.D., DELAND M.P., PITCHFORD W.S., 1996 – Breed differences in the fatty acid composition of subcutaneous and intramuscular lipid of early and late maturing, grain-finished cattle***. Australian Journal of Agricultural Research*** 47, 943-952.