Qualität von Schweinefleisch und Speck mit erhöhten Gehalten an mehrfach ungesättigten Fettsäuren.

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Schweinefleisch wurde gezüchtet mit etwa 10, 20 und 30% Linolsäure in den Depotfetten. Dazu wurde Rindsfett in die Diäte (zum Teil) durch Soja-öl versetzt. Fettsäurezusammensetzungen werden gegeben für einige Fleisch-, Fettgewebe- und Leber-proben. Fette im Fleisch zeigten im Allgemeinen die niedrigsten Gehälte an mehrfach ungesättigten Fettsäuren. Kupfer- und α-Tocopherolgehälte wurden bestimmt in einem geringen Anzahl von Proben. Unterschiede in α-Tocopherolgehälte wurden zwischen den drei Gruppen beobachtet; die ungesättigten Geweben erwiesen die niedrigsten Gehälte. Sensorische Beurteilungen von der Farbe und dem Geruch/Geschmack sind durchgeführt worden sowohl an verschiedenen Proben frisches Fleisch und Speck als an gelagerten Proben. Keine signifikante Unterschiede zwischen den drei Gruppen konnten hierbei festgestellt werden. Die Fettoxidation wurde während der Lagerung verfolgt mittels Bestimmungen von Peroxidzahlen und p-Anisidin-werten. An die frischen ungesättigten Geweben wurden für beide Oxidationsindikatore hohe Werte festgestellt. Diese Werte setzten allerdings ab wenn unter Vakuum und bei niedrigen Temperaturen gelagert wurde. Die Ergebnisse der Experimenten mit aus diesem Fleisch hergestellten Produkten werden woanders in der Fachliteratur veröffentlicht.

Quality of pork meat and fat with increased levels of polyunsaturated fatty acids.

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Pork has been produced with about 10, 20 and 30% linoleic acid in the depot fats. The unsaturation was reached by (partially) replacing the tallow by soy-oil in the diets. Fatty acid compositions are given for some lean meat, fatty tissue and liver samples. Lipids in lean meats generally showed lower levels of polyunsaturated fatty acids than those in fatty tissues. Copper and α-tocopherol contents have been estimated in a limited number of samples. Differences in α-tocopherol contents were found between the three blocks; the unsaturated tissues showing lower levels. Taste panel evaluations of color and odor/taste have been performed on several meat and fat samples fresh and after different storage periods. No significant differences between the three blocks have been observed. Lipid oxidation was followed during storage by measuring peroxide-numbers and p-anisidine values. For the fresh unsaturated tissues high values were measured for both oxidation indicators. These were however decreasing upon storage under vacuum at low temperatures. Results of experiments with products derived from this meat will be published elsewhere.

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Qualité de viande de porc avec des teneurs élevées en acides gras polyinsaturés.

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Viande de porc a été produite avec environ 10, 20 et 30% de l'acide linoléique dans les gras de dépôts. L'insaturation était atteinte par un échange (partiel) de la graisse de boeuf par de l'huile de soui dans leur diètes. Des compositions d'acides gras sont données pour quelques échantillons de viande maigre, de lard et des foies. Les gras dans les viandes maigres montraient en général des teneurs en acides gras polyinsaturés inférieures que ceux dans les lards. Des teneurs en cuivre et en α-tocophérol sont estimées dans un nombre d'echantillons limité. Des différences dans les teneurs en α-tocophérol étaient trouvées entre les trois blocs; les tissus insaturés montrant des teneurs inférieures. Des jugements de la couleur et de l'odeur/goût ont été executés sur plusieurs échantillons de viande maigre et de lard, ceci frais et après différentes périodes de stockage. Des différences significatives entre les trois blocs n'ont pas été observées. L'oxydation des matières grasses pendant le stockage était poursuite par la mesure des indices de peroxyde et des valeurs de p-anisidine. Pour les tissus insaturés frais des valeurs hautes ont été mesurées pour ces deux indicateurs d'oxydation. Pourtant ces valeurs descendaient pendant un stockage sous vide à des températures basses. Les résultats des expériments avec les produits qui sont derivés de ces viandes seront publiés autre part.

Качество свинины и свиного сала с повышенными уровнями кратноненасыщенных жирных кислот.

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Была произведена свинина с примерно 10, 20 и 30% линолевой кислоты в резервном жире. Ненасыщенность была достигнута тем, что сало в рационах было замещено (частично) соевым маслом. Приводится состав жирных кислот для некоторых образцов нежирного мяса, жировой ткани и печени. Липиды в нежирном мясе в большинстве случаев показали низшие уровни кратноненасыщенных жирных кислот, чем в жировых тканях. Содержание меди и альфа-токоферола определилось в ограниченном наборе образцов. Различия в содержании альфа-токоферола найдены между тремя видами производства, причем уровни в более ненасыщенных оказались низшими. Дегустационные обсуждения окраски и аромата-вкуса проведены на различных образцах мяса и жира как в свежем состоянии, так и после различных сроков хранения. Достоверных различий между тремя видами не было обнаружено. Липидное окисление прослеживалось в течение хранения путем определения перекисного и р-анизидинного чисел. В свежих более ненасыщенных образцах были найдены высокие значения для обоих показателей окисления, которые, однако, уменьшались во время хранения при низких температурах. Результаты опытов на продуктах, изготовленных на основе такого мяса, будут опубликованы на другом месте.

Quality of pork meat and fat with increased levels of polyunsaturated fatty acids

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Introduction

Diets high in fats have often been associated with the increasing numbers of people with heart and bloodvessel diseases in our Western societies. Fats are not only high in Joules but also the composition of a specific fat may play an important role. Both factors may work out negative in man's diet. Several Nutrition Councils recommended the general public among other things to change their diets towards lower levels of fat energy intake. The majority advised in addition to partially replace saturated fats by fats rich in polyunsaturated fatty acids, particularly in linoleic acid.

In this context it appeared very interesting to investigate the possibility of changing a rather saturated fat like pork fat towards a more unsaturated state. Pork fats high in linoleic acid have been produced on several occasions (BAYLEY and SUMMERS ,1975, BROOKS, 1971, JURGENS et al.,1970, KOCH et al., 1968 and VILLEGAS et al., 1974), most of these projects concerned however the introduction of new plant raw materials in pigs diets.

Only SKELLEY et al. (1975) performed a research with the aim of reaching higher linoleic acid levels in pork fat; the maximum they reached was 21,3% of this acid in the backfat (ANDERSON, 1976, gives in her review a level of about 10% for normal backfat). This pork meat and fat appeared to be highly acceptable.

In all these references no attention was paid to the stability towards lipid oxidation of such meats.

The literature apparently lacking, an investigation was set up in which three groups of pigs were fed with the aim of reaching about 10, 20 and 30% linoleic acid in the depot fats. The unsaturation was reached by (partially) substituting the tallow in the diets by soy oil. Representative samples of meats and fats have been judged fresh and after different storage periods. Chemical analysis have been performed on the composition of the fats and on oxidative processes in the lipid fraction.

Materials and methods

Animals and diets

Great Yorkshire barrows were used in this investigation. Thirty pigs were randomly allotted within descent and weight in three equal groups. Diets were formulated in consultation with the Unilever Research Laboratory (Vlaardingen). Codes N (Normal), M (Medium) and H (High) were given for the three blocks. Feeds for these groups contained resp. 4.0% tallow; 2.0% tallow and 4.25% soy-oil and 8.5% soy-oil as visible fats. Pigs were fed on an energy base for feeder pigs and kept at an experimental farm of the I.V.V.O. "Hoorn". Feeding started at an average weight of 30.4 kg (range 23.5 - 37.0 kg). Feed intake and growth did not present problems. Mean weight at slaughtering was 104.1 kg (range 95.5 - 111,5 kg).

After a 24 h chill at 4 $\pm$ 1°C the carcasses were partially deboned and split up in big pieces. Visually there were no differences between the carcasses, however the butchers (unaware of experimental details) noticed sometimes that the fat of M- and H-pigs had a weaker/softer consistency.

Sampling and storage of meat and fat

From two animals chosen at random within every block all the samples have been collected in a strictly comparable way. Reference samples were always vacuum packaged and stored at - 40 $\pm$ 1°C.

Back fat, belly fat and the M. longissimus dorsi were sampled at about (or around)the tenth rib. Further samples of the M. sartorius, the M. adductor and the livers were taken. From these samples fatty acid compositions have been determined.

Samples of the belly fat, steaks of the ham muscles and of the loins have been judged sensorically: fresh, after two weeks at 2 $\pm$ 1°C and (except the loins) also after two months at - 20 $\pm$ 1°C (both stored under vacuum).

Lipid oxidation has been followed during these storage experiments by measuring peroxide-numbers and p- anisidine-values. Samples for chemical analysis were always stored (vacuum packaged) at - 40 $\pm$ 1°C

and as soon as possible analysed.

Sensory evaluations

All evaluations have been performed by an expert panel of the Central Institute for Nutrition and Food Research TNO (CIVO/TNO, Zeist) consisting of 5 - 8 members. Judgements have been done by comparing the three blocks for each type of sample in one session using blind codes. The loins have after storage also been evaluated against reference samples. Figures on a scale from 1 (very poor) to 10 (excellent) were given for the characteristics: color and odor/taste. The color was judged on the raw materials; the odor/taste on still warm heated (3 hours at 75°C in a vacuum pouch)samples. Ranked data have been treated statistically (KAHAN et al., 1973).

Methods of analysis

p-anisidine value*	: IUPAC Annexe II_5 - PT 1972.
copper	: by atomic absorption spectro-photometry.
fat	: butyrometric method (KROL and MEESTER, 1963).
fatty acid composition*	: NEN (Netherlands Standardization Organization) 3428.
peroxide number*	: NEN 1046.
α-tocopherol	: by high pressure liquid chromatography.

*Fats have always been extracted with chloroform.

The analytical work has in majority been performed by various departments of the CIVO/TNO.

Results and discussion

Fatty acid compositions

Tables I and II present fatty acid compositions and fat contents of the different samples. From Table I can be concluded that the first aim of reaching linoleic acid levels of resp. about 10, 20 and 30% in the depot fats has been reached succesfully.

Compared with these levels in the depot fats rather low values have been measured for the lean meats. This is however in agreement with recent literature (ANDERSON, 1976, JURGENS et al., 1970, KOOS et al., 1968 and SKELLEY et al., 1975). Apparently fatty acid compositions of lipids present in lean meats are not so easily influenced as those in fatty tissues. The majority of the fats in lean meats being probably structural lipids. Arachidonic acid was detected in significant amounts in the lean meats, but particularly in the livers (up to 16,1% of the fatty acid methyl esters). Also of interest are the other long chain polyunsaturated fatty acids found in this organ (CRAWFORD 1974, 1975).

Lipid oxidation in meats and fatty tissues

Table III presents peroxide numbers and p-anisidine values measured in fresh and stored samples. Striking are the high peroxide numbers determined in fresh M- and H-samples. In the recent literature only a few comparable data (for the N-samples) have been traced. VOLD (1974) reported for fresh back fat a peroxide number range of 0.64 - 0.73 meq/kg fat. BREMNER et al. (1976) investigating the storage stability of beef with increased linoleic acid contents did not detect peroxides in the fresh meats. WURZIGER (1967) and PARDUN (1975) state that the border for the organoleptical detection of rancidity (for lard) corresponds in general with a peroxide number of 20 meq/kg fat. This figure might apply to the samples of the N-block. In vegetable oils onset of rancidity starts at much higher levels of peroxide-numbers,in average at about 100 meq/kg fat (PARDUN, 1975). The fats present in the tissues from the M- and H-blocks, showing no sign of deterioration, behave in this respect probably more like vegetable oils.

The p-anisidine value is a substitute of the benzidine number (PARDUN et al., 1976). With this method aldehydes and especially 2-alkenals, both secondary products of lipid oxidation, are estimated. For these new determination data related to meat are not available. The values assayed for the fresh M- and H-products seem (rather) high again.

In this investigation a general decrease in peroxide numbers and p-anisidine values has been observed during storage. These experiments were however conducted und vacuum at 2 and - 20°C in the dark.

Table IV shows results of the copper and α-tocopherol determinations in some selected samples. Interesting differences between the three blocks can be observed concerning the α-tocopherol contents. For the N-block these contents are in general the highest; for the H-samples the lowest. The α-tocopherol contents of the higher unsaturated tissues may already have been lowered by reactions with (peroxyl) radicals (TAPPEL, 1973 and WITTING, 1975). This kind of meats should probably be better stabilized by increasing the α-tocopherol levels of the tissues (ROTH and KIRCHGESSNER, 1975).

Table I - Fatty acid compositions of lipids present in fatty tissues [a].

	Belly fat.						Back fat.					
	N[b]		M[b]		H[b]		N[b]		M[b]		H[b]	
10:0	0.1	0.1	0.1	-	-	-	0.1	-	0.1	0.1	0.1	-
12:0	0.2	0.2	0.1	0.1	-	-	0.2	0.2	0.1	0.1	0.1	0.1
14:0	1.6	1.8	1.4	1.3	1.0	1.0	1.7	1.6	1.2	1.1	1.0	0.9
15:0	-	0.1	-	-	-	-	0.1	-	0.1	-	0.1	-
16:0	24.8	24.8	21.2	21.3	17.3	18.7	23.8	24.0	19.1	19.9	16.3	17.8
16:1	1.8	1.9	1.4	1.2	1.0	1.1	2.0	1.8	1.2	1.1	1.1	0.8
17:0	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1
17:1	0.2	0.2	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.2	0.2	0.1
18:0	10.4	11.4	10.2	9.5	7.1	8.6	11.5	11.0	10.1	9.7	6.4	8.5
18:1	43.7	43.0	37.4	38.7	29.5	33.7	43.4	44.4	35.8	37.7	29.7	32.7
18:2	11.8	13.2	23.1	23.1	37.6	30.8	14.3	13.2	27.2	25.4	39.0	33.0
18:3	0.7	0.7	1.6	1.6	3.6	2.9	0.8	0.7	2.0	1.9	3.7	3.1
20:0 ai	0.4	0.2	0.3	-	-	-	0.1	0.1	-	-	-	-
20:0	0.5	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
20:1	1.3	0.8	1.0	0.8	0.5	0.8	0.7	1.2	0.8	0.8	0.3	0.6
20:2/20:3	0.5	0.6	1.0	1.0	1.0	1.0	0.5	0.7	1.2	1.1	1.1	1.4
20:3	0.1	0.1	0.1	0.2	0.3	0.4	0.1	0.2	0.4	0.3	0.3	0.4
20:3/21:0	-	-	0.1	-	-	-	-	-	-	-	-	-
20:4	0.2	0.1	0.1	0.2	0.3	0.2	0.1	0.1	0.2	0.2	0.3	0.2
20:0 ai	1.5	0.4	0.4	-	-	-	-	-	-	-	-	-
22:1	0.1	-	-	-	-	-	-	-	-	-	-	-
22:2	-	-	-	-	0.1	-	-	-	-	-	-	-
24:1	-	-	-	-	-	-	-	-	-	-	0.1	-
Fat content[c]	42.6	31.8	34.5	42.3	37.8	48.3	78.0	87.6	84.0	82.8	73.5	78.0

a data present weight percentages of the fatty acid methyl esters.

b two animals per block have been sampled; the samples of each individual pig are always presented in the same sequence.

c weight percentages.

Table II - Fatty acid compositions of lipids present in lean meats and livers[a].

	M. longissimus dorsi (ribs 7 to 10).						M. sartorius.				Livers.	
	N[b]		M[b]		H[b]		N[b]		M[b]		H[b]		N[d]	M[d]
10:0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-
12:0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-
14:0	1.6	1.5	1.4	1.4	1.5	1.3	1.5	1.3	1.3	1.2	1.3	1.0	0.5	0.3
15:0	-	-	-	-	-	-	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1
16:0 i	-	-	-	-	-	-	0.1	-	0.1	-	-	-	0.1	0.1
16:0	25.9	26.4	24.4	24.5	22.5	23.1	25.1	24.7	23.1	22.1	23.0	22.6	15.6	12.0
16:1	2.9	2.9	2.6	2.4	2.4	2.1	2.9	2.5	2.0	2.0	2.3	1.7	0.5	0.4
17:0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.3	0.5
17:1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
18:0	12.7	11.6	11.2	10.6	9.7	10.0	11.2	10.8	10.2	9.3	8.7	8.7	24.7	28.0
18:1	48.5	48.8	44.6	47.3	39.4	39.9	43.7	42.2	37.8	39.7	34.8	32.8	19.2	14.2
18:2	6.2	6.1	12.5	10.9	20.5	19.2	10.9	12.9	19.7	20.1	24.3	27.5	15.2	21.3
18:3	0.4	0.3	0.8	0.8	1.8	1.4	0.5	0.5	1.1	1.2	1.8	1.7	0.5	0.8
20:0 ai	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
20:0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20:1	0.6	1.0	0.7	0.8	0.4	0.6	0.6	0.8	0.8	0.7	0.4	0.4	0.2	0.2
20:2/20:3	0.2	0.2	0.5	0.5	0.6	0.7	0.3	0.3	0.6	0.6	0.6	0.7	0.5	0.6
20:3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.7
20:3/21:0	-	-	-	-	-	-	-	-	-	-	-	-	0.6	0.5
20:4	0.3	0.4	0.5	0.2	0.4	0.9	1.8	2.2	2.0	1.9	1.2	1.9	16.1	16.0
22:0 ai	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1
22:0	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-
22:1	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.2
22:2	-	-	-	-	-	-	-	0.1	-	-	0.1	-	0.1	0.2
22:3	-	-	-	-	-	-	-	-	-	-	-	0.2	1.0	0.9
22:5	-	-	-	-	-	-	0.2	0.3	0.2	0.2	-	-	0.2	-
24:0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24:1	-	-	-	-	-	-	-	0.1	-	-	-	-	1.5	1.8
22:6	-	-	0.1	-	0.1	0.1	0.2	0.2	0.2	-	-	-	1.8	0.9
Fat content[c]	2.0	1.6	1.4	1.8	1.5	1.0	0.6	0.9	1.0	1.3	0.7	0.8	3.5	3.0

abc see footnotes table I.

d only two livers were analysed due to some laboratory error; these livers are derived from the same pigs as the N- and M-samples presented in second position.

Table III-Course of the lipid oxidation indicators during storage of the different meat and fat samples

Storage		Peroxide-numbers (meq/kg fat). Fresh	14d 2°C	62d - 20°C	p-Anisidine-values (calculated on fat base). Fresh	14d 2°C	62d - 20°C
Belly fat	N	0.3	0.5	0.9	0.4	0.3	0.7
	M	14.2	0.8	1.1	2.7	1.9	1.0
	M	49	5.3	12.6	7.1	0.7	3.8
Loins	N	1.2	0.5		0.9	0.9	
	M	11.2	1.1		4.0	4.0	
	H	21.6	6.9		7.8	7.8	
Ham steaks	N	4.0	4.0	0.7	4.0	1.1	9.1
	M	49	13.8	2.3	38.2	4.0	21.8
	H	58	23.5	22.1	44.2	9.4	32.5

Table IV- Copper and α-tocopherol determinations (both in mg/kg).

	Copper. N	M	H	α-Tocopherol (as acetate). N	M	M
Belly fat[b]	0.9	0.8	0.8	1.3	1.9	1.7
	0.9	0.6	0.7	3.1	1.8	1.7
M. sartorius[b]	2.0	2.1	2.5	1.0	0.7	0.7
	1.1	1.2	1.2	1.8	1.0	1.2
Liver[b]	37	29	41			
	26	15	12			
Back fat[b]				4.1	2.5	2.2
				4.1	2.7	1.0

[b] see footnote table I.

Sensory evaluations

In practice it is generally agreed that the best way to judge samples in relation to rancidity comprises a sensory evaluation and some form of lipid oxidation measurement. The chemical part will give information about the progress of the oxidative processes proceeding, the sensory evaluation will however prevail in most judgements.

During this investigation no significant differences in the scores for color and odor/taste were observed between the three blocks with all the samples collected. The scores for the stored loins did not show a significant decrease compared to the judgements for the reference samples. In all the sessions no remarks on rancidity were made.

Meats and fats produced in this investigation appeared thus highly acceptable.

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