Fatty acid composition of Swiss cooked sausages

Keywords
- Meat product
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- Analyses

By Alexandra Schmid, Marius Collomb and Ruedi Hadorn

In Switzerland, cooked sausages are very popular and belong to the most often consumed meat products. The aim of this study was to determine the detailed fatty acid composition in commercially available Swiss cooked sausages. Analyses were performed in 8 sausage types (N = 5): frying sausage from veal, Cervelat, Vienna sausage, Lyoner sausage, meat loaf, frying sausage from pork, pork sausage, and Lyoner sausage from poultry. The fatty acid content ranged from 15.8 to 22.6 g per 100 g edible sausage. On average 40% of the fatty acids were saturated, 48% monounsaturated, and 9% polyunsaturated. The cooked sausages also contained small amounts of CLA and trans fatty acids. Similar patterns were found regarding the individual fatty acid composition of the sausages. However, depending on the meat and fat type (pork, poultry, beef, veal) as well as the recipes used for the different sausages, slight differences in the individual fatty acid concentrations were detected.

In Switzerland, sausages represent 20% of all meat consumed in households with a total consumption of 90,000 t of meat products per year (Proviande, 2007 and 2008). There is a vast choice of meat products in Switzerland of which cooked sausages like frying sausage from veal, Cervelat and Vienna sausages are probably the best known and among the most frequently consumed. Meat products often contain a non-negligible amount of fat. For Swiss cooked sausages it's about 10 to 30 g fat per 100 g sausage (Schmid et al., in press) which corresponds to similar products in Germany (Honikel, 2004). In a society with dietary recommendations favouring a low intake of fat, this amount has to be seen as a disadvantage. Although epidemiological studies failed to find a correlation between the consumption of animal fat and coronary heart disease (Fehily et al., 1993; Halton et al., 2006; Hu et al., 1997), animal fat is still regarded as unhealthy because of its large amount of saturated fatty acids (SFA). In this context the substantial amounts of mono- and polyunsaturated fatty acids (MUFA and PUFA) in meat fat are often neglected. However, the PUFA content is generally limited to about 10% in meat products due to technical requirements.

To address questions about the nutritional quality and possible health effects of a low or high consumption of cooked sausages, it is of great interest to know their fatty acid composition. Unfortunately, in Switzerland such data do not exist for meat products. Therefore, the aim of the present study was to determine the fatty acid composition of various commonly available cooked sausages in Switzerland.

Material and methods

▶ Samples

Eight well known, typically Swiss cooked sausages differing in composition and production process were chosen: frying sausage from veal, Cervelat, Vienna sausage, Lyoner sausage, meat loaf, frying sausage from pork, pork sausage, and Lyoner sausage from poultry. For every type of cooked sausage five different products from retail business were collected (40 samples in total). Each sample comprised 2.5 kg of the same product (but not necessarily of the same production lot). Samples of the first four types of cooked sausages were bought in November 2006, the ones of the second four types in June

Tab. 1: Concentration of fatty acid groups (g per 100 g edible parts) in 8 Swiss cooked sausages (mean and SD)

	Cervelat	Frying sausage from veal	Lyoner	Vienna sausage	Meat loaf	Frying sausage from pork	Pork sausage	Lyoner from poultry
	N = 5	N = 5	N = 5	N = 5	N = 5	N = 5	N = 5	N = 5
Short chain FA[a]	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)	0.07 (0.02)	0.05 (0.00)	0.06 (0.01)	0.05 (0.01)
Medium chain FA[b]	6.37 (1.00)	6.51 (0.79)	6.56 (0.84)	6.09 (0.41)	7.37 (0.54)	6.23 (0.30)	7.47 (1.65)	5.53 (1.41)
Long chain FA[c]	13.68 (2.17)	13.43 (1.32)	13.85 (2.28)	13.11 (0.85)	15.17 (1.15)	12.62 (0.67)	14.84 (3.75)	10.21 (2.96)
Saturated FA[d]	8.20 (1.31)	7.89 (0.97)	8.21 (1.12)	7.79 (0.49)	8.77 (0.70)	7.36 (0.36)	9.03 (2.24)	5.11 (1.36)
Unsaturated FA[e]	11.40 (1.86)	11.61 (1.14)	11.76 (1.96)	10.96 (0.76)	12.83 (1.00)	10.59 (0.59)	12.28 (3.08)	9.82 (2.94)
MUFA[f]	9.68 (1.67)	9.68 (0.91)	10.16 (1.58)	9.36 (0.66)	10.82 (0.81)	8.79 (0.40)	10.38 (2.58)	7.48 (2.34)
PUFA[g]	1.72 (0.21)	1.93 (0.25)	1.60 (0.45)	1.59 (0.16)	2.01 (0.20)	1.80 (0.24)	1.90 (0.51)	2.34 (0.61)
TFA without CLA *t*[h]	0.24 (0.03)	0.30 (0.09)	0.24 (0.04)	0.23 (0.04)	0.21 (0.04)	0.18 (0.03)	0.26 (0.10)	0.18 (0.05)
TFA with CLA *t*[i]	0.28 (0.03)	0.38 (0.11)	0.29 (0.05)	0.27 (0.05)	0.26 (0.04)	0.22 (0.04)	0.31 (0.11)	0.20 (0.06)
n-3 FA[k]	0.18 (0.02)	0.22 (0.04)	0.18 (0.03)	0.18 (0.02)	0.24 (0.03)	0.21 (0.03)	0.22 (0.06)	0.26 (0.06)
n-6 FA[l]	1.51 (0.19)	1.65 (0.20)	1.39 (0.42)	1.39 (0.14)	1.76 (0.18)	1.59 (0.21)	1.68 (0.45)	2.08 (0.55)
Total FA	20.08 (3.18)	19.97 (2.11)	20.44 (3.11)	19.23 (1.24)	22.61 (1.68)	18.90 (0.96)	22.36 (5.41)	15.79 (4.36)

[a] $C_{4:0}$ to $C_{10:1}$; [b] $C_{12:0}$ to $C_{16:1}$ *c*; [c] $C_{17:0}$ to $C_{22:6}$; [d] $C_{4:0}$ to $C_{10:0}$, $C_{12:0}$, $C_{13:0}$ iso, $C_{13:0}$ aiso, $C_{14:0}$ iso, $C_{14:0}$, $C_{15:0}$ iso, $C_{15:0}$ aiso, $C_{15:0}$, $C_{16:0}$ iso, $C_{16:0}$, $C_{17:0}$ iso, $C_{17:0}$ aiso, $C_{17:0}$, $C_{18:0}$ iso, $C_{18:0}$ aiso, $C_{18:0}$, $C_{19:0}$, $C_{20:0}$ and $C_{22:0}$; [e] $C_{10:1}$, $C_{14:1}$ *ct*, $C_{16:1}$ *ct*, $C_{17:1}$ *t*, $C_{18:1}$ *t*4 to $C_{18:1}$ *c*14+*t*16, $C_{18:2}$ *tt*NMID to $C_{18:2}$ *c*9*c*15, $C_{20:1}$ *t* to $C_{20:2}$ *c,c* (*n*-6), $C_{20:3}$ (*n*-6) to $C_{22:6}$ (*n*-3); [f] $C_{10:1}$, $C_{14:1}$ *ct*, $C_{16:1}$ *ct*, $C_{17:1}$ *t*, $C_{18:1}$ *t*4 to $C_{18:1}$ *c*14+*t*16, $C_{20:1}$ *t*, $C_{20:1}$ *c*5 to $C_{20:1}$ *c*11; [g] $C_{18:2}$ *tt*NMID to $C_{18:2}$ *c*9*c*15, $C_{18:3}$ *c*6*c*9*c*12, $C_{18:3}$ *c*9*c*12*c*15 to $C_{20:2}$ *c,c* (*n*-6), $C_{20:3}$ (*n*-6) to $C_{22:6}$ (*n*-3); [h] $C_{14:1}$ *t*, $C_{16:1}$ *t*, $C_{17:1}$ *t*, $C_{20:1}$ *t*, $C_{18:1}$ *t*, $C_{18:2}$ *t* (without CLA *trans*) ; [i] $C_{14:1}$ *t*, $C_{16:1}$ *t*, $C_{17:1}$ *t*, $C_{20:1}$ *t*, $C_{18:1}$ *t*, $C_{18:2}$ *t* + CLA *trans* ; [k] ($C_{18:2}$ *t*11*c*15 + *t*9*c*12) + $C_{18:2}$ *c*9*c*15, $C_{18:3}$ *c*9*c*12*c*15, $C_{20:3}$ (*n*-3), $C_{20:5}$ (EPA) (*n*-3), $C_{22:5}$ (DPA) (*n*-3) and $C_{22:6}$ (DHA) (*n*-3); [l] $C_{18:1}$ *t*12, $C_{18:1}$ *c*12, $C_{18:2}$ *t*9*t*12, ($C_{18:2}$ *c*9*t*12+*c,c*-MID+*t*8*c*13), $C_{18:2}$ *c*9*c*12, $C_{18:3}$ *c*6*c*9*c*12, $C_{20:2}$ *c,c* (*n*-6), $C_{20:3}$ (*n*-6) and $C_{20:4}$ (*n*-6)
c = *cis*, *t* = *trans* ; NMID = non methylene interrupted diene, MID = methylene interrupted diene; FA = fatty acids; + = within the same peak in the chromatogram

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2007. The following specifications were considered when samples were collected:

- only standard products (no low budget or premium products)
- only Swiss products with identifiable manufacturers and places of production
- a high market coverage (the inclusion of the products of the two retail shop chains with the highest market coverage was mandatory)
- a country-wide distribution of the products and manufacturers to account for regional product differences

The samples were bought directly in the shops and transferred immediately in coolers to Agroscope Liebefeld-Posieux Research Station ALP by ALP-staff. All the products were registered and the information given on the packages was recorded (name of product, producer, lot number, composition, nutrient declaration, etc.). The samples were then portioned, coded and forwarded internally to be freeze-dried (lyophilised) before being sent to the lipid laboratory at ALP. During transport and preparation of the samples, they were kept under continuous cool conditions and were then stored at –20 °C until analysis.

▶ Analysis of fatty acids

Total lipids of 1.5 g freeze-dried sausages were extracted with 60 mL of dichlormethane/methanol (2:1, v:v) by homogenisation (Polytron PT-MR 3100, Kinematica, Littau, Switzerland; 30 s, 13,500 revolutions per minute) at room temperature. The solution was filtered in a separating funnel containing 1 mL of a solution of 2 g/100 g $MgCl_2$ and 20 mL of water. The organic phase was separated and evaporated to dryness. Glycerides were saponified with 3 mL of a solution of NaOH 0.5 M in methanol (3 min at the boiling point). Three mL of borontrifluoride (14% wt/vol) were added, and the solution was warmed at the boiling temperature for 4 min for the methylation of the free fatty acids.

Fatty-acid methylesters (FAME) were analyzed using an Agilent 6890 gas chromatograph equipped with an on-column injector and an FID according to Collomb and Bühler (2000). The fatty acids were separated on a capillary column CP-Sil 88 (100 m × 0.25 mm i.d., 0.20 µm; Varian BV, Middleburg, Netherlands) and quantified using tridecanoic acid as an internal standard. The results were expressed as g fatty acids per 100 g edible sausage parts. The pure methylesters of fatty acids, including CLA, were obtained from Matreya Inc., Pleasant Gap, PA, USA.

CLA isomers were analyzed by silver-ion (Ag^+)-HPLC (Agilent LC 1100, Santa Clara, CA, USA) equipped with a photodiode array detector (234 nm) using three ChromSpher Lipid columns in series (stainless steel, 250 × 4.6 mm, 5 µm particle size; Chrompack, Middleburg, Netherlands) according to Collomb et al. (2004). The solvent consisted of UV-grade hexane with 0.1% acetonitrile and 0.5% ethyl ether (flow rate 1 mL/min), prepared fresh daily. The injection volume was 10 µL, corresponding to <250 µg lipid. The HPLC areas for *t*7*c*9 + *t*8*c*10 + *c*9*t*11 (*t* = *trans*, *c* = *cis*) were added and used for comparison of the peak area of the three isomers from the GC chromatogram. The results were expressed as mg per 100 g edible sausage parts.

▶ Data treatment

For every type of cooked sausage the arithmetic mean of the five samples was calculated. All statistical calculations were performed with Systat® for Windows version 11 (Richmond, CA, USA) and Microsoft Excel 2003. The results in this publication are given as mean of the 5 sausage samples with the standard deviation in brackets. All values refer to 100 g fresh weight of the raw, edible sausage parts.

Results and discussion

Table 1 presents the concentrations of various fatty acid groups, whereas Tables 2 and 3 show in detail the concentration of the individual fatty acids in the eight cooked sausages. The mean total amount of fatty acids ranges between 15.8 g (Lyoner from poultry) and 22.6 g (meat loaf) per 100 g edible sausage. SFA concentrations from 5.1 g (Lyoner from poultry) to 9.0 g (pork sausage) per 100 g edible sausage were determined, with palmitic acid ($C_{16:0}$) and stearic acid ($C_{18:0}$) contributing the highest amounts. MUFA content was slightly higher than SFA content [7.5 g (Lyoner from poultry) to 10.8 g (meat loaf) per 100 g sausage]. The predominant MUFA was oleic acid ($C_{18:1}$ *cis*-9), being also the most prevalent individual fatty acid in the sausages. The PUFA concentrations range from 1.6 g (Vienna sausage and Lyoner) to 2.3 g (Lyoner from poultry), with linoleic acid ($C_{18:2}$ *cis*-9, *cis*-12) as dominating fatty acid. Calculating the proportions of the

Tab. 2: Fatty acid composition in 8 Swiss cooked sausages (mean and SD) in g per 100 g edible parts

Fatty acids	Cervelat	Frying sausage (veal)	Lyoner	Vienna sausage	Meat loaf	Frying sausage (pork)	Pork sausage	Lyoner (poultry)
	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5
$C_{12:0}$	0.04 (0.02)	0.06 (0.04)	0.05 (0.02)	0.03 (0.00)	0.04 (0.02)	0.04 (0.01)	0.03 (0.01)	0.08 (0.04)
$C_{14:0}$	0.36 (0.07)	0.51 (0.11)	0.42 (0.06)	0.33 (0.04)	0.40 (0.06)	0.32 (0.04)	0.38 (0.10)	0.20 (0.05)
$C_{16:0}$	4.78 (0.78)	4.64 (0.57)	4.85 (0.67)	4.56 (0.28)	5.17 (0.39)	4.32 (0.23)	5.26 (1.28)	3.50 (0.97)
$C_{16:1}$ *c*	0.52 (0.09)	0.59 (0.07)	0.56 (0.08)	0.50 (0.05)	0.56 (0.04)	0.45 (0.02)	0.55 (0.14)	0.71 (0.24)
$C_{18:0}$	2.66 (0.40)	2.32 (0.28)	2.52 (0.39)	2.52 (0.16)	2.77 (0.23)	2.36 (0.11)	2.97 (0.78)	1.04 (0.27)
$C_{18:1}$ *t*9	0.06 (0.01)	0.06 (0.01)	0.06 (0.01)	0.05 (0.01)	0.06 (0.01)	0.05 (0.00)	0.05 (0.01)	0.04 (0.01)
$C_{18:1}$ *t*10-11	0.06 (0.01)	0.09 (0.04)	0.06 (0.02)	0.07 (0.02)	0.04 (0.01)	0.03 (0.01)	0.07 (0.04)	0.04 (0.01)
$C_{18:1}$ *t*13-14+*c*6-8	0.02 (0.00)	0.03 (0.01)	0.02 (0.00)	0.01 (0.01)	0.02 (0.01)	0.02 (0.00)	0.03 (0.01)	0.02 (0.01)
$C_{18:1}$ *c*9	8.04 (1.39)	7.92 (0.69)	8.41 (1.36)	7.77 (0.50)	8.92 (0.66)	7.24 (0.33)	8.54 (2.12)	6.04 (1.88)
$C_{18:1}$ *c*11	0.67 (0.12)	0.63 (0.05)	0.69 (0.12)	0.64 (0.05)	0.85 (0.06)	0.70 (0.03)	0.78 (0.18)	0.43 (0.13)
$C_{18:2}$ *c*9*c*12	1.36 (0.17)	1.47 (0.17)	1.23 (0.39)	1.24 (0.14)	1.58 (0.16)	1.41 (0.19)	1.49 (0.40)	1.97 (0.53)
$C_{18:3}$ *c*9*c*12*c*15	0.10 (0.01)	0.13 (0.02)	0.08 (0.03)	0.09 (0.01)	0.13 (0.01)	0.11 (0.02)	0.12 (0.04)	0.13 (0.04)
$C_{20:0}$	0.03 (0.00)	0.03 (0.00)	0.03 (0.01)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.04 (0.01)	0.01 (0.00)
$C_{20:5}$ (*n*-3) (EPA)	0.02 (0.01)	0.01 (0.00)	0.04 (0.01)	0.04 (0.01)	0.02 (0.00)	0.02 (0.01)	0.02 (0.00)	0.10 (0.01)
∑ C_{12}, C_{14} + C_{16}	5.19 (0.86)	5.21 (0.65)	5.32 (0.71)	4.92 (0.32)	5.62 (0.44)	4.68 (0.24)	5.66 (1.38)	3.78 (1.04)
∑ $C_{18:1}$	8.95 (1.54)	8.87 (0.81)	9.37 (1.48)	8.67 (0.58)	10.03 (0.74)	8.16 (0.37)	9.61 (2.39)	6.65 (2.05)
∑ $C_{18:2}$	1.46 (0.19)	1.63 (0.21)	1.35 (0.40)	1.34 (0.14)	1.71 (0.17)	1.51 (0.20)	1.61 (0.43)	2.05 (0.56)
∑ $C_{18:1}$ *t*[a]	0.17 (0.02)	0.21 (0.06)	0.17 (0.03)	0.17 (0.03)	0.15 (0.03)	0.13 (0.02)	0.19 (0.07)	0.12 (0.03)

[a] $C_{18:1}$ *t*4 to $C_{18:1}$ *t*13-14 + *c*6-8, $C_{18:1}$ *t*16+*c*14 ; *c* = *cis*, *t* = *trans*, FA = fatty acids; + = within the same peak in the chromatogram

Source: Schmid, Collomb and Hadorn

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fatty acid groups shows, that SFA's constitute on average 40% of the total fatty acids, although Lyoner from poultry has to be highlighted with a SFA content of 32.4%. The MUFA content varies from 46 to 50%. The PUFA content amounts generally to about 9%; only the Lyoner from poultry differs from it with 14.8% which is attributable to the use of meat and fat from poultry in this sausage type.

The P:S ratio describes the relation between PUFA to SFA and ranges preferably from 1 to 1.5 in human nutrition (Maid-Kohnert, 2002). In fresh meat and meat products the P:S ratio is often below this range because the SFA's outweigh the PUFA's by far (Enser et al., 1996; Jakobsen, 1999). The analysed cooked sausages are no exception with P:S ratios at 0.2. Only the Lyoners from poultry featured a somewhat higher P:S ratio (0.5), but it is also below the desired limit. Out of nutritional considerations, an increase of the ratio in cooked sausages would be desirable. Due to technological reasons (decreased oxidative stability, softer texture and therefore more difficult to process) however, this is often not possible, although these technological aspects are more important in long-ripened meat products than in cooked sausages (Hadorn et al., 2008).

Another important aspect regarding fatty acid composition in human nutrition is the *n*-6:*n*-3 ratio, which preferably is ≤5:1 (Gassmann, 2006). The meat fat of beef and lamb usually shows favourable ratios (<5), whereas pork and poultry are above the desired value (Enser et al., 1996; Jakobsen, 1999). Cooked sausages normally contain a large amount of pork fat which has a negative impact on the *n*-6:*n*-3 ratio. The values between 7.5 and 8.4 found in the analysed sausages mirror this fact.

If it is assumed that fat provides 35% of the energy in the human diet, the consumption of about 100 g of cooked sausage constitutes between 22 and 32% of the total fat intake of a woman (based on a size of 1.65 m and a sedentary lifestyle) and between 18 and 25% of the total fat intake of a man (1.80 m body height and sedentary lifestyle) based on the Daily Recommended Intake (DRI; Food and Nutrition Board, 2004). However, the sausage also covers 10 to 16% and 7 to 12%, respectively, of the linoleic acid as well as 7 to 12% and 5 to 8%, respectively, to the linolenic acid requirements (based on the DRI for women and men aged between 19 and 50 years, respectively – Food and Nutrition Board, 2004).

Conjugated linoleic acid (CLA) consists of a group of geometric and positional isomers of linoleic acid with conjugated double bonds. Data from animal studies suggest that CLA has positive effects on cancer, cardiovascular disease, diabetes, body composition, immune system, and bone health (Tricon and Yaqoob, 2006). However, findings from human studies are not yet conclusive. The amount of CLA in the Swiss cooked sausages ranges from 22.1 (Lyoner from poultry) to 78.9 mg (frying sausage from veal) per 100 g sausage (Tab. 3). The CLA content of frying sausage from veal exceeds the content of the other sausages, which is probably due to the high amount of veal in this sausage type exceeding 50 mass-% compulsory from the legal point of view. CLA occurs mainly in ruminant products because of the bacterial biohydrogenation of unsaturated fatty acids in the rumen.

Tab. 3: Content of conjugated linoleic acids (CLA) of 8 Swiss cooked sausages (mean and SD) in mg per 100 g edible parts

	Cervelat	Frying sausage (veal)	Lyoner	Vienna sausage	Meat loaf	Frying sausage (pork)	Pork sausage	Lyoner (poultry)
	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5
$C_{18:2}$ *t12 t14*	0.2 (0.0)	0.4 (0.2)	0.3 (0.1)	0.3 (0.0)	0.2 (0.0)	0.1 (0.0)	0.3 (0.2)	0.1 (0.1)
$C_{18:2}$ *t11 t13*	0.6 (0.1)	1.0 (0.3)	0.5 (0.2)	0.5 (0.2)	0.5 (0.1)	0.4 (0.1)	0.7 (0.3)	1.6 (0.7)
$C_{18:2}$ *t10 t12*	0.2 (0.1)	0.5 (0.3)	0.3 (0.0)	0.2 (0.0)	0.2 (0.1)	0.3 (0.2)	0.2 (0.1)	0.2 (0.1)
$C_{18:2}$ *t9 t11*	2.5 (0.6)	3.1 (0.7)	2.7 (0.8)	2.1 (0.5)	3.3 (0.8)	2.4 (0.7)	2.8 (1.2)	1.2 (0.7)
$C_{18:2}$ *t8 t10*	0.7 (0.1)	0.4 (0.1)	0.6 (0.4)	0.7 (0.3)	0.6 (0.2)	0.5 (0.3)	0.6 (0.1)	0.6 (0.2)
$C_{18:2}$ *t7 t9*	0.7 (0.2)	0.7 (0.1)	0.6 (0.2)	0.6 (0.3)	0.9 (0.4)	0.6 (0.2)	0.6 (0.2)	0.7 (0.3)
$C_{18:2}$ *t6 t8*	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)	0.2 (0.1)	0.2 (0.2)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)
$C_{18:2}$ *c12 t14*/ *t12 c14*	0.3 (0.1)	0.6 (0.1)	0.3 (0.1)	0.3 (0.0)	0.3 (0.1)	0.3 (0.1)	0.4 (0.1)	0.2 (0.1)
$C_{18:2}$ *t11 c13*	0.9 (0.2)	2.2 (1.3)	0.9 (0.4)	1.0 (0.4)	0.7 (0.2)	0.5 (0.2)	1.2 (0.8)	0.4 (0.2)
$C_{18:2}$ *c11 t13*	0.6 (0.1)	0.8 (0.1)	0.7 (0.2)	0.6 (0.1)	0.8 (0.1)	0.5 (0.1)	0.7 (0.2)	0.1 (0.1)
$C_{18:2}$ *t10 c12*	0.2 (0.1)	0.5 (0.1)	0.3 (0.1)	0.2 (0.1)	0.2 (0.0)	0.2 (0.0)	0.3 (0.1)	0.1 (0.1)
$C_{18:2}$ *c9 t11*	33.0 (3.9)	62.6 (21.6)	35.1 (10.0)	30.5 (7.6)	37.4 (5.6)	27.1 (8.4)	34.8 (14.5)	14.8 (7.3)
$C_{18:2}$ *t8 c10*	0.9 (0.1)	3.1 (1.1)	1.3 (0.4)	0.9 (0.3)	1.2 (0.2)	0.9 (0.3)	0.9 (0.4)	0.9 (0.4)
$C_{18:2}$ *t7 c9*	1.7 (0.2)	3.0 (0.6)	1.7 (0.5)	1.6 (0.3)	1.9 (0.2)	1.5 (0.4)	1.8 (0.8)	0.9 (0.4)
Total CLA	42.8 (4.7)	78.9 (24.9)	45.3 (12.4)	39.7 (9.3)	48.6 (7.1)	35.6 (10.1)	45.2 (18.3)	22.1 (10.4)

c = *cis*, *t* = *trans*

Source: Schmid, Collomb and Hadorn — Fleischwirtschaft International 5/2009

The CLA concentrations of the other sausage types, which contain mainly meat and fat from pork, may therefore partly be attributed to the varying beef meat additions. Hence, it is not surprising, that the Lyoner from poultry with no such addition shows the lowest CLA content. The detected CLA concentration ranges from 0.2 to 0.4% of total fatty acids, which is comparable to the findings of Fritsche and Steinhart (1998) in German meat products (0.27 to 0.44%). In animal products, the CLA isomer $C_{18:2}$ *cis*-9,*trans*-11 is usually the predominant one (Schmid et al., 2006), which is confirmed in the analysed sausages (Tab. 3).

Trans fatty acids (TFA), primarily from partially hydrogenated fat, have been positively associated with the risk of coronary heart disease (Mozaffarian et al., 2006). However, TFA are also found in ruminant products, although, their biological effects seem not identical to the industrial ones (Chardigny et al., 2008; Jakobsen et al., 2007; Motard-Bélanger et al., 2008). The analysed sausages contain between 0.18 (Lyoner from poultry, frying sausage from pork) and 0.30 g (frying sausage from veal) TFA's per 100 g sausage. This is about 0.9 to 1.5% of the total fatty acids, which corresponds to the findings of Aro et al. (1998) in sausages in the Transfair Study. This rather low concentration of TFA – in ruminant fat a level of 3 to 8% is stated as normal (Gebauer et al., 2007) – can be attributed to the considerable portion of pork meat and fat in cooked sausages. The slightly higher TFA concentration found in frying sausage from veal supports this assumption. The sum of the isomers $C_{18:1}$ *trans*-10 and *trans*-11 constitutes in most of the sausages the main fraction, which is not surprising since vaccenic acid ($C_{18:1}$ *trans*-11) is usually the predominant TFA in animal products (Gebauer et al., 2007; Huth, 2007). $C_{18:1}$ *trans*-9 (elaidic acid) was found to be second. However, some sausages (e.g. frying sausage from pork) show a higher proportion of $C_{18:1}$ *trans*-9 than $C_{18:1}$ *trans*-10+*trans*-11 what generally indicates partially hydrogenated fat. The fatty acid concentration and composition of pork fat largely depends on the diet because most dietary fats are absorbed unmodified in monogastric animals (Fontanillas et al., 1998; Gläser et al., 2002). Pork feed containing partially hydrogenated fat, mostly of vegetable origin, may therefore explain the findings.

All in all, Lyoner from poultry has the lowest fat content of the analysed eight sausages and from a nutritional point of view the most

advantageous fatty acid profile (lower in SFA, higher in PUFA compared with the other sausages). However, the fat content and the fatty acid profile should not be the only criteria to choose a food, of similar importance is the energy value, the nutrient content and last but not least the different sensory aspects like taste, texture, colour, appearance, etc.

Conclusion

The present study provides the first analytical data regarding the individual fatty acid composition of Swiss cooked sausages. The analysed eight sausage types show a similar pattern regarding the fatty acid composition. With single exceptions, the SFA content is about 40% of total fatty acids, the MUFA concentrations vary around 48% and the PUFAs around 9%. Cooked sausages also contain small amounts of conjugated linoleic acid and trans fatty acids. However, depending on the sausage composition, which refers mainly to the used meat and fat type (pork, poultry, beef, veal), slight differences in the individual fatty acid concentrations are seen.

Importance for practice

To address questions about the nutritional quality and possible health effects of a low or high consumption of cooked sausages, it is of great interest to know their fatty acid composition. Unfortunately, detailed information about the fatty acid composition of cooked sausages is not widespread. Therefore, the presented data provide nutritionists, scientists and sales people with the necessary data to address questions in this area or to develop future research aims.

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References

Literature references can be downloaded at *www.fleischwirtschaft.com/literature* or requested from the author and the editorial office, respectively.

Authors' address

Dipl. oec. troph. Alexandra Schmid, Dr. Marius Collomb and Dr. Ruedi Hadorn, Agroscope Liebefeld-Posieux Research Station ALP, Schwarzenburgstr. 161, 3003 Bern, Switzerland