EFFECTS OF BREED, HALOTHANE GENOTYPE AND SEX ON THE LIPID COMPOSITION OF TWO SKELETAL MUSCLES AND ADIPOSE TISSUE IN SWINE

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SUMMARY

Fatty acids are structural as well as functional parts of cell membranes. In meat and meat products, they represent important nutritional components, which are known to influences nutritionaly oriented diseases, e.g. arteriosclerosis, adiposity or colon cancer. 35 pigs of two different breeds (German Landrace = DL, Pietrain = PI), two genotypes (halothane negative = H^-; halothane positive = h^+) and different sex were fed a standard diet ad libitum. After reaching a body weight of approximately 100 kg, animals were slaughtered, muscle samples (musc. long. thoracis = m.l.t., musculus supraspinatus = m.sp.) and adipose tissues (backfat = BF, intermuscular adipose tissue = IAT) were removed and lipids extracted. Fatty acids were determined by gas chromatography.

Total lipid content was mainly affected by breed and halothane genotype, where the h^+ pigs showed significantly lower total lipid contents. Relative amounts of saturated fatty acids (SFA) in all tissues examined were significantly higher in DL animals, whereas, except for IAT, the monoenic fatty acids were significantly reduced. In general, H^- animals have significantly higher relative amounts of SFA and lower relative amounts of PUFA compared to the h^+ animals. Female pigs showed relatively higher amounts of PUFA throughout all tissues.

INTRODUCTION

The nutritional value of meat and meat products depends strongly on lipid content and lipid composition. For human diets a well balanced relation between saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA) is recommended (HORROBIN, 1983; BEARE-ROGERS, 1989). These recommendations have also strong influences on the qualitative considerations of meat products. In general, fat derived from slaughter animals is low in polyunsaturated fatty acids and therefore considered as less desireable in human diets. Anyway, the lipid composition of animal tissues is also an important factor in meat processing, e.g. in fermented dry sausage production a high amount of saturated fatty acids is desired.

In the living animal, the lipid composition of different tissues gives also information on the composition of membranal systems (SEEWALD, 1991). Polyunsaturated fatty acids are known to be integral components of membranal phospholipids, their type and distribution presumably affects different membrane functions. It was the aim of this study to investigate the influence of breed, halothane genotype and sex on the fatty acid pattern in two muscles and two types of adipose tissue in swine.

MATERIALS AND METHODS

17 German Landrace pigs (DL) and 18 Pietrain pigs (PI) were obtained from different breeding schemes, whereas half of each breed group was tested to be halothane positive (h^+) and half was halothane negative (H^-). 23 animals were castrated male and 12 were female. Animals were fed with no restriction standard diet. After reaching an average body weight of approximately 100 kg, animals were slaughtered and muscle samples (musc. long. thoracicus, musc. supraspinatus) and adipose tissues (backfat, intermuscular adipose tissue) were removed, lipids were extracted with chloroform and methanol (HALLERMAYER, 1976). 29 fatty acids were determined by gas chromatography as fatty acid methyl esters after transesterification with sodium methylate (SHEHATA, 1970). Single fatty acids were calculated as percentage of all detected fatty acids and further subsummarized into main fatty acid groups. Data were analysed and statistical significance was determined by ANOVA.

RESULTS AND DISCUSSION

The total lipid content in all examined tissues was mainly affected by genotype. The H^- animals showed significantly higher total lipid contents. The influence of the breeds was not as uniform, whereas PI, showed in the muscles higher, and in both

adipose tissues lower total lipid contents. Sex did not significantly influence the total lipid content (Tab.1 - 4).

The relationship between total lipid content and the fatty acid patterns was examined by regression analysis. In gene an increase in total lipid contents is accompanied by a significant decrease of the relative amounts of PUFA. This situation caused a decrease of the PSQ values (PSQ = PUFA/SFA). A possible explication is the lower density of membranes with increasing amounts of fat deposits. The relations of the total lipid content and saturated fatty acids (SFA) and monoenic fatty acids (MFA) are different. Total lipid content in muscle is positively correlated with the relative amount of monoenic fatty acids (MFA), but in adipose tissue the total lipid content is positively correlated with the relative amount of saturated fatty acids (SFA).

DL pigs showed in all tissues significantly higher amounts of SFA and lower contents of MFA compared to the Pietrain animals, except for the intermuscular adipose tissue. In intermuscular adipose tissue of the PI animals, saturated fatty acids (SFA) were exchanged for PUFA, resulting in significant higher PSQ values (Tab.3).

With few exceptions, in our experiment the halothane positive animals showed lower relative amounts of saturated fatty acids (SFA) and higher amounts of polyunsaturated fatty acids (PUFA) compared to the more stressresistant H^- animals. These results were also in accordance with data published by HONKAVAARA (1989). A further result is the elevated PSQ in all tissues of h^+ animals. This effect was mainly caused by significantly higher amounts of n-6 fatty acids. Genotype had no effect on the relative amounts of monoenic fatty acids (MFA).

Female animals showed reduced relative amounts of saturated fatty acids (SFA) in all examined tissues. In intermuscular adipose tissue (IAT) and musc. long. thoracis the polyunsaturated fatty acids (PUFA) were significantly higher in female than in castrated male animals.

CONCLUSIONS

Our results indicate, that the fatty acid patterns in muscle and adipose tissue are affected by breed, halothane genotype and sex. Halothane genotype and sex predominantly influences the relative amounts of polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA), whereas the relations between monoenic and saturated fatty acids were influenced by breed. The shifts in fatty acid profiles may be indicative for a genetic alteration of the lipid metabolism. There is plain evidence, that the fat content and the fatty acid pattern of porcine tissues can be largely influenced by genetic means. However, limits have to be considered due to strong relationships between lipid metabolism and genetically limited stress susceptibility.

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Tab. 1: Total lipid content (%), relative amounts of fatty acid classes (PUFA, SFA, MFA) and the ratio of SFA and PUFA (=PSQ) for two breeds (German Landrace = DL, Pietrain = PI), two halothane genotypes (halothane negative = h^+, halothane positive = H^-) and different sex in musc. longissimus thoracis.

musc. long. thoracis			total lipid	n-3 FA	n-6 FA	PUFA	SFA	MFA	PSQ
breed	DL	LSM	1.56	2.59	16.32	18.92	37.09	43.99	0.518
	n = 17	SE	0.07	0.14	0.58	0.70	0.43	0.64	0.0221
	PI	LSM	1.77	2.76	16.84	19.60	33.96	46.43	0.582
	n = 17	SE	0.08	0.15	0.60	0.72	0.44	0.65	0.0228
	significance		n.s.	n.s.	n.s.	n.s.	***	*	n.s.
genotype	H-	LSM	1.87	2.38	15.33	17.71	36.42	45.87	0.492
	n = 18	SE	0.07	0.16	0.61	0.73	0.45	0.66	0.0233
	h+	LSM	1.46	2.97	17.84	20.81	34.63	44.55	0.608
	n = 16	SE	0.08	0.19	0.73	0.87	0.53	0.79	0.0277
	significance		**	n.s.	*	*	*	n.s.	*
sex	c. male	LSM	1.77	2.43	15.08	17.51	36.51	45.98	0.481
	n = 22	SE	0.07	0.13	0.51	0.61	0.37	0.55	0.0193
	female	LSM	1.56	2.92	18.08	21.02	34.54	44.44	0.619
	n = 12	SE	0.10	0.19	0.51	0.89	0.55	0.81	0.0284
	significance		n.s.	n.s.	**	*	*	n.s.	**
coefficient of regression (b) on total lipid content			-127.40 ***	-926.21 ***	-1054.62 ***	29.92	1027.70 ***	-0.303 ***	

LSM = least square means
SE = standard error
* = $p < 0.05$

PUFA = polyunsaturated fatty acids SFA = saturated fatty acids
MFA = monoenic fatty acids PSQ = SFA / PUFA
** = $p < 0.01$ *** = $p < 0.001$

Tab. 2: Total lipid content (%), relative amounts of fatty acid classes (PUFA, SFA, MFA) and the ratio of SFA and PUFA (=PSQ) for two breeds (German Landrace = DL, Pietrain = PI), two halothane genotypes (halothane negative = h^+, halothane positive = H^-) and different sex in musc. supraspinatus.

musc. supraspinatus			total lipid	n-3 FA	n-6 FA	PUFA	SFA	MFA	PSQ
breed	DL	LSM	3.15	1.64	10.96	12.61	37.00	50.40	0.345
	n = 17	SE	0.34	0.11	0.38	0.48	0.42	0.53	0.0148
	PI	LSM	4.39	1.70	11.57	13.27	33.82	52.91	0.393
	n = 17	SE	0.36	0.11	0.38	0.47	0.43	0.53	0.0149
	significance		*	n.s.	n.s.	n.s.	***	**	n.s.
genotype	H-	LSM	4.48	1.56	10.59	12.15	36.64	51.21	0.335
	n = 18	SE	0.33	0.10	0.36	0.44	0.40	0.50	0.0141
	h+	LSM	3.06	1.78	11.95	13.72	34.18	52.10	0.403
	n = 16	SE	0.37	0.12	0.42	0.52	0.47	0.58	0.0164
	significance		**	n.s.	*	n.s.	**	n.s.	*
sex	c. male	LSM	3.96	1.65	10.76	12.41	35.69	51.89	0.352
	n = 22	SE	0.30	0.08	0.30	0.37	0.34	0.42	0.0119
	femal	LSM	3.58	1.69	11.78	13.46	35.12	51.89	0.386
	n = 12	SE	0.44	0.12	0.45	0.55	0.50	0.62	0.0176
	significance		n.s	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
coefficient of regression (b) on total lipid content			- 13.20 **	- 89.94 ***	- 103.13 ***	0.31	102.83 ***	- 0.0296 ***	

LSM = least square means
SE = standard errors
* = $p < 0.05$

PUFA = polyunsaturated fatty acids SFA = saturated fatty acids
MFA = monoenic fatty acids PSQ = PUFA / SFA
** = $p < 0.01$ *** = $p < 0.001$

Tab. 3: Total lipid content (%), relative amounts of fatty acid classes (PUFA, SFA, MFA) and ratio of SFA and PUFA (=PSQ) for two breeds (German Landrace = DL, Pietrain = PI), two halothane genotypes (halothane negative = h^+, halothane positive = H^-) and different sex in intermuscular adipose tissue.

intermuscular adipose tissue			total lipid	n-3 FA	n-6 FA	PUFA	SFA	MFA	PSQ
breed	DL	LSM	67.74	1.42	8.48	9.90	40.66	49,44	0.250
	n = 17	SE	1.33	0.07	0.38	0.43	0.32	0.50	0.020
	PI	LSM	65.20	1.74	11.37	13.11	37.74	49.15	0.350
	n = 17	SE	1.43	0.07	0.42	0.49	0.36	0.57	0.030
	significance		n.s.	**	***	***	***	n.s.	***
genotype	H-	LSM	68.76	1.47	8.82	10.29	40.68	49.08	0.260
	n = 18	SE	1.30	0.07	0.38	0.44	0.30	0.48	0.020
	h+	LSM	64.18	1.70	11.02	12.72	37.77	49.51	0.340
	n = 16	SE	1.46	0.08	0.46	0.53	0.39	0.61	0.040
	significance		*	n.s.	**	**	***	n.s.	***
sex	c. male	LSM	67.94	1.44	8.71	10.15	40.01	49.84	0.260
	n = 22	SE	1.19	0.06	0.35	0.41	0.30	0.47	0.011
	female	LSM	65.01	1.72	11.14	12.86	38.37	48.75	0.340
	n = 12	SE	1.74	0.09	0.51	0.59	0.44	0.68	0.016
	significance		n.s.	*	**	**	*	n.s.	*
coefficient of regression (b) on total lipid content				- 2.71 ***	- 23.75 ***	- 26.46 ***	19.40 ***	7.06	- 0.005 ***

LSM = least square means
SE = standard errors
* = $p < 0.05$
PUFA = polyunsaturated fatty acids
MFA = monoenic fatty acids
** = $p < 0.01$
SFA = saturated fatty acids
PSQ = PUFA / SFA
*** = $p < 0.001$

Tab. 4: Total lipid content (%), relative amounts of fatty acid classes (PUFA, SFA, MFA) and ratio of SFA and PUFA (=PSQ) for two breeds (German Landrace = DL, Pietrain = PI), two halothane genotypes (halothane negative = h^+, halothane positive = H^-) and different sex in backfat.

backfat			total lipid	n-3 FA	n-6 FA	PUFA	SFA	MFA	PSQ
breed	DL	LSM	83.77	1.84	10.80	12.63	40.05	47.33	0.320
	n = 17	SE	1.30	0.05	0.35	0.37	0.42	0.36	0.012
	PI	LSM	76.83	1.59	11.40	12.98	36.90	50.11	0.357
	n = 17	SE	1.40	0.06	0.42	0.43	0.50	0.43	0.015
	significance		**	*	n.s.	n.s.	***	***	n.s.
genotype	H-	LSM	82.60	1.68	10.70	12.38	39.34	48.27	0.320
	n = 18	SE	1.28	0.05	0.32	0.33	0.38	0.33	0.011
	h+	LSM	78.01	1.74	11.49	13.23	37.59	49.17	0.358
	n = 16	SE	1.49	0.06	0.39	0.40	0.46	0.40	0.014
	significance		*	n.s.	n.s.	n.s.	*	n.s.	n.s.
sex	c. male	LSM	82.29	1.82	10.37	12.19	39.30	48.50	0.314
	n = 22	SE	1.22	0.05	0.30	0.31	0.36	0.31	0.011
	female	LSM	78.31	1.61	11.81	13.42	37.63	48.95	0.364
	n = 12	SE	1.78	0.07	0.44	0.46	0.53	0.45	0.016
	significance		n.s.	*	*	n.s.	*	n.s.	*
coefficient of regression (b) on total lipid content				- 3.44 ***	- 31.46 ***	- 34.91 ***	29.07 ***	5.84	- 0.010 ***

LSM = least square means
SE = standard errors
* = $p < 0.05$
PUFA = polyunsaturated fatty acids
MFA = monoenic fatty acids
** = $p < 0.01$
SFA = saturated fatty acids
PSQ = PUFA / SFA
*** = $p < 0.001$