Decoding the aroma of salmon

Aleksandra Zhogoleva, Hanna Lang, **Sirli Rosenvald**

Abstract

The sensory properties of fish alternatives have yet to meet the diverse expectations of consumers. A notable gap in knowledge surrounds the identification of key molecules responsible for the characteristic flavor of salmon and other fish species, which serves as a valuable foundation for replicating these qualities in alternative products.

The First objective is to get a list of the most relevant aroma molecules in salmon with quantitative data. The measure of success is the ability to put together the aroma of salmon with selected pure molecules. The second objective is to recreate the aroma of salmon by using different fat sources and carrying out flavor reactions.

The gained knowledge could be directly used to develop either new food ingredients or new alternative products. For example, fish alternative producers will get the knowledge of which fat source will contribute to different flavor types and how to guide it by using different processing parameters.

Background

As concerns about sustainability, overfishing, and environmental impact grow, there's an increasing demand for alternative protein sources. Fish alternatives have the potential to provide a more sustainable and ethical option for consumers seeking to reduce their reliance on traditional seafood. While there is a growing market for fish alternatives, consumer satisfaction with these products often hinges on their sensory attributes, particularly taste and aroma. Meeting or exceeding the sensory expectations of consumers is vital for the acceptance and adoption of these products. Developing fish alternatives requires a deep understanding of ingredients and formulations. Identifying key flavor molecules allows for more precise ingredient selection and formulation adjustments to better mimic the taste and aroma of real fish.

Methods

HS-SPME GC-Olfactometry

GCMS-QP2020 NX system (Shimadzu): GC-2030, mass spectrometer QP2020, autosampler AOC-6000 Plus GC-O: PHASER-L olfactory port with SilFlow splitter, Olfactory Voicegram software (GL Sciences Inc.) Sample prep. 1.0g in 20 ml vial, extraction at 50°C for 50min. Smart SPME fiber (DVB/Car/PDMS, 1 cm 4 trained assessors in two replicates. 1−3 Intensity scale (1-weak, 3-strong). GC–Olfactometric data were processed using modified frequency (MF%).

HS-SPME GC-MS analysis

GC-TQMS system (2030; Shimadzu): mass spectrometer (8050NX Triple Quadrupole; Shimadzu), autosampler (AOC-6000). Sample preparation: 1.0g in 10 ml vial + ISTD, extraction at 50°C for 40min. DVB/Car/PDMS SPME fiber, ZB5-MS column.

Preliminary results

Table 1. Key odor-active molecules in cooked salmon fillet with their modified frequency values (max 100) and potential formation pathway.

Class of compounds	Compound	Odour	LRI	MF (%)	Precursor
Amine	Trimethylamine	fishy	<500	100	TMAO
Polyunsaturated aldehydes	(E,Z)-2,4-Heptadienal	floral	1000	29	DHA, EPA, Linolenic acid (PUFAs)
	(E,E)-2,4-Octadienal	fatty	1118	43	Linolenic acid (PUFAs)
	(E,Z)-2,6-Nonadienal	cucumber	1160	94	EPA, Linolenic acid (PUFAs)
	(E,E)-2,4-Nonadienal	fatty	1227	63	Linoleic acid (PUFAs)
	(E,E)-2,4-Decadienal	fatty	1332	63	Linoleic acid (PUFAs)
Unsaturated aldehydes	(Z)-4-Heptenal	fishy	902	87	Linolenic acid (PUFAs)
	2-Methyl-2-butenal; 3-Penten-2-one	chemical	738	60	Linolenic acid (PUFAs)
Aliphatic aldehydes	Propanal	alcohol	<500	14	Linolenic acid (PUFA)
	Hexanal	grass	802	63	Linoleic acid, Oleic acid (PUFA, MUFA)
	Octanal	floral	1005	56	Oleic acid (MUFA)
	Nonanal	fresh	1107	46	Oleic acid (MUFA)
	Decanal	citrus	1211	20	Oleic acid (MUFA)
	Undecanal	washing	1311	14	Linoleic acid, Oleic acid (PUFAs, MUFAs)
Aldehydes	Methional	boiled potato	913	66	Methionine
	3-Methylbutanal	whiskey	655	7	Leucine
	Phenylacetaldehyde	honey	1061	32	Maillard
Ketones	2,3-Butanedione	buttery	587	40	Maillard
	2,3-Pentanedione	buttery	690	31	Maillard
	6-Methyl-5-Hepten-2-one	metallic	983	60	Xanthophylls and Carotens degradation
	3,5-Octadien-2-one	citrus	1102	54	EPA (PUFAs)
	2-Cyclohexen-1-one, 4-hydroxy-	popcorn	1030	46	Maillard
Alcohols	1-Penten-3-ol	cheesy	683	28	DHA, EPA (PUFAs)
	(Z)-2-Penten-1-ol	roasted onion	764	20	DHA, EPA (PUFAs)
	1-Octen-3-ol; 1-Octen-3-one	mushroom	979	71	Linoleic acid (PUFAs)
	2-Butyloctanol	floral	1373	54	Linolenic acid (PUFAs)
Pyrazine	2,3-Dimethylpyrazine	popcorn	927	66	Maillard

Table 2. Fatty acid composition of salmon oil and some reference oils based on the averages from the literature and product specifications.

	Linseed oil	Hemp seed oil	Commercial algae oil from Schizochytrium sp.	Commercial salmon
Fat content (%)	93 – 99	100	98 – 99	6 – 18
SFA (%)	9 – 11	9 – 10	20 – 30	14 – 20
Palmitic acid (%)	5 – 11	6 – 9	5 – 27	8 – 13
MUFA (%)	16 – 20	12 – 16	15 – 20	40 – 50
Oleic acid (%)	15 – 20	11 – 16	1 – 13	13 – 39
PUFA (%)	69 – 75	70 – 80	40 – 50	30 – 41
Linolenic acid (ALA) (%)	40 – 64	16 – 20	0.5 – 2.5	1 – 14
Linoleic acid (LA) (%)	14 – 19	50 – 70	0.1 – 0.2	1 – 10
Eicosapentaenoic acid (EPA) (%)	nd	nd	0.5 – 0.6	2 – 7
Docosahexaenoic acid (DHA) (%)	nd	nd	40 – 46	4 – 14

Conclusions and future steps

GC-O analysis confirmed that most of the odor-active molecules originated from fat sources. Specifically, PUFAs are the main source of important odor-active molecules. Trials for quantitation with GC-MS are ongoing in parallel with omission tests to validate the importance of each single molecule.

Heating trials with different plant and algal fats have partially been conducted, though the presence of antioxidants in commercial oils has been an obstacle. In the future fat extraction for the aroma reaction testing will be carried out.

By the end of the project, potential quantitative data on salmon aroma molecules will be determined and the best oils for generating these aroma molecules together with the technological scheme will be developed.