SELECTION OF FISH OILS FOR DESIGNING OF MEAT PRODUCTS ENRICHED IN OMEGA-3 FATTY ACIDS

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Introduction

The aim of this study was to determine the most adequate type of fish most adequate as source of oil rich in polyunsaturated omega-3 fatty acids for functional meat products processing. Five methods of solvent extraction were chosen for comparison with supercritical carbon dioxide extraction in terms of their efficiency in extracting non degraded lipids from three different kinds of fish: orange roughy, hake and kingklip. The methods were firstly compared regarding to the amount of total fat extracted, as well as fatty acid profile. In a second step fish oils were compared with the fatty acid profile of several commercial meat products fortified with omega-3 fatty acids marketed in Spain.

Materials and Methods

Raw material. **Fish skin** provided by Pescanova, which obtains it as a by-product of the processing of fish steaks. Three different kinds of fish were compared: orange roughy (*Hoplostethus atlanticus*), hake (*Merluccius capensis - Merluccius paradoxus)* and kingklip (*Genypterus capensis*). Frozen fish skin was cut into small pieces (2-5 mm equivalent average diameter) with a cutter (CT25, Talleres Cato S.A. Spain). **Commercial meat products** enriched in omega-3 fatty acids. Six products were analysed: chicken and turkey burger, turkey burger, turkey breast, pork ham, "chorizo" and "salchichon".

Fish oil extraction. Six different extraction methods were compared: 1. Bligh and Dyer method (1959) using chloroform/methanol/water (2:1:0,8) as solvent; 2. Nilsson et al. (1994) using n-hexane/isopropanol; 3. Hara and Radin (1978) using n-hexane/isopropanol (3:2), followed by a wash of the extract with aqueous sodium sulphate to remove nonlipid contaminants. 4 and 5. Soxhlet using petroleum ether or hexane as solvent in a Büchi extraction system (B-811); 6. Extraction with supercritical carbon dioxide (SFE). SFE was carried out in a semi-pilot SFE-plant at 40 ºC, 25 MPa and 10 kg CO_2/h during 4 hours.

Extraction of fat from meat products. Bligh and Dyer method was used.

Fatty acid composition. Fatty acid methyl esters were prepared according to AOAC (2000). Methyl tricosanoate (23:0) was used as an internal standard, and fatty acid methyl esters were analyzed using gas chromatography.

Free Fatty Acids (FFA). FFA-contents were determined by acidimetric titration of the different extracts using phenolphthalein as an indicator. The FFA content was calculated as oleic acid (AOCS, 1990).

Results and Discussion

Kingklip showed the most suitable fatty acid profile, with a high proportion of DHA and EPA, followed by hake that also presented a high content of these fatty acids (Figure 2). However, orange roughy, that contained a lot of fat (see Table 1), exhibited a proportion of omega 3 fatty acid far below than the other two species (Figure 1). If total oil content and fatty acid profile are taken into account, hake is the best choice as source of oil for omega-3 fortified meat product elaboration. Regarding the extraction method, supercritical fluid extraction is beyond all question the election technique, since no toxic solvents are used and operation temperature is low restricting degradation of oil extracted. Free fatty acid values could be influenced both by the selectivity of the method, due to the solubility of different types of lipids in each solvent, and by the degradation of fat during extraction since FFA is an index of fat hydrolysis. In this sense, SFE produce the best oil in terms of oil degradation (Table 1). Hexane extraction, which is nowadays used as industrial scale, could be a second option to consider; however it presented worse performance both in oil yield and degradation (Table 1).

Table 1. Total lipid yield (%) and free fatty acids (%) corresponding to different extraction methods

Extraction method	Hake		Orange roughy		Kingklip	
	Yield	FFA	Yield	FFA	Yield	FFA
SFE	4.0	2.7	33.8	0.4	0.7	-
Bligh and Dyer	4.9	5.3	46.8	0.5	0.6	-
Nilsson et al.	3.7	5.3	34.5	0.8	0.5	-
Hara and Radin	4.1	6.6	37.3	0.5	0.9	-
Soxhlet (eter)	4.0	3.7	35.7	0.8	0.1	-
Soxhlet (hexane)	3.7	5.2	27.6	0.7	0.1	-

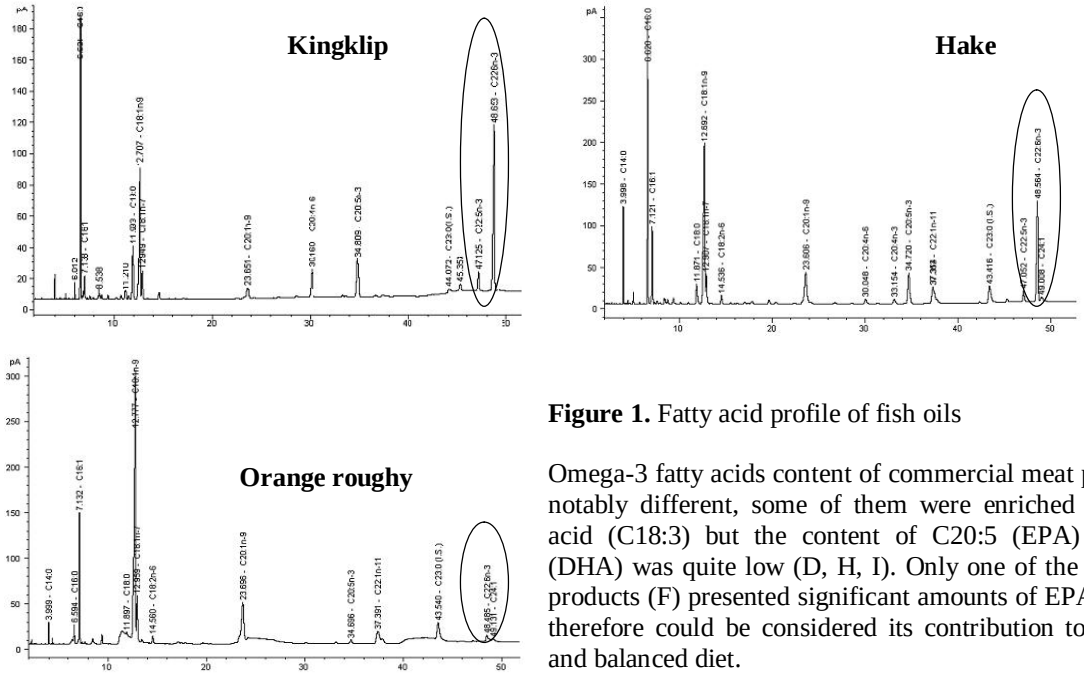

Figure 1. Fatty acid profile of fish oils

Omega-3 fatty acids content of commercial meat products are notably different, some of them were enriched in linolenic acid (C18:3) but the content of C20:5 (EPA) and C22:6 (DHA) was quite low (D, H, I). Only one of the commercial products (F) presented significant amounts of EPA and DHA, therefore could be considered its contribution to a healthier and balanced diet.

Table 2. Fatty acid composition of three fish oils and commercial omega-3 enriched meat products

Fatty acid	Fish oils			Commercial omega-3 enriched meat products					
(mg/g oil)	A	B	C	D	E	F	G	H	I
C14:0	4.0	18.8	3.1	9.8	5.3	7.9	7.8	9.5	10.2
C16:0	70.1	108.2	5.5	195.3	98.8	74.7	107.2	171.2	177.5
C18:0	31.8	18.5	16.4	79.5	44.6	42.8	54.2	98.0	100.0
Saturated	105.9	145.6	25.0	284.6	148.6	125.4	169.3	278.7	287.7
C16:1	8.7	30.5	33.6	31.4	13.3	17.2	16.4	17.5	18.5
C18:1	103.9	142.6	187.2	334.6	152.1	105.9	197.9	302.5	310.4
C20:1	14.4	48.4	42.2	5.2	2.4	8.0	6.3	6.2	5.7
C22:1	1.9	33.2	13.5	-	-	4.1	1.9	-	-
Monounsaturated	127.0	221.6	263.0	371.2	167.8	131.1	220.6	326.2	334.6
C18:2	10.1	6.3	3.7	219.7	106.9	55.7	65.9	86.0	80.6
C18:3 w-3	**-**	**2.2**	**0.6**	**16.2**	**9.3**	**3.8**	**4.1**	**18.7**	**17.1**
C20:4	23.5	5.0	1.2	15.5	7.2	16.8	11.0	2.8	2.8
C20:5 w-3	**24.5**	**32.4**	**2.4**	**3.6**	**1.8**	**30.5**	**10.4**	**-**	**-**
C22:5	11.5	9.2	0.6	2.8	1.5	7.5	2.9	1.6	1.4
C22:6 w-3	**117.1**	**79.9**	**4.2**	**5.4**	**3.6**	**35.4**	**8.7**	**3.1**	**3.0**
C24:1	4.6	6.7	2.3	-	-	-	-	-	-
Polyunsaturated	191.3	141.7	15.0	263.2	130.3	149.7	103.0	112.2	105.0

Fish: (A) kingklip, (B) hake, (C) orange roughy; Meat products: (D) chicken and turkey burger, (E) turkey burger, (F) turkey breast, (G) pork ham, (H) "chorizo" and (I) "salchichon".

Conclusions

Hake oil is the most suitable for omega-3 fatty acid fortification of meat products. SFE must be used for obtaining fish oil, since oil modification is slight and solvent used is no toxic. Fatty acid composition of functional meat products must be improved for their effective contribution to nutritional needs of omega-3 fatty acids.

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