VOLATILES IN MEAT PRODUCTS WITH ELEVATED N-3 FATTY ACID CONTENTS

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Introduction

Long-chain n-3 polyunsaturated fatty acids (PUFA) such as eicosapentaenoic acid (EPA, C20:5n-3) and docosapentaenoic acid (DHA, C22:6n-3) are considered to have beneficial effects on human health. One possibility to increase the intake of n-3 PUFAs without changing the nutritional behavior of the consumers, would be to fortify traditional food items such as meat and meat products, e.g. by feeding diets containing linseed to pigs. Linseed is rich in α-linolenic acid (ALA, C18:3n-3), a precursor of longer-chain n-3 PUFAs. On the other hand, PUFAs are known to be more susceptible to oxidation than monounsaturated fatty acids (MUFA) or saturated fatty acids (SFA) which might negatively affect the quality of processed meat products. The objective of the present study was to compare the volatile compounds of ham and bacon produced from pigs which have been fed either a diet containing 5 % of extruded linseed or a control diet.

Material and Methods

Forty Large White pigs, 20 females and 20 castrated males from 10 litters, fattened from 30 kg to 106 kg live weight were allocated to two treatments balanced according to gender, litter and initial weight. The diet was composed of barley, rice, soy groats, wheat, potato flour and supplemented with amino acids and minerals. The experimental diet contained 5 % of extruded linseed (Tradilin®). The fat and energy level of the control diet was adjusted by 1.4% lard. Belly and ham of the one side of 4 animals per treatment were taken to produce dry-cured bacon and ham.

The fatty acid composition was determined by gas chromatography (GC) of the derivatized fatty acid methyl esters from the extracted lipid fraction. Four homogenized ham samples (10 g each) per treatment were analyzed by purge and trap (P&T) GC coupled to mass spectrometry (MS) employing a Tekmar 3100 P&T system. GC-MS was performed on an HP 5890 Series II instrument equipped with a 5972 MSD using a SPB-1 sulfur capillary column. Solvent-assisted flavor evaporation (Engel et al., 1999) was used to isolate the aroma-active compounds of two bacon samples, and GC-MS with olfactometric detection was employed to analyze them. The volatiles were separated on an Optima-5-MS capillary column. Four trained panelists described the odor notes perceived at the olfactometry detector port (ODP).

Results and Discussion

The dry-cured air-dried bacon and ham produced from the pigs fed with the experimental diet with 5 % extruded linseed contained less MUFAs, but significantly more PUFAs as compared to the group fed the control diet (table 1). Particularly the ALA and the C20:3n-3 fatty acid contents were 3-4 times higher in the meat products of the experimental group (Sottnikova et al., 2004). The content in EPA was twice as high than the control, however, the DHA-contents in the experimental products were slightly lower compared to the control products.

Tab. 1: Fatty acid composition of bacon and ham produced from pigs fed diets with different contents of PUFA

	Bacon		Ham	
Fatty acid	Control diet	PUFA enriched diet	Control diet	PUFA enriched diet
SFA	41.4[a]	41.8	37.0	37.9
MUFA	49.9	46.8	50.7	47.9
PUFA (total)	8.6	11.4	11.9	13.9
- C18:2n-6	6.7	7.4	8.1	8.4
- C18:3n-3 (ALA)	0.65	2.56	0.60	2.2
- C20:3n-3	0.10	0.37	0.10	0.30
- C20:5n-3 (EPA)	0.03	0.06	0.19	0.41
- C22:6n-3 (DHA)	0.11	0.08	0.32	0.27

[a] Values in % of fatty acid methyl esters determined by gas chromatography

Dynamic headspace extraction of the volatiles (P&T) coupled to GC-MS was employed to analyze the volatile products formed from lipid oxidation. Table 2 compares the peak areas of selected volatile lipid oxidation products of ham produced from pigs fed a control diet to pigs fed the PUFA enriched diet. The experimental ham products showed 1.6-4.5 times more intense signals than the control products, e.g. for nonanal, pentane, and 1-

penten-3-ol. Vinyl alcohols such as 1-penten-3-ol or 1-octen-3-ol originate from n-3 and n-6 fatty acid autoxidation, respectively. Other typical oxidation products of n-3 and n-6 PUFAs, e.g. ALA, are aldehydes such as pentanal, hexanal, and heptanal, which may exhibit green, fatty and soapy aroma notes when present above their odor threshold concentrations. Hexanal, but also 1-penten-3-ol have been suggested as lipid oxidation markers of PUFAs (Olsen et al., 2005a, b). Heptanal was only found in the experimental ham. Probably, nonanal accumulated as relatively stable saturated aldehyde during the autoxidation process of the PUFAs (Belitz et al., 2004) present at higher concentrations in the experimental ham as compared to the control ham.

Tab. 2: Comparison of selected volatile oxidation products of ham produced from pigs fed diets differing in PUFA contents

	Mean peak area[a]	
Compound	Control diet	Diet enriched in PUFA
Pentanal	21829	34890
Hexanal	15968	33069
Heptanal	not detected	1891
Nonanal	346191	511395
1-Penten-3-ol	11422	26261
Pentane	72401	139939

[a] Mean values from four ham samples per treatment

To identify the aroma-active oxidation products of the bacon samples, solvent-assisted flavor evaporation/GC-MS (Engel et al., 1999) combined to olfactometry was employed, and the odor notes of the GC-effluent were described by four trained panelists. Table 3 gives a selection of aroma-active compounds detected in the bacon samples. Butanoic acid, possibly derived from lipolysis, was clearly perceived as acidic, sweaty and rancid, and its signal intensity was almost 10 times higher in the experimental bacon compared to the control product. 2-Heptanone and 2-undecanone were described as cheesy and oxidized fat-like, respectively, whereas 1-octen-3-ol, a typical oxidation product of n-6 linolenic acid, was perceived as mushroom-like. The three compounds were found more intense in the experimental bacon. (*E,E*)-2,4-Decadienal originating from e.g. linoleic acid exhibited a fatty, oily odor resembling oxidized frying fat. It was found in traces in the control bacon and showed a little more intense signal in the experimental bacon. (*E,E*)-2,4-Heptadienal, the corresponding autoxidation product from ALA, was not sensorially perceived in the samples, probably due to its low concentration, as it is very sensitive to autoxidation itself (Belitz et al., 2004).

Tab. 3: Selected aroma-active compounds in bacon produced from pigs fed diets differing in PUFA contents

	Mean peak height[a] /1000		
Compound	Control diet	Diet enriched in PUFA	Odor quality
Butanoic acid	51	462	Acidic, sweaty, rancid
2-Heptanone	36	313	Cheesy
2-Undecanone	4	34	Oxidized fat
1-Octen-3-ol	9	103	Mushroom-like
(*E,E*)-2,4-Decadienal	traces	3	Fatty, oily, oxidized frying fat

[a] Mean values from two samples per treatment

Conclusions

Ham and bacon produced from pigs fed PUFA enriched diets showed higher contents of n-3 polyunsaturated fatty acids compared to the control. GC-MS analysis of their volatiles revealed more intense signals for typical lipid oxidation products such as aldehydes and vinyl alcohols as compared to the control products. These compounds might be useful early lipid oxidation markers which could help to determine the quality of PUFA enriched food items. Further investigations are necessary to correlate the analytical concentrations of potential oxidation markers with sensory data in order to estimate the sensory shelf-life of these products.

Literature

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