FISH OIL BULLETIN

FISH OIL BULLETIN NO. 20

The Usage of Hydrogenated Fish Oils in Margarines, Shortenings and Compound Fats

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FOREWORD

Fish oils have been used as edible oils for the past fifty years. In excess of 95% of fish oil production is used for human food. The oils are refined and hydrogenated resulting in a hard fat with a number of desirable characteristics. The fat is palatable and is a concentrated source of energy. Margarines and shortenings require the characteristics of smoothness and plasticity, which are described by the ß' (beta prime) crystal form. This is the stable form for hydrogenated fish oils and they influence any blends of which they are a part in that crystalline form.

Hardened fish oil in the melting point of 30° C - 38° C helps the production of a clean melting domestic margarine. More highly hydrogenated oils, 40° C -50° C melting point are used in small quantities (5 - 10%) in table and creaming margarines, and in larger amounts (30 - 60%) in puff pastry blends. Fat blends containing substantial quantities of hydrogenated fish oil have particularly good creaming performance, that is air-incorporation properties, when used in cake batters.

In South America lightly hardened fish oils are being used as the base stock of a compound cooking and salad oil.

The world production of fish body oils over the past twenty-five years has remained more or less static at about one million metric tonnes.

Exports have been generally in the range of 600 - 800 thousand tonnes per annum. The main exporting countries are

Norway	Iceland
U.S.A.	Chile
Denmark	Japan

All these countries, with the exception of Japan, are members of the International Association of Fish Meal Manufacturers (IAFMM) which continuously reviews the quality specifications of its members' products.

The main consuming countries are

United Kingdom	Peru
Netherlands	Norway
West Germany	

The members of the IAFMM are aware that a number of additional countries and companies are currently expressing interest in importing and using fish oil. However, uncertainties exist in the minds of these new users concerning the properties of crude fish oils, how to handle and process them, and how best to use the hardened products in finished fat blends.

Four Fish Oil Bulletins have thus been commissioned by the IAFMM on the following subjects

The Chemical and Physical properties of Crude Fish Oils for Refiners and Hydrogenators (No. 18 - June 1986)

The Refining and Hydrogenation of Fish Oils (No. 17 - August 1985)

The Chemical and Physical properties of Hydrogenated Fish Oils for Margarine and Shortening Manufacturers (No. 19 - August 1986)

The usage of Hydrogenated Fish Oils in Margarines, Shortenings and Compound Fats. (No. 20 - August 1986)

This Fish Oil Bulletin is one of the four.

It is hoped that these Bulletins will form a comprehensive practical guide to the use of fish oil. The IAFMM will attempt to answer any further questions which might arise when using fish oil. In this case enquiries should be addressed to the undersigned.

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THE USAGE OF HYDROGENATED FISH OILS IN MARGARINES, SHORTENINGS AND COMPOUND FATS

Summary

The purpose of this Bulletin is to survey the use of hydrogenated fish oils for food products. Over 1 million tonnes of fish oil per annum is used in the preparation of food. It is used for the preparation of salad oils, frying fats, table margarines, low calorie spreads and industrial margarines and shortenings, to make bread, pastries, cakes, cookies, biscuits and synthetic creams. It is also used in the production of emulsifiers for food applications.

With good refining practice the hydrogenated fish oil ranks in quality with hydrogenated soyabean and rapeseed oils. Guidelines for the quality of refined, hydrogenated fish oil are given in Table 1.

Table 2 describes the properties of the most commonly used hydrogenated fish oils.

Because of their broad spectrum of component fatty acids and, consequently, triglycerides, commercial fish oils, when hydrogenated, are in the ß'-category as shown in Table 3. They therefore influence any blends of which they form a part to crystallise in the ß'-form, which is desirable for most margarines and shortenings because of the smooth texture and, in the case of industrial uses, improved handleability and performance which it gives to the product. When a product changes from the ß'-form to the ß-form it becomes either sandy/grainy or hard and brittle.

At melting points of 30°C and below the hardened fish oil often still has a small amount of tri-unsaturated fatty acids which render it less stable to oxidation than oils with higher melting points. The stability of the oil can be improved by selecting good quality crude oil, refining it thoroughly and subjecting it to very selective hydrogenation conditions.

As hydrogenation progresses, the selective conditions used in the hydrogenation, together with the increased content of trans fatty acids, are responsible for the relatively steep solid fat content curve of the lower melting fish oils. This steepness is very useful in that it helps to give a product a clean, or non-waxy, palate sensation.

Hardened fish oils with melting points of 40-50°C are widely used to give body or increased plastic range, that is plasticity over a wide temperature range, to products. Even at melting point 46/48°C, the solid fat content curve falls sharply away at temperatures above 30°C so that by suitable blending the improved "body" can be obtained without materially affecting the melt-down.

Detailed descriptions are given of the various hydrogenated fish oils of differing melting points, together with a review of the food products in which these fish oils can be used.

When processing into food products, individual oils crystallise at different rates. Hardened fish oil has an intermediate rate of crystallisation and is similar to hardened soyabean oil. Blends incorporating hardened fish oils which are to be used for creaming purposes benefit, in terms of performance and resistance to variations in storage temperatures, from tempering. They are thus similar to blends incorporating other hydrogenated liquid oils.

L'UTILISATION DES HUILES DE POISSON HYDROGENEES DANS LES MARGARINES, LES MATIERES GRASSES POUR PATISSERIE ET LES MELANGES DE MATIERES GRASSES

Résumé

Nous nous proposons dans ce bulletin de passer en revue l'utilisation des huiles de poisson hydrogénées dans les aliments. On utilise plus d'un million de tonnes d'huile de poisson par an dans la préparation des aliments. Elle est utilisée pour la production d'huile de table, de matières grasses pour les fritures, de margarines de table, de produits pour tartiner à basse teneur en calories et de margarines industrielles et matières grasses pour pâtisserie, pour faire le pain, les pâtes, les gâteaux, les petits pains au lait, les biscuits et les crêmes synthétiques. Elle est aussi utilisée pour produire des émulsifiants pour les besoins de l'industrie agro-alimentaire.

En utilisant une bonne technique de raffinage, les huiles de poisson hydrogénées se placent sur le même plan que les huiles de soja et de colza hydrogénées. Les directives à suivre pour obtenir cette qualité d'huile de poisson raffinée et hydrogénée sont exposées dans le Tableau 1.

Le Tableau 2 décrit les propriétés des huiles de poisson hydrogénées les plus communément utilisées.

Le Tableau 3 montre que les huiles de poisson commercialisées, quand elles sont hydrogénées, se rangent dans le catégorie ß' à cause du spectre étendu d'acides gras qui les composent et par conséquent de triglycérides. Pour cette raison elles influent sur tous les mélanges dont elles forment une partie qui cristallise sous la forme ß', ce qui est souhaitable dans la plupart des margarines et matières grasses pour pâtisserie à cause de la structure lisse obtenue et, dans les cas d'utilisations industrielles à cause de la facilité de maniement et de rendement qui sont améliorés, qu'elles confèrent au produit. Si un produit passe de la forme ß' à la forme ß, il devient soit granulaire/sableux, soit dur et cassant.

Au point de fusion de 30°C et en dessous, l'huile de poisson "durcie" contient souvent une petite quantité d'acides gras tri-insaturés qui la rendent moins stable à l'oxydation que les huiles ayant des points de fusion plus élevés. La stabilité de l'huile peut-être améliorée en sélectionnant une huile brute de bonne qualité, en la raffinant à fond et en choisissant très soigneusement les conditions d'hydrogénation.

Au fur et à mesure que l'hydrogénation progresse, les conditions sélectives utilisées pour l'hydrogénation, liées à l'accroissement du taux d'acides gras trans, influent sur la pente relative de la courbe de la partie solide des huiles de poisson à point de fusion inférieur. La pente de cette courbe est très utile pour aider à obtenir une sensation de produit épuré et non cireux sous la langue.

Les huiles de poisson "durcies" ayant des points de fusion de 40-50°C sont largement utilisées pour donner aux produits du "corps" ou un éventail plastique accru qui est la plasticité au dessus d'une large gamme de températures. Même au point de fusion 46/48°C, la courbe des matières grasses à l'état solide chutè brusquement et profondément à des températures au dessus de 30°C, si bien que par des mélanges appropriés on peut obtenir une amélioration du "corps" sans affecter sensiblement la fonte.

L'article donne des descriptions détaillées de diverses huiles de poisson hydrogénées ayant des point de fusion différents, ainsi qu'une liste des produits alimentaires dans lesquels on peut utiliser ces huiles de poisson.

Quand on fabrique des aliments, chaque huile cristallise à des vitesses différents. L'huile de poisson "durcie" a une vitesse de cristallisation intermédiaire et est similaire à l'huile de soja "durcie". Les mélanges contenant des huiles de poisson "durcies" qu'on doit utiliser pour obtenir un effet de crême, tirent profit du point de vue du rendement et de la résistance aux variations de température de stockage, du malaxage. Ainsi elles sont similaires aux mélanges contenant d'autres huiles liquides hydrogénées.

DIE VERWENDUNG VON GEHÄRTETEN FISCHÖLEN IN MARGARINEN, BACKFETTEN UND MISCHFETTEN

Zusammenfassung

Zweck dieses Bulletins ist es einenÜberblick über die Verwendung von gehärteten Fischölen in Lebensmittelprodukten zu geben. Jährlich werden über eine Million Tonnen Fischöl zur Herstellung von Lebensmitteln verwendet. Es dient zur Produktion von Salatöl, Bratfetten, Tafelmargarine, kalorienarmen Brotaufstrich, Industriemargarine und Backfetten für die Herstellung von Brot, Torten, Kuchen, Keks, Zwieback und synthetischer Sahne. Auch findet es Verwendung zur Herstellung von Emulgatoren in der Lebensmittelproduktion.

Bei guter Raffination unterscheidet sich gehärtetes Fischöl in der Qualität nicht von gehärteten Soja – und Rapsölen. Richtlinien für die Qualität von raffiniertem gehärteten Fischöl bringt Tabelle 1.

Tabelle 2 beschreibt die Eigenschaften der am meisten verwendeten gehärteten Fischöle.

Aufgrund des breiten Spektrums der darin enthaltenen Fettsäuren und daher auch der Triglyceride gehören gehärtete Fischöle zur ß'- Kategorie wie in Tabelle 1 angegeben. Sie begünstigen daher in allen Mischungen, in denen sie enthalten sind, die Kristallisation in der ß' – Form, welche für die meisten Margarinen und Backfette wegen der weichen Struckturr erwünscht ist und bei der industriellen Verwendung die Handhabung sowie die Produkteigenschaften verbessert. Wenn ein Fett von der ß'-Form in die ß-Form wechselt, wird es entweder sandig/körnig oder hart und krümelig.

Bei einem Schmelzpunkt von 30°C und niedriger enthält gehärtetes Fischöl oft noch eine geringe Menge von dreifach ungesättigten Fettsäuren ,welche es gegenüber einer Oxidation weniger stabil machen als Öle mit höhoren Schmelzpunkten. Die Stabilität des Öls kann durch die Auswahl von rohen Ölen guter Qualität, sorgfältige Raffination und Anwendung sehr selektiver Härtungsbedingungen verbessert werden.

Mit fortschreitender Härtung sind die angewendeten selektiven Bedingungen zusammen mit dem erhöhten Anteil an trans-Fettsäuren für den relativ steilen Verlauf der Kurve für feste Fette in den niedriger schmelzenden Fischölen verantwortlich. Dieser steile Anstieg ist sehr nützlich, da er hilft, dem Produkt eine klare, nichtwachsartige, schmackhafte Eigenschaft zu verleihen.

Gehärtete Fischöle mit Schmelzpunkten von 40-50°C werden in großen Umfang zur Herstellung eines "Körpers" oder erhöhten plastischen Bereichs eingesetzt, d.h. Plastizität der Produkte über einen weiten Temperaturbereich. Schon bei einem Schmelzpunkt von 46/48°C fällt die Kurve des Anteiles fester Fette bei einer Temperatur oberhalb 30°C scharf ab, sodaß durch geeignete Mischung ein verbesserter "Körper" ohne wesentliche Beeinflussung des Abschmelzens erzeilt werden kann.

Es werden detaillierte Beschriebungen der verschiedenen gehärteten Fischöle mit unterschiedlichen Schmelzpunkten gebracht, zusammen mit einer Übersicht über die Lebensmittelprodukte, für die diese Fischöle einsgesetzt werden können.

Bei der Einarbeitung in Lebensmittel kristallisieren die einzelnen Öle in unterschiedlichem Umfang. Gehärtetes Fischöl hat einen mittleren Kristallisationsgrad und verhält sich ähnlich wie gehärtetes Sojaöl. Mischungen mit gehärtetes Fischöl, die für sahnige Produkte verwendet werden, begünstigen Gleichmässigkeit und Beständigkeit gegen Änderungen der Lagertemperatur beim Tempern. Sie verhalten sich somit ebenso wie Mischungen, die andere gehärtete Öle enthalten.

EL USO DE ACEITES DE PESCADO HIDROGENADO EN MARGARINAS, SHORTENINGS Y GRASAS O MENTECAS COMPUESTAS

Resumen

El objeto de este boletín es investigar el uso de los aceites de pescado hidrogenados en productos alimenticios de uso humano.

Sobre un millón de toneladas de aceites de pescado se utilizan en la preparación de alimentos. Se emplean en la producción de aceites para ensaladas, grasas para frituras, margarinas de mesa, margarinas de bajas colorias para esparcir, margarinas industriales y shortenings para fabricar pan, pasteles, queques, galletas, biscochos y cremas sintéticas. También son utilizados en la producción de emulsificantes para aplicaciones en alimentos.

Con buenas prácticas de refinación, los aceites hidrogenados se comparan en calidad con los aceites hidrogenados de soya y raps. Guías de calidad de aceites hidrogenados de pescado, refinados se dan en la tabla # 1.

La tabla # 2 describe las propiedades de los aceites de pescado hidrogenados de uso más frecuentes.

Debido al amplio expectro de composición de los ácidos grasos de los triglicéridos, los aceites de pescado comerciales, cuando se hidrogenan están en la categoria ß, tal como se muestra en la tabla # 3. Ellos por tanto influencian cualquier mezcla en los que entran a formar parte cristalizándose en forma ß', lo cual es conveniente en la mayoria de las margarinas y shortenings, debido a su textura suave, y en el caso de usos industriales, mejoran la manuabilidad y resultados que dan al producto final. Cuando un producto cambia de forma ß', se convierte en un producto arenoso/granuloso o duro y quebradizo.

A punto de fusión 30°C y más bajos, los aceites de pescado endurecidos a menudo contienen pequeñas cantidades de ácidos grasos tri insaturados que dan un producto menos estable a la oxidación que aquellos aceites que tienen un punto de fusión más elevado. La estabilidad del aceite puede ser mejorada mediante la selección de aceites crudos de buena calidad, refinándolos posteriormente en forma acabada y sometiéndolos a condiciones de hidrogenación muy selectivas.

A medida que la hidrogenación progresa, las condiciones selectivas utilizadas junto con el aumento del contenido de ácidos grasos trans influyen en la pendiente relativa de la curva de la parte sólida de los aceites de pescado de punto de fusión inferior. La pendiente de esta curva es muy útil para ayudar a obtener en la lengua una sensación de producto puro y no grasoso.

Los aceites de pescado endurecidos con puntos de fusión de 40 a 50°C son ampliamente utilizados para dar cuerpo o aumentar el rango plástico, vale decir, dar plasticidad en un amplio rango de temperatura a los productos. Aún a puntos de fusión 46/48°C, la curva de contenido de grasas sólidas cae rapida y profundamente a temperaturas por debajo de 30°C, en tal forma que con mezclas apropiadas se puede obtener una consistencia o cuerpo mejorado sin prácticamente afectar la fusión baja.

Se dan descripciones detalladas de los diferentes aceites de pescado hidrogenados, de diferentes puntos de fusión, junto con una revisión de productos alimenticios en los cuales esos aceites de pescado pueden ser usados

Cuando se procesan en productos alimenticios, los aceites individuales cristalizan a diferentes velocidades. El aceite de pescado endurecido tiene una velocidad intermedia de cristalización que es similar a la del eceite de soya endurecido. Las mezclas que incorporan aceites de pescado endurecidos, las cuales serán usadas para propósitos de cremosidad, en términos de resultados y resistencias a variaciones de temperaturas de almacenamiento por calentamiento, son similares a las mezclas que incorporan otros aceites líquidos hidrogenados.

1. INTRODUCTION

The purpose of this bulletin is to survey the use of hydrogenated fish oils for food products.

Over one million tonnes of fish oil per annum is used in the preparation of food. This figure is, at the time of writing, in excess of world production figures for corn oil and palmkernel oil. Most of the world's fish oil production is processed and used in Europe, South America and Japan. It is used for the production of salad oils, frying fats, table margarines, low calorie spreads and industrial margarines and shortenings used to make bread, pastries, cakes, cookies, biscuits and synthetic creams. It is also used in the production of emulsifiers for food applications.

Fish oils as extracted contain highly unsaturated fatty acids which are susceptible to oxidation. The oil must therefore be hydrogenated to modify such fatty acids before the oil can be used for normal commercial food purposes. With good refining practice the hydrogenated product ranks in quality with hydrogenated soyabean and rapeseed oils. Guidelines for the quality of refined, hydrogenated fish oil are given in **Table 1**.

Hydrogenated (otherwise known as hardened) fish oil is therefore to be numbered amongst the other edible oils e.g. soyabean, cottonseed, rapeseed, palm, lard, tallow etc. which may be used for the products mentioned, and takes its place in the practice of interchangeability of oils and fats for blending purposes. In general, interchangeability has a modulating effect on the oils and fats market.

The use of any oil or fat in a particular market or product is governed by such factors as:

a) price,
b) product specification, e.g. plant or animal origin; purpose of product; quality or grade of product,
c) prohibitions or restrictions imposed by legislation,
d) religious prohibitions,
e) traditional preferences e.g. of flavour or texture.

To expand on these factors, under (b) "purpose of product" is meant, for example, avoiding the use of an oil or fat which suffers from the development of unacceptable off-flavours in a product which is sensitive to them, for example a synthetic cream. As mentioned, however, in (e) flavour acceptability differs from one part of the world to another. A good example of texture preference is the grainy structure most widely sought for vanaspati or vegetable ghee. Religious prohibitions apply usually to pig fats and beef tallow but may also extend to other animal fats and marine oils.

TABLE 1

Quality of Fully Refined Hydrogenated Fish Oil

F.F.A. (as oleic acid), %	0.10 max
Peroxide Value, m.equivs/kg fat	nil
Total Oxidation Value (T.V.)[a]	Less than half T.V. of the bleached hydrogenated oil
Copper, $\mu g/g$	0.05 max
Iron, $\mu g/g$	0.12 max
Nickel, $\mu g/g$	0.20 max
Soap	nil
Colour, 5¼" Lovibond	3.0 Red, 30 Yellow max
Appearance	Clear and bright
Flavour & odour	Bland

(a) the total oxidation value is calculated as the anisidine value + 2 × peroxide value.

2. HYDROGENATED FISH OILS

2.1 GENERAL CONSIDERATIONS

Before describing the commonly used hydrogenated fish oils (**Table 2**) it is necessary to discuss solid fat content and the crystallisation of fats.

In order to achieve marketing acceptability the oil or fat product must possess the correct degree of fluidity or solidity under the conditions of use. This state is determined by melting point or, in the case of refrigerated salad oils, by the cloud point but, particularly for solid products, more exact and informative data are obtained by determining the percent-

TABLE 2

Solid Fat Indices, Dilatations, Solid Fat Contents of Hydrogenated Fish Oils of Different Melting Points

Melting Point Range (slip)[a], °C		26/28 [b]	30/32	32/34	34/36	36/38	40/42	43/45 [b]	46/48
Iodine Value Range		95/100	78/85	75/83	72/80	68/75	50/60	40/45	35/40
Solid Fat Index (Dilatation, mm³/25g) I.U.P.A.C., 1979, 2.141	10°C	19 (475)	39 (975)	40 (1000)	44 (1100)	50 (1250)	59 (1475)	67 (1675)	>69 (>1725)
	15°C	15 (375)	33 (825)	35 (875)	41 (1025)	47 1175	59 (1475)	67 (1675)	73 (1825)
	20°C	11 (275)	26 (650)	29 (725)	37 (925)	43 (1075)	57 (1425)	67 (1675)	74 (1850)
	25°C	8 (200)	16 (400)	20 (500)	30 (750)	34 (850)	53 (1325)	66 (1650)	73 (1825)
	30°C	4 (100)	5 (125)	9 (225)	18 (450)	22 (550)	44 (1100)	65 (1625)	68 (1700)
	35°C	0	0	1 (25)	4 (100)	9 (225)	30 (750)	59 (1475)	ca60 (ca1500)
	40°C			0	0	2 (50)	12 (300)	36 (900)	ca40 (ca1000)
	45°C					0	0	-	ca20 (ca500)
Solid Fat Content, % NMR I.U.P.A.C., 1982, 2.323	10°C	26	53	55	60	68	80	92	>95
	15°C	17	39	42	50	58	74	84	92
	20°C	10	27	31	40	47	65	78	87
	25°C	7	15	19	29	34	55	72	80
	30°C	3	4	8	16	20	42	68	71
	35°C	0	0	1	3	7	26	ca55	58
	40°C			0	0	1	8	ca35	40
	45°C					0	0	-	15

(a) "slip" or "rise" melting point e.g. British Standard BS6 84: Section 1.3: 1976
(b) solid fat index by A.O.C.S. Method Cd 10-57

ages of solid fat at given temperatures. The official methods employed for the determination and the units of expression are as follows:

Dilatation:	- International Union of Pure and Applied Chemistry (IUPAC) 1979, Method 2.141	- ml/kg (μl/g) of fat or μl/25g (mm^3/25g) of fat
	- American Oil Chemist's Society (AOCS) Official Method Cd 10-57	- ml/kg of fat stated as Solid Fat Index (SFI)
N.M.R.:	- IUPAC, 1982, Method 2.323	- % Solid Fat Content (SFC)
	- AOCS Official Method Cd 16-81	- % Solid Fat Content

Note: N.M.R. = Nuclear magnetic resonance spectrometry (low resolution pulse).

Apart from the differing modes of expression of the results the methods vary in the tempering treatment given to the sample before measurement and therefore the method employed must be known before attempts are made to convert from one means of expression to another. If the same method is used SFI can be converted to dilatation by multiplying by 25 and vice versa. **Appendix 1** is a conversion table for dilatation in mm^3/25g at various temperatures (°C) into %SFC using the above IUPAC methods in both cases. Note: stabilisation is a step introduced into the methods when testing cocoabutter and similar fats. The solid fat data for hydrogenated fish oils in **Table 2** are typical results obtained by the IUPAC methods. The results are given in both SFI (with dilatation in brackets) and %SFC.

%SFC or its alternative is normally one of the principal parameters in the specification of a fat product. It is normally expressed at at least four temperatures, for example 10, 20, 30, 35°C or 20, 30, 35, 40°C depending on the product conditions of use. 10°C is useful for table margarines spreadable from the refrigerator, 20 and 30°C for ambient temperatures and 35 and 40°C for "mouth-feel" i.e. waxiness on the palate, and performance of puff-pastry fats. The specified figures for a particular type of product vary considerably in different parts of the world because of ambient conditions and, in the case of industrial fats, due to differing methods of utilisation.

Oils and fats are composed primarily of triglycerides which may be liquid or solid at ambient or refrigerator temperatures, depending on the character and siting of the fatty acid radicals in the triglyceride molecule. When the triglycerides are solid they are polymorphic, that is to say they can exist in several crystalline forms which differ in their stability.

By means of X-ray diffraction three principal crystallisation patterns have been identified in triglycerides. These have been named the alpha (∝), beta (ß) and beta prime (ß') forms. On shock-chilling, as employed in the processing of margarines and shortenings, the fat crystallises first in the ∝-form which has the lowest melting point of the three. The ∝-form is unstable and becomes transformed into the ß'-form in a short time measurable in seconds or minutes depending on the oil/triglycerides and the crystalline conditions. The ultimately stable form is ß but the time for the ß' to ß change of an oil or blend is dependent on its fatty acid composition and triglyceride structure and on the processing and storage conditions of the product. The period for this change varies from days to months as a result of which fats can be classified according to their crystal habit as given in **Table 3**. The ß' form is desired for most margarines and shortenings because of the smooth texture and, in the case of industrial uses, improved handleability and performance which it gives to the product. When a product changes to the ß-form it becomes either sandy/grainy or hard and brittle.

TABLE 3

Classification of Fats & Oils According to Crystal Habit

Beta-type	**Beta prime-type**
Soyabean	Cottonseed
Safflower	Palm
Sunflower	Tallow
Sesame	Commercial Fish Oils
Peanut	Rapeseed (high erucic acid)
Corn	Coconut
Canola	Palm Kernel
Olive	Milk Fat (butter oil)
Lard	Modified Lard
Cocoa Butter	

To produce a fat with enhanced ß' stability it is necessary to avoid a preponderance of one triglyceride or closely similar triglycerides. It is because of their broad spectrum of component fatty acids and consequently triglycerides that the commercial fish oils when hydrogenated are in the ß' category in **Table 3**. They therefore influence any blends of which they form part to crystallise in the ß'-form, thus giving the desired characteristics to the product.

The processes employed for the refining and hydrogenation of fish oils are described in the IAFMM Fish Oil Bulletin No. 17 mentioned in the Foreword. Examples of the hydrogenation conditions used to produce the hardened oils listed in **Table 2** and their fatty acid compositions are given in Fish Oil Bulletin No. 19. The oils in the Table range in melting point (m.pt) from 26 to 48°C. At m.pt.30°C and below the oil often still has a small amount of tri-unsaturated fatty acid radicals which render it less stable to oxidation than oils with higher melting points. The stability of the oil can be improved by selecting good quality crude oil, refining it thoroughly and subjecting it to very selective hydrogenation conditions. Indeed, in this manner oils of acceptable stability are produced with melting points as low as 26/28°C.

As occurs in the commercial hydrogenation of all high iodine value (IV over 90) soft oils, trans-acids are formed in the hydrogenation of fish oils. The quantity formed at the lower melting points is dependent on the conditions employed and varies between 20 and 50%. As hydrogenation progresses the trans-acid content increases to a maximum of 40 to 60% at a melting point in the 36/38°C region before falling away with increasing saturation. The trans-acids together with the selective conditions used in the hydrogenation are responsible for the relatively steep SFC curve of the lower melting fish oils. This steepness is very useful in that it helps to give products a clean, or non-waxy, palate sensation.

With continued decrease of the iodine value, more saturated acid radicals are formed with the result that the solids content at 35 and 40°C rises. Hardened fish oils with melting points of 40 to 50°C are widely used to give body or increased plastic range, i.e. plasticity over a wide temperature range, to products. As can be seen from the Table, even at m.pt 46/48°C the SFC falls sharply away at temperatures above 30°C so that by suitable blending the improved "body" can be obtained without materially affecting the mouth melt-down.

2.2 INDIVIDUAL HYDROGENATED FISH OILS

HFO IV 110-120

Fish oils with iodine values of over 140 when hydrogenated under highly selective conditions can yield a product of IV 110-120 in which all fatty acids having more than three double-bonds have been eliminated. When this oil is winterised a liquid fraction, or olein, is obtained which can be blended with a "soft" oil for example soyabean oil, and the blend used as a salad oil. Because of the possibility of flavour reversion the solid fraction, or stearin, from "dry" winterisation should be re-hydrogenated to a melting point of 34°C or above for use in margarines or shortenings. However, the stearin from solvent ("wet") winterisation is used for the same purpose without further hydrogenation.

HFO 30/32°C

This oil and the m.pt 26/28°C mentioned earlier can be used in a similar manner to lightly (or brush) hydrogenated soyabean oil (IV 95-105). However its principal use is as a replacement for soyabean oil when the latter, or similar soft oil, is considered to be too expensive. The soft vegetable oil can be completely replaced if adjustments are made to the content of other oils in the blend to allow for the solid fat content of the hardened fish oil. It is, however, more usual to retain some liquid oil in the blend for plasticity reasons.

HFO 32/34, 34/36°C

These are the most commonly used melting points. They are much valued as "middle-melting" components of margarines and shortening blends because of their steep solid fat content figures. The plastic range of blends incorporating these oils can be increased by the use of higher melting point fats combined again with soft oils for plasticity. Blends containing 50 to 70% of hardened fish oils of this melting range are widely used for margarines, both table and industrial, and shortenings. For certain products these oils are used on their own.

HFO 36/38, 40/42°C

As can be seen from **Table 2** the solid fat content curve has become flatter when the melting point has reached 40/42°C. Because of their relatively high solid fat contents at 30°C and above, the 40/42°C fat and those with higher melting points are frequently referred to as hardstocks. They give the product its skeleton of solid triglycerides at 25 to 35°C which are responsible for the long plastic range needed for good bakery performance. The 40/42°C oil is frequently used in combination with those in the 32/36°C range. In these cases it is sometimes convenient for manufacturers to use the 36/38°C melting point in place of the other two.

HFO 46/48°C

This fat is used either in small quantities of about 5% in wrapped or stick table margarines or in lower melting point industrial products to improve temperature resistance, or at much higher levels, about 50 to 60%, for puff pastry products having melting points in the 40/44°C range.

3. PRODUCTS

3.1 SALAD OILS

The basic process for this product using hydrogenated fish oil was described in the previous section. A typical blend is 50% of the winterised hardened fish oil with 50% of soyabean oil. Salad oils with such blends are principally produced in South America.

3.2 FRYING FATS

The salad oil described above can be used for single-use shallow frying.

Hydrogenated fish oils of higher melting points, preferably 34/36°C, which are of improved stability are used for deep fat frying either on their own or as a predominant component of a blend with, for example, palm oil. As with all hydrogenated oils used for this purpose a good quality crude oil should be used and the oil should be thoroughly refined both before and after hydrogenation to prevent development of the so-called hardening smell.

3.3 BREAD FATS AND BREAD EMULSIONS

The HFO 32/36 range is used for traditional bread processes both on its own and blended with such oils as HFO 46/48, palm oil, lard and beef tallow depending on the texture and melting point desired.

For the high speed dough mixing bread process a fat with a higher melting point is required to withstand the temperature rise which accompanies the mixing. For this purpose HFO 46/48 is used in higher proportion (20%-50%) in combination again with one or more of HFO 32/36, lard and beef tallow and, in some instances, liquid vegetable oils. Bread emulsions consisting basically of fat, water and emulsifier, and with other bread additives if desired, are made using similar blends to those of the high speed mixing process but usually with a higher solid fat content to compensate for the added water.

HFO 36/38 and 40/42 are also suitable for use in bread fats and are adjusted where necessary to obtain the desired melting point or solid fat content by the use of other oils and fats.

3.4 MARGARINES

3.4.1 RETAIL OR DOMESTIC TABLE MARGARINES

The solid fat content figures for hydrogenated fish oils are very similar to those of hydrogenated soyabean and rapeseed oils for melting points from 30°C upwards. The oils of the same melting point are therefore interchangeable with only minor adjustments. This fact can be used as a first stage in the introduction of hardened fish oil.

Wrapped or stick table margarines have blends of which the solid fat content curve is adapted to the ambient temperature. For this reason and because of local availability of oil types the blends vary widely. Hardened fish oil in the 32/36°C melting point range is a principal and frequently the predominant component of such blends which are not specified as of all vegetable origin. It comprises from 25 to 85% of the oil blend and is used amongst others with lauric oils, palm oil, lard, beef tallow and liquid vegetable oils.

As discussed earlier in this bulletin the crystal structure of the solidified product is of major importance and should be for margarines in the ß' form. Hardened fish oil possesses this crystal habit but at 34/36°C melting point the solid content at 20°C is too high and at higher ambient temperatures it may be too low to prevent the product oiling-out i.e. the appearance of free liquid oil. Other oils must therefore be added to:

- retain the ß' structure under varying temperature conditions,
- lower the solids at 20-25°C,
- improve the resistance of the product at higher temperatures,
- ensure that the product has good meltdown and flavour release characteristics.

Two blends used in Europe for wrapped margarines which have these properties are blends 1 and 2 below (%):

	Blend 1	Blend 2	Blend 3	Blend 4
HFO 46/48	-	3	-	-
HFO 34/36	50	60	50	-
HFO 30/32	-	-	-	65
Palm oil	20	27	20	15
Lauric oil	15	-	-	-
Liquid vegetable oil	15	10	30	20

These blends can be softened or hardened by variations of the percentages of the components.

Margarines which are required to be spreadable at refrigerator temperatures are made using similar blends but incorporating more liquid oil in order to lower the solid fat content curve as shown in Blend 3. Blend 4 gives an example of the use of HFO 30/32 to reduce the liquid oil content. Blends 3 and 4 may also be used for the production of soft low-calorie spreads.

3.4.2 INDUSTRIAL CAKE AND CREAMING MARGARINES

These margarines are required to give good air incorporation into the cake batter or cream so that the product will have a good volume and light texture. It has been found that a wide spectrum of triglyceride types such as is found in hardened fish oils helps to produce this effect.

A somewhat longer plastic range is required for these products compared with the wrapped retail margarines to allow for the higher temperatures normally experienced in bakeries. However when used to produce synthetic creams the final cream must melt cleanly in the mouth. The oils and blends used are therefore similar to those used for wrapped table margarines but containing of the order of 5% HFO 46/48 or 15% HFO 40/42 depending mainly on ambient conditions.

3.4.3 INDUSTRIAL PUFF OR FLAKY PASTRY MARGARINES

Basically there are three fat blend melting point ranges used in margarines and 100% fat products used for these types of baked goods. The ranges are 35/39, 40/44 and 46/52°C. The lowest range is used for Danish pastries and has excellent melting characteristics in the mouth. The intermediate range is a widely used standard commercial product with acceptable meltdown properties, and the high range gives a good volume and is used primarily for baking products eaten hot. Examples of the solid fat content ranges of these products are shown in **Table 4**.

TABLE 4

Puff-Pastry Margarines

Temperature, °C	Solid Fat Content (NMR), % Soft	Medium	Hard
10	36	66	66
20	26	46	59
30	11	27	40
35	5	16	32
40	0	5	26
Melting point, °C (slip)	35	41	50

The "soft" product can be prepared using a blend similar to that used for the wrapped table margarine. The flatter solid fat content figures of the "medium" product require the use of a higher melting point fat. Such SFC figures can be obtained using a blend of 60% HFO 46/48, 30% beef tallow and 10% liquid oil. The formulation for the "hard" product is frequently a blend of beef tallow and the stearin obtained from the fractionation of beef tallow. HFO 50/52 can be used as a substitute for a considerable proportion of the beef stearin.

3.5 SHORTENINGS

Shortenings, or compound cooking fats as they are sometimes termed, are 100% fat products sold in both the retail and the industrial market. They are used for frying, roasting, creaming and tin greasing and for baked goods such as bread, pastries, biscuits, cookies and cakes. The solid fat content curve, and therefore the blend, is dependent upon the use of the product and local conditions.

A general purpose retail shortening is given an SFC curve and blend similar again to that for the wrapped retail margarine but with a slightly higher content of higher melting fat (HFO 40/42 or 46/48) to improve the cake and pastry baking performance. In many cases industrial shortenings are given a longer plastic range at the same melting point (Europe 35/37°C) to improve their baking performance and to produce what is known as a "moist" crumb structure in cakes. For these products an approximate fat blend is 20% HFO 46/48, 25% HFO 34/36, 15% palm oil, 40% liquid oil.

Shortenings for biscuit doughs have melting points between 36 and 40°C largely depending on the type of dough mixing and depositing equipment used. Satisfactory blends for such products are composed of hardened fish oil and palm oil and/or beef tallow. These blends have a relatively flat SFC curve.

In contrast, biscuit cream filling fats are required to have quick melting characteristics and therefore should have a steeper curve. The fat blends are preferably made up from palm and/or lauric oils, "soft" or hydrogenated. A lower priced substitute is made from HFO 34/36 and palm oil.

As stated earlier compound fats for puff pastry can be made from blends similar to those used for the equivalent margarines. They are, however, usually not as popular with the baker as are the margarines.

Industrial cake shortenings have melting points in the 36/40°C range; the actual melting point and solids range again depend mainly on the requirements of the baker. A useful blend for these products which can be modified as desired is 15% HFO 46/48, 50% HFO 34/36, 35% palm oil.

3.6 EMULSIFIERS

Emulsifiers are used in the oils and fats industry to stabilise emulsions such as margarines and to improve air incorporation in whipped creams, ice cream and in cake batters. They are prepared from various fatty raw materials including hardened fish oils. Two types of emulsifiers for which HFO is used are monoglycerides and the polyglycerol esters of fatty acids.

4. PROCESSING

Margarines and shortenings are produced using a shock-chilling process in which the liquid oil or emulsion is cooled rapidly by heat exchange against liquid ammonia or freon. The main piece of equipment is the chilling unit which is usually a scraped-surface tubular heat exchanger or, less frequently today, a scraped-surface chilling drum. After chilling, the product is allowed to crystallise while either being worked or rested before being packed.

Individual oils crystallise at different rates and therefore the composition of a blend affects its crystallisation time and consequently the plant configuration or throughput. Coconut oil crystallises rapidly, palm oil slowly. Hardened fish oil is intermediate and similar to hardened soyabean oil. It therefore presents no problem in this respect to the processor.

Blends incorporating hardened fish oils which are to be used for creaming purposes benefit, in terms of performance and resistance to variations in storage temperature, from tempering. They are thus similar to blends incorporating other hydrogenated liquid oils.

Bulk pumpable shortenings containing hardened fish oils are processed in a manner similar to those made from other oils.

Appendix 1

Conversion Tables: Pulse NMR Parallel Versus Dilatation Serial Results
Unstabilised (Margarine) Fats

Solids (%)	D 10	D 15	D 20	D 25	D 30	D 35	D 40	D 45
1	25	25	25	25	35	35	40	50
2	45	45	55	55	65	70	80	90
3	60	70	80	80	95	105	120	130
4	80	90	105	110	125	135	155	165
5	100	115	135	135	155	165	190	205
6	115	135	160	165	180	200	225	240
7	135	160	185	190	210	230	255	280
8	150	180	215	220	235	260	290	315
9	170	205	240	245	265	290	320	355
10	190	225	265	275	290	320	350	390
11	205	250	290	300	320	350	380	
12	225	270	320	330	345	380	410	
13	245	295	340	355	375	410	440	
14	260	315	365	380	400	440	465	
15	280	340	385	405	425	465	495	
16	300	360	405	430	455	495	520	
17	315	385	430	455	480	525	545	
18	335	405	450	480	505	550	570	
19	355	430	475	505	535	580	590	
20	370	450	495	525	560	605	615	
21	390	470	515	550	585	630	635	
22	410	490	540	575	610	660	660	
23	425	510	560	600	635	685	680	
24	445	530	580	620	660	710	700	
25	460	550	605	645	685	735	715	
26	480	565	625	670	710	760	735	
27	500	585	645	690	735	785	755	
28	515	605	670	715	760	810	770	
29	535	625	690	740	785	835	785	
30	555	645	710	760	810	855	800	
31	570	665	730	785	835	880		
32	590	685	755	810	860	905		
33	610	705	775	830	885	925		
34	625	720	795	855	910	950		
35	645	740	815	875	930	970		
36	665	760	840	900	955	990		
37	680	780	860	920	980	1015		
38	700	800	880	945	1000	1035		
39	720	820	900	965	1025	1055		
40	735	835	920	990	1050	1075		
41	755	855	940	1010	1070	1095		
42	770	875	965	1035	1095	1115		
43	790	895	985	1055	1115	1135		
44	810	915	1005	1080	1140	1155		
45	825	935	1025	1100	1160	1175		
46	845	950	1045	1120	1185	1190		
47	865	970	1065	1145	1205	1210		
48	880	990	1085	1165	1230	1225		
49	900	1010	1110	1185	1250	1245		
50	920	1030	1130	1210	1270	1260		
52	955	1065	1170	1250	1315			
54	990	1105	1210	1295	1355			
56	1030	1145	1250	1335	1400			
58	1065	1180	1290	1380	1440			
60	1100	1220	1330	1420	1480			
62	1135	1255	1370	1465	1520			
64	1175	1295	1410	1505	1560			
66	1210	1330	1450	1545	1600			
68	1245	1370	1490	1585	1635			
70	1285	1405	1525	1625	1675			
72	1320	1445	1565	1665				
74	1355	1480	1605	1705				
76	1395	1520	1645	1745				
78	1430	1555	1680	1785				
80	1465	1595	1720	1825				
82	1500	1630	1755	1865				
84	1540	1670	1795	1900				
86	1575	1705	1830	1940				
88	1610	1745	1870	1975				
90	1650	1780	1905	2015				
92	1685	1820	1945					
94	1720	1855	1980					

Reference: J.C. van den Enden, A.J. Haighton, K. van Putte, L.F. Vermaas, D. Waddington, Fette, Seifen, Anstrichmittel, 1978, 80(5), 180-186.