International Association of Fish Meal Manufacturers

P1823

Development of Foods containing Unhydrogenated Fish Oil

April 1986

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for

The International Association of Fish Meal Manufacturers

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DEVELOPMENT OF FOODS CONTAINING UNHYDROGENATED FISH OIL

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1. SUMMARY

Four varieties of fish oil were refined in the laboratory, conditions being optimised for a bland flavour and minimal loss of eicosapentaenoic and docosahexaenoic acids in menhaden oil.

The stabilities of these oils were assessed by both subjective and objective means.

Blends of the fish oils with stable vegetable oils and various antioxidant combinations were also studied.

A range of foodstuffs was prepared which incorporated various levels of fish oil. In most cases, there were no major technical problems involved in manufacture and the flavour of the finished product was acceptable.

2. INTRODUCTION

Natural fish oils are known to contain high concentrations of highly unsaturated fatty acids, and they therefore have specific nutritional advantages in comparison with vegetable oils. The highly unsaturated fatty acids of most importance are eicosapentaenoic and docosahexaenoic acids (EPA and DHA, respectively). These two acids have 20 and 22 carbons with 5 and 6 double bonds, respectively, and they are therefore abbreviated to C20:5 (= EPA), and C20:6 (= DHA). These fatty acids also confer oxidative instability to the fish oils containing them, allowing the oils to be broken down rapidly by the action of atmospheric oxygen, quickly producing off-flavours and fishy odours. For this reason the oils are not used in a natural state, but are instead partially

hydrogenated before incorporation into human foods. This hydrogenation increases the resistance to oxidation and extends the shelf-life. Unfortunately, as it converts the highly unsaturated fatty acids to their more saturated counterparts, it also reduces the nutritional advantages of the oil.

It was therefore decided that an effort should be made to explore new methods of oil processing, techniques for incorporation of fish oils into a range of foodstuffs and novel forms of packaging. It was hoped that success in this area would produce foods with a satisfactory shelf-life and which would retain the nutritional advantages of the EPA and DHA components of natural fish oils.

The Food R.A. was asked to prepare a range of foodstuffs which incorporated different levels of fish oil. The antioxidants butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT) had been added at a level of 100 ppm to each type of oil.

It was agreed to pursue development of six categories of foods, which are listed below. Priorities were assigned to the order of preparation of the categories by representatives of the IAFMM.

Group	Foods	Priority
A	Spreads and pastes	1
B	Butter analogues and margarines	3
C	Salads and salad dressings	1
D	Dairy products	4
E	Oils and oil blends	1
F	Sausages, smoked and spiced foods	2

Priorities: 1 = high, 4 = low

Finished products were assessed informally by Dr S Barlow, Mr V Young and staff of the Food R.A.

Samples of some products have been stored to give preliminary indications of shelf-life.

This report describes the development of oil processing methods, determination of the composition and stability of each processed oil batch and the production of trial batches of foods containing unhydrogenated fish oils. The report also includes an evaluation of the foods and gives recommendation for future work.

Detailed procedures, formulations and analyses are given in the appendices.

3. OBJECTIVES

1. To optimise processing conditions for the refining and deodorisation of fish oils.

2. To determine the composition of the deodorised fish oils, especially with regard to the EPA and DHA content.

3. To assess the flavour stability of the deodorised oils by subjective and objective means.

4. To assess properties of various oil blends and antioxidant combinations.

5. To demonstrate the feasibility of the inclusion of such oils in a range of foodstuffs and to give some indications as to the acceptability of the finished products.

4. OPTIMISATION OF REFINED FISH OIL PRODUCTION

4.1 Processing of Fish Oil

Four varieties of fish oil were received; they were: Atlantic menhaden; Norweigan pout and sprat; Chilean pilchard oil; and herring oil.

The different oils were neutralised, bleached and deodorised according to the conditions given in Appendix I.

The processing conditions were optimised for menhaden oil, in an attempt to obtain a combination of flavour stability and maximum retention of the essential fatty acids EPA and DHA.

Subsequent tests showed menhaden to be the most successfully refined, there being a reduction of only 2.7% in the concentration of the essential fatty acids (EFA), and the flavour stability was good.

Under the same processing conditions the performances of herring oil and Norweigan pout and sprat were comparable. They both exhibited good stability and the loss of EFA was minimal at 1.5% in both cases.

The pilchard oil showed the least stability after this processing, a strong flavour reversion being apparent after only 24 hours.

The effect of the addition of a number of antioxidants was also examined; the commercial antioxidants such as Grindox 109 and 110 and TBHQ conferring a greater stability to the oil than any of the natural antioxidants such as rosemary, sage, lecithin or alpha-tocopherol.

4.2 Conclusions

1. It is possible to refine fish oils to produce a bland oil of reasonable stability. Some fish oils, notably menhaden, were found to be easier to process than others, although other oils, such as pilchard, may prove equally attractive if processed under conditions more suited to their own requirements. Only one batch of each oil was processed, and batch-to-batch variation within an oil type may explain the disappointing results with pilchard oil.

2. The temperature at which the oil is deodorised is critical. When a temperature of 215°C was used the essential fatty acids DHA and EPA were found to have been partially lost; whereas at a working temperature of approx. 200°C, this loss was minimal.

3. Omission of a second addition of citric acid was also found to be beneficial in producing a bland oil of good stability.

5. DEVELOPMENT OF FOOD PRODUCTS CONTAINING FISH OILS

5.1 Pastes and Spreads. Group A

5.1.1 Tuna fish spread

A tuna fish spread was prepared using a blend of menhaden fish oil and olive oil (60:40), the total fish oil content of the finished product being 10.8%.

Comments made during informal tasting indicated that the product was acceptable.

5.1.2 Tuna fish and mayonnaise spread

A mayonnaise base was used to replace the oil in a typical fish spread. The fish oil content of the product was 2.7%. A sample was prepared for comparison with a commercially available tuna and mayonnaise spread.

Comments made during informal tasting indicated that the experimental product compared favourably with the commercial sample.

5.1.3 Cheese spread

Cheddar cheese spreads were prepared using pout/sprat, and herring fish oils and compared with a sample made with butter.

The oils or butter were added at a level of 3.3%. Samples were informally tasted after storage for a period of 1 month at $4^{o}C$. No detectable flavour deterioration was noticed in either fish oil based product when compared with the control.

5.1.4 Peanut butter

Peanut butter incorporating pout and sprat fish oil at levels of 0%, 5% and 10% was produced. Samples were tasted at home by IAFMM representatives who reported that there were no discernible flavour differences. Slight differences in texture were, however, noticed. Increasing levels of fish oil caused a lower viscosity. This was due to a higher total oil content.

5.2 Butter Analogues and Margarines. Group B

These products would require larger quantities of refined, deodorised fish oils than were available during this project. No work was therefore carried out under this category.

5.3 Salads and Salad Dressings. Group C

5.3.1 Mayonnaise

Using a proven recipe for a basic Mayonnaise, attempts were made to incorporate a blend of menhaden and groundnut oil into the formulation. No successful emulsions were formed, even at a ratio of 10:90 fish oil:groundnut oil.

Further work was considered inappropriate within this project.

5.3.2 Spoonable salad dressing

A sample of a "spoonable" salad dressing was prepared which contained 60% total oil as a 60:40 blend of menhaden fish oil and olive oil. This dressing was compared with a formulation based only on olive oil. Samples were kept refrigerated in glass containers for 4 days before they were tasted. The sample containing fish oil had a pronounced odour and taste of fish.

5.3.3 Salad cream

Salad creams were prepared containing oil components as shown in Table I.

TABLE I Salad cream preparations

	% sunflower oil	% groundnut oil	% olive oil	% pout & sprat oil	
Control	25.0	0.0	0.0	0.0	
Trial 1	12.5	10.0	0.0	2.5	9:1
Trial 2	12.5	5.0	0.0	7.5	7:3
Trial 3	12.5	0.0	10.0	2.5	9:1
Trial 4	12.5	0.0	5.0	7.5	7:3

All salad creams were kept for 6 days at 4°C before tasting. Samples which contained 2.5% fish oil were quite acceptable, but those which contained 7.5% fish oil were thought to exhibit an initial fish flavour which was quickly masked by the mustard flavour.

The vegetable oil used for blending with the fish oil did not appear to influence the product characteristics.

5.4 Dairy Foods. Group D

5.4.1 Natural yoghurt

Samples of natural yoghurt were prepared and contained the following amounts of pilchard fish oil:-

a) 0% fish oil
b) 1.5% fish oil
c) 0.9% fish oil + 0.6% groundnut oil
d) 0.3% fish oil + 1.2% groundnut oil
e) 0.9% fish oil + 0.6% groundnut oil + 1% stabiliser

The milk/oil base was homogenised and held at chill temperature overnight prior to addition of a starter culture. Some reversion of the fish oil had taken place prior to incubation. Staff at the Food R.A. assessed the finished product and described all the samples as unacceptable because of a strong fish flavour. Attempts to improve the taste of the yoghurt using fruit flavours were unsuccessful.

5.5 Oils and Oil Blends. Group E

5.5.1 Salad oil dressing

A standard French dressing was prepared containing 51.8% olive oil for comparison with two samples, one containing 31% menhaden fish oil and the other 10%. The oil content of both was maintained at 51.8% by addition of olive oil.

5.5.2 Coleslaw

Samples of coleslaw were prepared using each of the dressings given in 5.5.1. Samples were tasted informally and it was concluded that there were no differences between the samples.

5.5.3 Canned tuna fish

Tuna fish steaks were prepared according to a commercial recipe and packed into 5-oz cans. Blended or pure menhaden fish oil was added at a level of 25% of the weight of fish flesh. The cans were sealed and processed to commercial sterility.

Five variations of product were made containing the following quantities of oil:

	% menhaden oil	% groundnut oil	% olive oil
a)	25	0	0
b)	15	10	0
c)	5	20	0
d)	15	0	10
e)	5	0	20

Informal tasting of these products indicated a difference between samples containing olive oil and those containing groundnut oil. Samples a, b and c were the most acceptable.

5.5.4 Canned sardines

A commercial recipe for canned sardines was used to prepare fish fillets for canning. Samples were packed in 5-oz cans which contained 30% oil and 70% fish flesh and were then processed to commercial sterility.

The range of samples produced were:-

Oil content per can

a) 30% groundnut oil
b) 30% herring fish oil
c) 30% pout/sprat fish oil
d) 18% herring oil 12% groundnut oil
e) 18% pout/sprat oil 12% groundnut oil

5.6 Sausages, Smoked and Spiced Foods. Group F

5.6.1 British pork sausage

The standard British pork sausage has been included in this work as there is a great deal of consumer interest in low-fat and healthier sausages. By incorporation of fish oils into a sausage, the polyunsaturated to saturated fat ratio can be increased from the standrd 0.1 to 0.45, this being the recommended level given in the COMA report. (Diet and Cardiovascular Disease. HMSO report on health and social subjects No. 28, 1984) In a standard sausage formulation 3.3% menhaden fish oil and 2.2% groundnut oil were substituted for back fat. The oils were added during the chopping stage.

On assessment of the sausages, no fish odour or any objectionable flavour changes were detected when a comparison was made with the control sausage.

5.6.2 Fermented sausage

Fermented "salami"-type sausages were prepared using pout/sprat fish oil and herring fish oil as a replacement for pork fat. The fish oils were added as part of the emulsion during the chopping stage. A control sausage was also fermented which contained pork back fat.

On assessment of the finished product, the sausage sample containing pout/sprat fish oil was thought to have reverted.

The sausage containing herring fish oil compared favourably with the control.

5.7 Conclusions

It has been demonstrated that several varieties of refined, deodorised fish oils can be successfully incorporated into a wide range of food products.

In most cases there were no serious technical or flavour problems associated with the trials. In those cases where problems were encountered, it was felt that further development work and the provision of optimally processed oils could provide a solution.

Shelf-life of the prepared foods has not been fully investigated.

6. RECOMMENDATIONS FOR FUTURE WORK

6.1 Processing, Composition and Stability of Fish Oils

6.1.1 Optimisation of processing conditions

The processing conditions used throughout the work so far were established for menhaden oil. It is possible that the other oils may perform better under different conditions; therefore it would be beneficial to carry out a more detailed study on each of the individual fish oils, using more than a single batch of each oil type. The conditions to be optimised are as follows

a) Temperature at each stage of processing

b) Type and amount of bleaching earth used should be varied, together with the contact time and temperature of the bleach.

c) Volume of steam and its distribution in the oil are other factors which are important in the deodorisation stage.

6.1.2 Natural antioxidants

The use of natural antioxidants such as rosemary and sage was considered. This could be explored in greater depth by obtaining samples from a series of different suppliers. The most suitable concentrations of each antioxidant could also be established. Furthermore, vitamin C palmitate should be studied, as well as the addition of various natural tocopherol (vitamin E) compounds.

6.1.3 Synthetic antioxidants

Synthetic antioxidants should also be studied in greater detail. Originally, these were only tried individually but they have been known to work more effectively when used in combination with one another, as synergism is often exhibited.

6.1.4 Investigation of any unknowns produced

A number of unknowns were produced during the processing of the fish oils. It is important, if the food products are to be sold on the basis of their high nutritive value, that any unknowns produced are thoroughly checked, preferably by GCMS to ensure that no unfavourable compounds have been produced.

6.2 Food Development, Packaging and Shelf-life

6.2.1 Product development

The work described in this report covers only a small cross-section of the total spectrum of possibilities and the level of oil inclusion has not been fully explored. It is recommended that further work should overcome any technical difficulties highlighted in this report and that the level of fish oil addition should be optimised/maximised for each product. The range of products could also be expanded.

6.2.2 Packaging

It is recommended that both established and new methods of packaging (e.g. plastic toothpaste tubes, gas packaging, etc.) should be explored in order to extend the shelf-life of fish-oil-containing products.

6.2.3 Shelf-life

It is recommended that full shelf-life studies be conducted on a selection of the most successful samples of foods.

6.2.4 Marketing considerations

An assessment of potential market volume and any consumer resistance to foods containing fish oils is recommended as part of any future project work.

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APPENDIX I - OIL PROCESSING, COMPOSITION AND STABILITY DATA

Processing of the Fish Oil

Four types of oil - Atlantic menhaden, Chilean pilchard, Norweigan pout and sprat, and herring oil - were supplied in quantities ranging from 10 to 50 kg batches. On arrival, these oils were transferred to 1-litre brown glass jars and stored at 2°C.

Degumming

The oil was heated under nitrogen at all times. At 60°C, 100 ppm of citric acid, as a 2% aqueous solution, was added to the oil, which was then stirred for 15 minutes.

To avoid excessive handling the precipitate formed was not removed prior to the neutralisation stage.

Neutralisation

The free fatty acid content of the crude oil was first measured. The required amount of 4M sodium hydroxide solution giving a 10% excess of caustic was then added to the oil at 80°C. After stirring for 15 minutes, under nitrogen, the oil was centrifuged at 6000 rev/min for 10 min to remove the soaps that had formed. Washing was carried out at 80°C, hot distilled water was added to the oil; and the water-soluble materials were removed. This was continued until the washings were neutral. The warm oil was filtered through IPS filter paper under a bed of sodium sulphate, in order to remove any excess water prior to the drying of the oil.

Drying

The oil was dried under vacuum at 105°C for 30 minutes or until no more water was apparent. A vacuum of 2 torr was obtained.

Bleaching

The neutralised washed and dried oil was heated to 80°C whilst being purged with nitrogen and stirred. One per cent by weight bleaching earth was added to the oil; the working temperature was raised to 105°C and held there for 15 minutes.

After cooling to 80°C under nitrogen, vacuum filtration was used to remove the bleaching earth from the warm oil.

Deodorisation

The deodorisation process was carried out on 2 litres of oil. An addition of 100 ppm of citric acid was made to the oil as a 10% solution. Nitrogen was passed through the apparatus prior to starting the vacuum. Once a vacuum of 1-2 torr had been obtained, the oil was heated to 200°C, the removal of volatiles being assisted by a steady flow of steam. This process was continued for 5 hours at which time the oil was cooled while the vacuum was maintained until a temperature of approximately 80°C was reached. Initially, a further 100 ppm of citric acid were added at this point but because this resulted in flavour reversion problems this step was omitted.

The refined bleached and deodorised oil was refrigerated under nitrogen in brown glass jars.

The initial method development work was carried out on the Atlantic menhaden oil and several quality control tests were carried out during the different stages of processing when working on this oil. Not all of these tests were applied once the method had been established.

The fatty acid composition of menhaden oil under different conditions of deodorisation was determined and the changes in levels of EPA and DHA are given in Table AI. It can be seen that losses of these essential fatty acids were minimal at 180°C but problems still remained with flavour reversion at this temperature. At 215°C significant EFA losses occurred without any apparent increase in stability. Only after the ommission of the final citric acid addition did favourable essential fatty acid levels combine with good oil stability. A deodorisation temperature of 200°C was finally chosen as this gave good stability and acceptable EFA losses.

Because of these findings it was decided to carry out all subsequent deodorisations at 200°C, omitting the final citric acid addition.

Comparison of the Different Oils under the Same Processing Conditions

The deodorisation of the different types of oils gave fatty acid compositions as shown in Tables AII to AV. Menhaden proved the most successful having no signs of flavour reversion for several days.

With herring oil and pout and sprat oils, only a very slight fishy smell was apparent; this was not unpleasant and was easily masked when present in the food products.

Accelerated oxidation tests showed herring oil to be less stable than pout and sprat oils, but when blended with olive oil, the antioxidants present in olive oil gave pout and sprat oils the greater stability. With groundnut oil the opposite was found. Pilchard oil was found to be the least stable of the four oils; this was also exhibited by the rapid flavour reversion, the oil remaining bland for only about a day.

TABLE AI

Results Obtained for Menhaden Oil at Different Deodorisation Temperatures

Temperature	Observation
180°C 6 hours	Concentrations of C20:5, C22:5. C22:6 remained relatively unchanged, but a fishy odour remained after deodorisation.
215°C 4 hours	C20:5 reduced from 17.4 to 15%. C22:5 increased from 3.1 to 6%. C22:6 reduced from 12.3 to 8%. Odour reversion after a short while.
200°C 5 hours	C20:5 reduced from 17.4 to 16.0%. C22:5 reduced from 3.1 to 2.8%. C22:6 reduced from 13.2 to 11.0%. Poor stability and odour reversion.
200°C 5 hours minus final citric acid addition	C20:5 reduced from 17.6 to 16.7%. C22:5 reduced from 3.1 to 2.8%. C22:6 reduced from 13.2 to 11.5%. Good stability.

TABLE AII

Fatty acid composition for atlantic menhaden oil during processing

Fatty acid	Crude	Refined	Bleached	Deodorised at 200oC
C12:0	0.1	0.1	0.1	0.1
C14:0	6.8	7.0	7.1	7.2
C14:1	0.2	0.2	0.2	0.2
C15:0	0.6	0.6	0.6	0.6
C15:1	tr	0.1	0.1	0.1
C16:0	17.1	17.0	17.5	17.6
C16:1 w7	7.0	7.0	7.1	7.0
C16:1 w5	0.2	0.2	0.2	0.2
C17:0	0.8	0.8	0.6	0.4
C17:1	1.2	1.2	1.2	1.2
C18:0	3.3	3.3	3.4	3.3
C16:4/17:2	0.8	0.9	0.9	0.9
C18:1 t	0.1	0.1	0.1	0.1
C18:1 w9	6.6	6.7	6.8	7.0
C18:1 w7	3.5	3.5	3.6	3.3
C18:1 w5	2.0	2.1	2.0	0.1
C18:2	1.1	1.1.	1.2	1.2
C18:3	0.5	0.6	0.5	0.6
C20:0	0.2	0.2	0.2	0.3
C20:1 t	1.1	1.1	1.1	1.4
C20:1 c	2.7	2.7	2.7	2.7
C20:2	0.3	0.3	0.4	0.3
C20:4	1.2	1.2	1.0	1.0
C22:0	0.1	0.1	0.1	0.1
C22:1	1.5	1.6	1.7	1.3
C20:5	17.6	17.8	17.4	16.7
C22:4	0.9	0.9	0.8	0.9
C24:0	0.5	0.5	0.5	1.1
C24:1	0.7	0.7	0.7	
C22:5	3.1	3.0	3.1	2.8
C22:6	13.2	12.7	12.3	11.5
Unknowns	5.0	2.8	4.8	8.8
Total	100.0	100.0	100.0	100.0

TABLE AIII

Fatty acid composition of pilchard oil

	Crude	Refined, bleached deodorised at 200°C
C12:0	0.1	0.1
C14:0	6.6	7.1
C14:1	0.2	0.3
C15:0	0.7	0.7
C16:0	16.6	17.6
C16:1	5.9	6.6
C16:2	0.5	
C17:0	0.6	1.2
C17:1	0.8	1.2
C18:0	3.4	3.5
C16:4	0.7	0.7
C18:1 w9	7.1	7.0
C18:1 w7	3.3	3.3
C18:2	2.7	2.5
C18:3 isomer	0.1	0.2
C20:0	0.2	0.3
C18:3	0.9	0.7
C20:1	1.3	1.4
C18:4	2.2	2.0
C22:0	1.4	1.4
C22:1	0.4	0.4
C20:4	1.0	0.8
C20:5	16.2	14.0
C24:0	0.9	1.1
C24:1	1.3	0.7
C22:5	3.0	2.6
C22:6	16.2	13.5
Unknowns	5.7	9.1
Total	100.0	100.0

TABLE AIV

Fatty acid composition of pout and sprat oils

	Crude	Refined, bleached deodorised at 200oC
C12:0	0.1	0.1
C14:0	5.5	5.9
C14:1	0.4	0.5
C15:0	0.5	0.1
C15 br	0.1	0.2
C15:1/14:2	0.1	0.2
C16:0	14.8	15.2
C16:1	5.4	5.4
C17:0	0.5	0.8
C17:1/16:2	0.7	0.8
C18:0	1.9	1.8
C16:3	0.3	0.3
C18:1 w9	10.6	10.6
C18:1 w7	3.1	2.0
C18:1 w5	0.2	0.2
C18:2	2.2	2.2
C20:0	tr	tr
C18:3	1.3	1.4
C20:0	8.1	8.5
C18:4	3.1	3.1
C22:0	tr	tr
C20:4	0.6	0.6
C22:1	14.2	14.2
C20:5	8.5	8.1
C24:0	0.1	0.1
C24:1	0.5	0.3
C22:4	0.7	0.6
C22:5	0.8	0.8
C22:6	11.0	9.9
Unknown	4.7	6.1
Total	100.0	100.0

TABLE AV

Fatty acid composition of herring oil

	Crude	Refined Bleached Deodorised at 200°C
C12:0	0.1	0.1
C14:0	7.2	7.2
C14:1	0.4	0.4
C15:0	0.3	0.3
C16 br	0.2	0.2
C16:0	10.5	10.4
C16:1 w7	8.1	8.1
C16:1 w5	0.5	0.5
C17:0	0.3	0.3
C16:2/17:1	0.7	0.7
C18:0	0.7	0.6
C16:3	0.3	0.4
C18:1 w9	8.0	8.0
C18:1 w7	2.0	2.0
C16:4	1.0	0.8
C18:2	1.1	1.1
C20:0	0.1	0.1
C18:3	0.6	0.6
C20:1	15.8	16.1
C18:4	3.0	3.0
C22:0	0.3	0.2
C22:1	19.7	19.5
C20:5	8.4	7.5
C24:0	0.4	0.3
C22:5	0.6	0.5
C22:6	5.0	4.4
Unknowns	4.7	6.7
Total	100.0	100.0

Results of Rancimat Test at 60°C

Blend	Induction Period (hours)
Pilchard oils	
100% fish oil	18
20:80 fish:olive	42
40:60 fish:olive	23
20:80 fish:groundnut	44
40:60 fish:groundnut	25
60:40 fish:groundnut	22.5
Herring oil	
100% fish oil	23
60:40 fish:olive	32
40:60 fish:olive	48
20:80 fish:olive	85
60:40 fish:groundnut	44
40:60 fish:groundnut	74
20:80 fish:groundnut	114
fish + Grindex 109	360
fish + Grindex 110	400
fish + rosemary	16.5
fish + sage	18
Menhaden oil	
100% fish oil	42
Pout & sprat oils	
100% fish oil	35.5
60:40 fish:olive	43
40:60 fish:olive	54
40:60 groundnut:fish	55.5
60:40 groundnut:fish	65.5
80:20 groundnut:fish	91.5
alpha-Tocopherol + fish oil	39
lecithin + fish oil	56
TBHQ + fish oil	

APPENDIX II - RECIPES AND METHODS OF MANUFACTURE

1 - Tuna fish spread 2 - Tuna fish spread with mayonnaise 3 - Cheese spread 4 - Peanut butter	Group A
5 - Mayonnaise 6 - Spoonable salad dressing 7 - Salad cream	Group C
8 - Yoghurt	Group D
9 - Salad oil dressing 10 - Coleslaw 11 - Canned tuna fish 12 - Canned sardines	Group E
13 - British sausage 14 - Fermented sausage	Group F

1. Tuna Fish Spread

Formulation		%
Tuna flesh		65
Oils	Menhaden	10.8
	Olive	7.2
Water		7.25
Corn starch		5.0
Glucose solids		2.0
Salt		1.1
MSG		0.5
Sodium polyphosphate		0.15

Method

Frozen tuna fish steaks were thawed and cooked in a microwave cooker for 5 min. The oil blend was placed with other ingredients in a Kenwood liquidiser and mixed at high speed for 60 seconds to form an emulsion. This emulsion was added to the tuna steaks in a Magimix food processor and chopped for 180 seconds.

The spread was filled and sealed into 5-oz cans, which were sterilised in a retort at 115°C for 70 minutes.

2. Tuna Fish Spread with Mayonnaise

Formulation

Same as 1, but substitute mayonnaise for the olive oil and fish oil.

Method

As for 1, replacing olive oil and fish oil with mayonnaise.

3. Cheese Spread

Formulation	%
Matured Cheddar cheese	55.0
Water	21.5
Whey powder	10.0
Skimmed milk powder	6.5
Pout/sprat or herring oil or butter	3.3
Salt	1.5
Trisodium orthophosphate	2.0
Sorbic acid	0.2

Method

Cheese, water, whey powder and the oils or butter were mixed to a creamy consistency and heated to 75°C in a steam jacketed pan. Salt, sorbic acid and half the phosphate were added and the pH adjusted to 5.2 using citric acid (50% m/V) solution. The remaining phosphate was added and the solution heated to 80°C for two minutes, then passed through an APV homogeniser (single-stage) at 1000 psig. The spread was filled into glass jars, then capped and pasteurised in a steam chest for 2 min. The products were stored in a refrigerator at 4C.

4. Peanut Butter

Formulation	%	%	%
Peanuts	91.3	86.5	81.3
Coconut oil	5.0	5.0	5.0
Sugar	0.7	0.7	0.7
Salt	3.0	3.0	3.0
Fish oil (pout & sprat)	-	5.0	10.0

Method

Peanuts were shelled and roasted in a convection oven at 160°C for 1 hour. Skins and endosperm were removed. Salt, sugar and oils were added to the nuts and mixed to give a homogeneous base. This was passed through a Glen Creston centrifugal mill twice to ensure a smooth-textured final product.

5. Mayonnaise

Formulation		%
A	Mustard flour	0.2
	Water	8.76
B	Egg yolk	7.12
	Egg white	2.32
	Sugar	1.16
	Salt	1.67
C	Spirit vinegar	3.65
D	Oil	75.11
	Mustard flavour	0.02

Oils used were groundnut and groundnut/menhaden blends 80:20, 90:10.

Method

Mustard flour and water were mixed into a slurry and stood for 15 minutes to activate the mustard. The slurry was homogenised in a

Silverson high-speed blender for 15 seconds. Egg yolk was added, followed by sugar, salt and egg white, all of which was mixed for a further 5 minutes. Half the oil was added very slowly whilst mixing was continued at high speed, followed by half the vinegar. The remainder of the oil was added and finally, the rest of the vinegar, whilst mixing was continued constantly.

6. Spoonable Salad Dressing

Formulation	%
Olive oil	36.0 (60% for control)
Menhaden fish oil	24.0 (0% for control)
Water	27.5
Vinegar	4.2
Dried egg yolk	2.6
Sugar	2.0
Salt	1.5
Mustard	1.0
(Starch) Instant Pure Flo	1.0
Xanthan gum	0.2

Method

Dry ingredients were mixed by hand with the vinegar, water and 15% of the oil until the salt and sugar had dissolved. Using the Silverson high-speed blender, the remainder of the oil was added slowly. The product was packed into glass jars and kept refrigerated until used.

7. Salad Cream

Formulation		%
A Mustard Mix	Sugar	6.40
	Mustard flour	3.01
	Salt	2.60
	Water	15.55

B Starch mix	Starch SC5A	1.63
	Xanthan gum	0.10
	Guar gum	0.07
	Malt vinegar	23.43
C Egg mix	Sugar	10.33
	Dried egg yolk	2.71
	(Purity) Starch 539	0.24
	Water	9.43

		OIL CONTENT %				
		Control	1	2	3	4
D Oil blends	Sunflower oil	25.0	12.5	12.5	12.5	12.5
	Groundnut oil	0.0	10.0	5.0	0.0	0.0
	Olive oil	0.0	0.0	0.0	10.0	5.0
	Pout & sprat oil	0.0	2.5	7.5	2.5	7.5

Method

'A' was mixed in the Silverson high blender and heated to 45°C for 5 min.

'B' was mixed in a Braun hand blender then added to 'A'. This mixture was heated to 87°C in a scraped-surface heat exchanger and cooled rapidly to 25°C.

'C' was mixed in the hand blender and then heated to an held at 60°C whilst the oils were added.

Using the Silverson high-speed blender, the oils were mixed with C, followed by A and B.

8. Yoghurt

Formulation

a) Standard yoghurt

b) Pure pilchard fish oil

c) 60:40 Pilchard oil/groundnut oil blend

d) 20:80 Pilchard oil/groundnut oil blend

e) 60:40 Pilchard oil/groundnut oil blend + stabiliser (Snowflake 06305)

	%				
	a	b	c	d	e
Skim milk powder	9.0	9.0	9.0	9.0	9.0
Pasteurised milk	39.0	39.0	39.0	39.0	39.0
Oil blend	–	1.5	1.5	1.5	1.5
Stabiliser	–	–	–	–	1
Water	52.5	50.5	50.5	50.5	49.5

Method

Using a Braun hand blender, the ingredients were mixed prior to pasteurisation in a steam jacketed pan. The mix was cooled to 40°C and passed through an APV two-stage homogeniser at 2,500 psig and 500 psig.

The homogenised milk was kept at 4°C overnight, before being filled into pots in a Mellerware yoghurt maker. 5% starter culture was added to each pot and they were incubated at 37°C until a pH of 4.5 was achieved.

9. Salad Oil Dressing (French dressing)

Formulation

	%	
Oil	51.76	Pure olive oil and olive oil:menhaden blends, 80:20, 40:60
Water	22.50	
Malt vinegar	18.00	
Spirit vinegar	5.00	
Salt	1.50	
Sugar	1.20	
Onion flavour	0.02	
Garlic flavour	0.02	

Method

Sugar, salt and flavours were mixed with the vinegars and water. To this, the oil blend was added whilst mixing was continued with the Braun hand blender. Samples were packed in suitable bottles and kept at 4°C until tasted.

10. Coleslaw

Formulation

	%
Cabbage	40
Carrot	40
Onion	10
French dressing	10

Method

Fresh vegetables were cleaned, sliced and tossed in a French dressing which has been described in Appendix II, 9. Samples were packed into plastic containers and stored at 4°C until tasted.

11. Canned Tuna Fish

Formulation

	%
Fish	74
Oil	25
Salt	1

Oil and blends used:

a) Menhaden fish oil 25%

b) Menhaden fish oil 15%, Groundnut oil 10%

c) Menhaden fish oil 5%, Groundnut oil 20%

d) Menhaden fish oil 15%, Olive oil 10%

e) Menhaden fish oil 5%, Olive oil 20%

Method

Frozen tuna fish steaks were thawed overnight at ambient temperature. Selected steaks were cooked for 5 minutes in a Brother microwave on "high" setting and then packed into 5-oz cans. The salt and oil were then added and the cans seamed and sterilised in a retort at 121.1°C for 70 minutes.

12. Canned Sardines

Formulation

	%
Sardines	70
Oil	30

Oil blends used were:

a) Goundnut oil

b) Herring oil

c) Pout & sprat oil

d) Herring:Groundnut (60:40)

e) Pout & sprat:Groundnut (60:40)

Method

Frozen sardines were allowed to thaw overnight at ambient temperature prior to cleaning and removing heads.

Fillets were soaked in a 17% brine solution for 5 minutes, steamed for 10 minutes in a steam chest at 100°C and then dried in a convection oven at 50°C for 3 hours.

These fillets were then packed into 5-oz cans and the oil added. Packs were sealed and sterilised in a steam retort at 121.1°C for 70 minutes.

13. British Sausage

Formulation

	%	
Pork shoulder (VL80+)	21.20	
Pork belly (VL60+)	13.80	
Back fat	16.69	Control 22.25%
Oil blend*	5.56	
Rind	9.75	
Water/ice	19.50	
Rusk	11.00	
Seasoning	2.50	

* Fish oil:Groundnut oil in a 60:40 ratio

+ VL = % Visual lean meat

Method

An Alexandrawerke 20-litre, two-speed bowl chopper was used in the following operations:

Addition	Chopping time	Chopping speed
Pork shoulder, rind and seasoning	30 sec	Slow
50% of the water	30 sec	Fast
Scrape bowl down	15 sec	Fast
Pork belly	30 sec	Slow
Pork backfat	30 sec	Slow
Rusk	30 sec	Slow
Scrape down bowl	15 sec	Fast

The meat mix was filled into reformed collagen sausage skins (58 g per sausage), using a Handtmann vacuum filler. Sausages were left for a 24-hour period for the rusk to hydrate (setting time) then frozen in a blast freezer at $-30^{\circ}C$. Frozen sausages were vacuum packed in sixes and stored in a deep freeze until used.

14. Fermented Sausage

Formulation

	Trial (%)	Control (%)
Beef forequarter (80VL)+	40.44	40.44
Pork shoulder (80VL)+	24.00	24.00
Pork trim (70VL)+	24.00	26.00
Ice	0.00	5.00
Emulsion:		
Pout/sprat or herring fish oil	2.00	0.00
Soya isolate	1.00	0.00
Water	4.00	0.00

Salt	2.50	2.50
Sucrose	0.50	0.50
Lactose	1.00	1.00
Red pepper	0.20	0.20
Black peppercorns	0.10	0.10
Pimento	0.10	0.10
Garlic powder	0.02	0.02
Black pepper	0.10	0.10
Sodium nitrite	0.03	0.03
Sodium nitrate	0.01	0.01

+ VL = % Visual lean meat

Starter culture added at 1 g per 2 kg meat mix.

Method

The fish oil emulsion was produced by hydrating the soya protein with water and chopping to a fine paste in the bowl chopper. Fish oil was added and chopped to a satisfactory consistency.

Meats at -2° to $0^{\circ}C$, salt, sugar and lactose were chopped in the bowl chopper at slow speed for 20 seconds. Flavour components and ice (when applicable) were added and chopped for 20 seconds at slow speed. Sodium nitrite, nitrate, Christian Hansen starter culture "Combistart 1505" and the oil emulsion (when applicable) were added and chopped at slow speed for 20 seconds.

Sausage mix was filled into fibrous casings in 1-kg portions using the vacuum filler. Sausages were allowed to stand at $20^{\circ}C$ for 24 hours and then fermented in an Atmos cooker at $23^{\circ}C$ and 93% relative humidity (rh) until the pH of the sausage reached pH 4.8.

The temperature and humidity were then reduced over three days to $14^{\circ}C$, 75% rh. These conditions were held until the sausages had lost one third of their initial weight. Samples were stored in chill conditions until assessed.