FATTTY ACID DISTRIBUTION IN PIG FAT AND SAUSAGE IN A MONITORING AND IMPROVEMENT BY FEEDING RAPESEED PRESS CAKE IN PIGS

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Abstract – In Germany, fat from meat products, mainly sausage, represents a big part of the total fat consumption and therefore information on fat composition is needed. Fatty acid distribution was investigated in backfat of a total of 70 pig carcasses, from fattening pigs *vs.* breeding sows, and in fat from 46 sausages, specified into Salami-type, Bologna-type and cooked sausages. Fattening pigs` backfat represented a higher percentage of SFA and a lower percentage of PUFA (41 and 11-14%) than sows` backfat (35 and 21%). At similar composition of the fat in the three studied sausage groups, the sausage fat agreed also with that of the backfat in less meaty fattening pigs. The present results correspond to the few data of the food tables, with exception of overestimated alpha-linolenic acid (ALA), an omega 3 PUFA, in these tables. Rapeseed press cake (RPC) has a high content of oil representing much of MUFA and relatively low and moderate percentages of linoleic acid (LA) and ALA. In pig feeding trials RPC increased the PUFA in backfat moderately with improvement of LA:ALA relation and this could be a challenge to improve the pig fat from a nutritional point of view.

I. INTRODUCTION

In Germany, fat from meat products, mainly sausage, represents roughly a quarter of the total fat consumption (1). In nutrition, fat quality means fatty acid (FA) distribution and a possibly high percentage of the polyunsaturated fatty acids (PUFA), particularly, these of the omega-3-type (also n-3-type). In addition, the monounsaturated fatty acids (MUFA) are favourable from nutritional point of view. Regarding the technological quality, the PUFA do not seem desirable because they accelerate fat oxidation and impair the storability of certain meat products, e.g. dry-cured salami and ham.

Objectives of the present study were to compare FA distribution of backfat from pig carcasses with fat from sausages of a typical German assortment. Carcasses should be specified according to category (fattening pigs) and sows, in addition, the fattening pigs to the carcass grade in the EUROP grading system, whereby grade E corresponds to *very meaty*, grade P to *very fat*. The sausage fat should be compared with the food tables (2) and recommendations of Societies of Nutrition Germany, Austria, Switzerland, DACH (3). On the other side, the findings should be discussed in relation to the results of German pig feeding experiments with application of the nutritionally favourable rapeseed oil (RO) via rapeseed press cake (RPC).

II. MATERIALS AND METHODS

The 50-100 g backfat samples originated from a total of 70 pigs taken from the left carcass half at the last rib level. The 4 pig groups slaughtered in the abattoirs Jena and Altenburg represented 8 breeding sows (*Deutsches Edelschwein*, *DE*, X *Landrace*, *LR*) 27 fattening pigs (22 grade E, 5 grade U), 21 fattening pigs from a quality programme for dry-cured hams (grade E) and 2 X 7 fattening pigs for comparison grade E und R, all fattening pig crossbreeds from *Pietrain X (DE X LR)*. Sausage fat samples originated from 23 Salami-type sausages, 9 Bologna-type sausages and 14 cooked sausages. The lipid fraction from backfat was won by microwave heating, from lyophilized finely ground sausage samples by extraction with 2:1 v/v hexane/acetone. After methylation with sodium methylate the FA were determined by gas liquid chromatography (Varian Star 3400 CX, Varian, Inc., 30 m fused silica capillary column BPX 70, temperature programme 130 to 240 °C, 3 °C per min, flame ionization detector). As standard a FA mix C 4-C 24 was used (Methylester: F.A.M.E. Mix, C4-C24 Unsaturates, 18919-1AMP, Sigma-Aldrich). The oxidation stabilität was measured by accelerated fat stability test in the Rancimat 743 (Metrohm AG, Filderstadt, Germany). Hereby, the induction time marks a plateau phase up to the onset of cleavage of the FA

into the sensorily active short chain compounds which characterize the fat deterioration. The data from the pig categories and sausage groups were subjected to ANOVA and Student-Newman-Keuls' test (SPSS Inc,Chicago, IL, USA).

III. RESULTS AND DISCUSSION

Fatty acids and stability of pig backfat

The backfat of sows contained about one sixth less SFA than that of fattening pigs (Table 1).

Table 1: Carcass weight, back fat thickness and selected fatty acids (FA), FA groups and induction time of the backfat in fattening pigs (n=27) and sows (n=8), mean ± SD. FA are related to totally detected FA. Except of MUFA and induction time significance of all differences (P<0,05).

	Fattening pigs preferably grade E	Sows
Carcass weight, kg	86,9 ± 6,3	163,8 ± 5,3
Back fat thickness, mm	13,5 ± 2,7	18,6 ± 8,0
Palmitic acid (16:0), %	24,8 ± 1,8	21,4 ± 1,3
Stearic acid (18:0), %	13,8 ± 1,9	11,4 ± 1,6
Oleic acid (18:1), %	40,5 ± 3,7	39,9 ± 2,1
Linoleic acid (18:2), %	11,6 ± 2,1	17,9 ± 2,0
alpha-linolenic acid (18:3), %	1,10 ± 0,23	1,56 ± 0,26
SFA, %	41,2 ± 3,3	34,8 ± 2,7
MUFA, %	44,0 ± 4,0	43,2 ± 2,4
PUFA, %	13,8 ± 2,4	21,3 ± 2,2
Relation n-6/n-3	11,1 ± 1,7	12,0 ± 1,2
Induction time, h	14,7 ± 4,5	13,0 ± 2,1

Abbreviations: SFA - saturated fatty acids, MUFA - monounsaturated FA, PUFA - polyunsaturated FA

At similar MUFA percentage in the fat of both pig categories, the sows showed a PUFA percentage by 1/3 higher than in fattening pigs. The ratio of linoleic acid, LA (the main representative of n-6 PUFA) to alpha linolenic acid, ALA (the main representative of n-3 PUFA) was roughly 10:1, which is far from 5:1 recommended for prevention of coronary heart disease by DACH (3).

The induction time of the sow backfat with higher PUFA level was numerically lower than in fattening pigs´ backfat. Backfat composition of 21 carcasses from the quality programme (only grade E) is not shown because it did not differ from the normal segment of fattening pigs (Table 1).

In the comparison of carcasses from pigs with different muscle/adipose tissue formation (Table 2) the more meaty pigs (grade E) had a lower SFA and higher PUFA percentage than the less meaty pigs (grade P). Leaner pigs synthesise less SFA, preferably 16:0 and 18:0, and also MUFA - the stearic acid (18:0) is desaturated to oleic acid (18:1) by Δ9 desaturase. SFA and MUFA created by *de novo* synthesis represent the body own fat part contrasting with the PUFA - indispensable, due to lacking synthesis capability of the organism and provided exogenously by the feed. Therefore body fat PUFA amount is fixed by the dietary

Table 2: Carcass weight, back fat thickness and selected fatty acids (FA)/ FA groups of the backfat in more or less meaty fattening pigs (FA related to totally detected FA, n=7, mean ± SD)

Grade in EUROP grading	Grade E	Grade R
Carcass weight, kg	89.8± 6.6	88,9± 0.9
Back fat thickness, mm	11.7*± 3.1	25,7± 3.4
Palmitic acid (16:0), %	24.4 ± 0.9	24.6 ± 1.0
Stearic acid (18:0), %	11.2± 0.6	12.3 ± 1.6
Oleic acid (18:1), %	42.3± 0.9	43.7 ± 1.7
Linoleic acid (18:2), %	11.8 ± 0.6	10.0*± 0.7
alpha-linolenic acid (18:3), %	1.23 ± 0.04	1.05*± 0.11
SFA, %	39.0± 0.9	40.1 ± 2.5
MUFA, %	46.6 ± 0.7	47.8 ± 2.0
PUFA, %	13.7 ± 0.7	11.6*± 0.8
Relation n-6/n-3	9.7± 0.6	9.6 ± 0.6
Induction time, h	13.2± 2.4	13.2 ± 2.2

*significant difference (P< 0,05)
For abbreviations see Table 1, footnote!

PUFA amount. However, in FA distribution PUFA percentage varies due to the level of body-own fat part, e.g. in less meaty pigs (carcass grade P) high *de novo* synthesis of SFA and MUFA means much of body fat which „dilutes" more the PUFA resulting in lower PUFA backfat percentage (4).

Fatty acids of the sausage fat

The fat of the three studied sausage groups (Salami-type, Bologna-type and cooked sausages) showed a similar composition (not shown).

The SFA, MUFA and PUFA percentages of sausage fat (Table 3) agreed with that of the backfat in fattening pigs with carcass grade P (Table 2). Indeed, for sausage less meaty pigs are preferred which explains the sausage PUFA percentage roughly by a quarter lower than in the backfat PUFA of more meaty pigs (grade E, Tables 1 and 2). The presented results correspond with the few data which are available in the food tables (2), with exception of the too high contents of ALA in the tables (Table 3).

Table 3: Selected fatty acids (FA) and FA groups in sausages bought in Thuringia - own results (mean ± SD) in comparison with German Food Tables (2). The investigated 23 Salami-type sausages, 9 Bologna-type sausages and 14 cooked sausages had mean fat contents of 32, 16 und 25 %.

	This study (n=46)	German Food Tables, range (n=9)
Palmitic acid (16:0), %	25.6 ± 0.9	23.8 - 25.6
Stearic acid (18:0), %	12.8 ± 1.0	12.6 - 13.6
Oleic acid (18:1), %	43.9 ± 1.4	43.8 – 46.9
Linoleic acid (18:2), %	9.0 ± 1.7	7.6 – 11.3
alpha-linolenic acid (18:3), %	0.70 ± 0.19	0.76 – 1.74
SFA, %	41.1 ± 1.8	38.5 - 45.2
MUFA, %	48.3 ± 1.7	46.4 – 49.5
PUFA, %	10.6 ± 2.0	8.3 - 12,2
Relation n-6/n-3	13.2 ± 2.5	6 - 10

For abbreviations see Table 1, footnote!

The induction time of the sausage fat ranged from a quarter of an hour up to just under an hour (not shown). In a former laboratory experiment with sausages produced only with salt and with curing salt, the nitrite variants showed a significant shorter induction time (5).

PUFA in pig backfat due to feeding rapeseed press cake (RPC)

In a monitoring of 23 RPC from 10 decentral Thuringian and Hessian oilmills a mean fat content of 142 g/kg dry matter was analysed (range 106 – 173 g/kg dry matter) compared with only a quarter of this fat content in *rapeseed meal, solvent extracted (RSM)* produced in larger oilmills (6).

In Germany, in the last decade, RPC was tested in three pig experiments (7, 8, 9). RPC is an excellent protein and lysine source and weight gains reached 760 (7), 870 (8) and 985 (9) g per day with good to excellent feed to gain ratios of 3.1 (7) and 2.8 (8, 9) kg feed per kg weight gain. RO has a high content of LA (18:2) – ca. 20% of total FA - and ALA – ca. 9% of total FA. The tested pig diets with at least 7.5 % RPC concentrated significantly the PUFA in the body fat (Tab. 4). There are differences in the RO effect on the backfat

Table 4: Polyunsaturated fatty acids (PUFA) in the backfat of pigs in three feeding trials with rapeseed press cake (RPC)

Ref. (pig number per group)	RPC % in the grower/finisher diet and rapeseed oil-equivalents g/kg feed	PUFA backfat %
Schöne et al.2002, n = 20	0% (control), 5 7.5%, 17 15%, 29	10.0[c] 12.1[b] 14.1[a]
Weber & Schöne 2007, n = 38	0% (control), 0[)] 5/7.5%, 5/8 7.5/12.5%,8/13	10.6[b] 10.7[b] 11.,8[a]
Berk 2008, n = 20	0/0% (control), 0[2)] 8/10%,11/14[2)]	12.1[b] 13.3[a]

[ab] Different indices in the same column segment characterize significant differences.

PUFA between the trials – each 10 g RO equivalents/kg feed increased backfat PUFA percentage by 1% in the two newer experiments (8, 9) and 2% in the former experiment (7). RPC and RO, respectively, improved the n-6 to n-3 PUFA ratio - from 8:1 (control) at 7:1 in ref. 7 and from 14:1 (control) at 10:1 in ref. 8 (in ref. 9 n-6 and n-3 PUFA are not given separately).

As previously mentioned, a fat with higher PUFA percentage is nutritionally-physiologically favourable, but not so oxidation stable and storable. (This statement should not be questioned by the less sensitive induction time in the comparison of backfat from fattening pigs *vs.* sows, highly different in PUFA.) However, the German meat product consumption of 30 kg per capita and year (10) is dominated by Bologna-type and cooked sausages and boiled ham with their short shelf life, chilled, in the range of less than one week up to 2 weeks. In general, these freshly consumed meat products and also a big part of raw sausage and ham – soft, because not or fast ripening – are not subject to a risk of fat deterioration. Fat oxidation would start only

after microbial induced rapid spoilage, this would mean and not relevant for quality, several weeks after the shelf life date. Therefore, pig fattening for the typical German sausage assortment with short shelf life should focus on optimization for human nutrition. The production of longer storable meat products, e.g. dry-cured salami, or ham, which requires a harder pig fat, should be considered in special quality programmes. Here, an upper PUFA content in backfat could be set at 15%. In pig diets, a grain and grain by-products´ part of more than two third creates a basic PUFA level via the grain fat from 7 to 15 g PUFA/kg diet resulting in a baseline for backfat PUFA of 8-11%, without plant oil addition to the diet. Therefore, in the mentioned quality programmes a level of 20 g RO equivalents/kg diet should not be exceeded.

IV. CONCLUSION

PUFA percentages in the range of 11 or 14% in carcass fat of less or more meaty fattening pigs and roughly 10% in the sausage point to a satisfying fat quality. More than 20% PUFA in sow backfat was surprisingly high. The present results of softer sow fat may not explain preferences of several processors for sow-raw material in producing dry-cured sausage. Other factors influencing the suitability of sow meat for longer storable meat products should be investigated. For the majority of meat products on German plates, intended for fresh consumption and characterized by a short shelf life, the fat should be optimized in accordance with the nutrition recommendations. This implies for the pig-fat deposits a higher percentage of omega 3 PUFA and so an improvement of n-6:n-3 PUFA ratio at significantly less than 10:1. This task could be solved by feeding RO and RPC, respectively, which are not only valuable energy carriers for the immense performance during fattening, but also with much of MUFA and relatively low and moderate percentages of LA and ALA they may support the production of a healthy pig and sausage fat.

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