A NEW HORIZON FOR FISH OIL IN FOOD INDUSTRY : A PROPOSED APPLICATION IN DAIRY PRODUCTS

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ABSTRACT

Researchers have shown considerable interest in the beneficial health effects of long-chain polyunsaturated fatty acids present in fish oil, and dietary advantages have been recognised. As a result food companies are keen to develop "health" foods containing refined and deodorised fish oils. This research is an attempt on this line.

Two product ideas are presented here, where it is proposed to incorporate fish oil in processed and spread cheese. The response of potential consumers is gauged through a purpose-designed questionnaire. The responses are discussed and analyzed using the statistical package SPSS.

The statistical analysis aimed at determining the factors that may affect product acceptability and buying trends. The results showed that sex, income and age of respondents added to their awareness of fish oil benefits and are factors that affect both product acceptability and buying trend and frequency with varying significance. The product that incorporates fish oil in processed cheese appears to be more acceptable and has a better potential market. The target groups of potential customers include the very young (< 20 years) and the old (> 40 years). Marketing needs to include strategies to increase the people's awareness of fish oil benefits.

It is recommended that the survey be re-conducted on a larger sample to confirm the results and that further work be carried out to develop a product acceptable to more than one market segment or cultural group.

TO MY PARENTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

There is a growing body of evidence that fish oil appears to be the elixir of the century. Studies suggest that a requisite dose of fish oil confers protection against certain diseases. Fish oil was shown to have a favourable affect on psoriasis, migraine headache and rheumatoid arthritis, and can help to prevent coronary artery disease.

The development of the medical interest in the beneficial effects of fish oil on diseases has led to a number of food companies showing interest in developing "health" foods that incorporate fish oils. In addition, many people would prefer to obtain the long-chain n-3 fatty acids, which have proven cardio vascular effects, in the food they eat. The need therefore arises for the development of non-fish products that contain fish oil relatively rich in n-3 fatty acid which do not taste fishy.

It is the main purpose of this study to introduce product ideas to satisfy the above need, investigate the acceptability of the new ideas and identify the potential market and target groups.

The product ideas that were investigated involve the incorporation of fish oil in two types of cheese; processed and spread. A comprehensive literature review is carried out into the chemical and nutritional properties of fish oil, its manufacture and processing, and its various applications. Background information on cheese that is relevant to the research is also provided.

The level of acceptability of the product ideas and the potential market are investigated through a questionnaire designed to serve this purpose and distributed in two cities in New Zealand . The results of a statistical analysis of the responses using the SPSS programme are discussed to provide the required answers.

CHAPTER 2

CHEMICAL AND NUTRITIONAL PROPERTIES OF FISH OILS

2.1 INTRODUCTION

The complex nature of fish oils makes it difficult to give general statements about their nutritive value since it is necessary to consider their various constituents, their chemical composition and their specific properties.

Chemically the composition of fish oil is different from most other natural oils and fats since it:

a has a greater variety of lipid compounds

b possesses larger quantities of fatty acids with chain length exceeding 18-Carbons

c has considerably greater proportions of highly poly-unsaturated fatty acids (five and six double bonds)

d has polyunsaturates primarily of long chain omega-3 (W-3) rather than the more usual omega-6 (W-6) variety

The chemical composition of fish oil varies significantly depending on the species of fish, the geographical location of the fish and the part of the fish from which the oil is made (1).

Fish oils contain glycerides and unsaponifiable matter. As a whole, fish glycerides have the same biological value as the fats of land animals and vegetable oils. In general, aquatic animal oils show a marked complexity in their fatty acid composition, involving the whole range of saturated fatty acids and unsaturated acids. This, however, usually has a minor influence on their nutritive value as a concentrated source of calories (2).

The unsaponifiable matter in fish oil varies markedly in amount, depending on the species of fish. It includes various components among which are vitamins such as A, D and E. Fish oil was long considered valuable only for its vitamin content since little was known about the important biological value of specific polyunsaturated fatty acids present in aquatic animals (2).

In most cases fish oils occur as triglycerides, and less frequently as phospholipids. It is the properties of these fatty acids which are the major focus when utilizing fish oils (3).

In order to cover the subject adequately, it is necessary to discuss in broad terms the nature of fatty acids, the classes of lipids, and the chemical and nutritional properties of fish oil. It is impossible to divide a subject of this nature into a number of watertight compartments and so some overlapping is

unavoidable.

2.2 NATURE OF FATTY ACIDS IN FISH OIL

To the organic chemist, fatty acids are long-chain monocarboxylic acids. The long chain acids (primarily C-20 and C-22) generally make up between one-fourth and one-third of all the fatty acids in fish oils and, in a few species, may approach one-half of the total fatty acid content. Likewise, five and six double-bonded fatty acids generally occur in 15-30% of fish oils (3).

The fatty acids differ from each other in terms of:

a the length of the carbon chain

- the term "fatty acid" is applied to those containing six or more carbon atoms, and which are insoluble in water (4)

b the nature of the links between carbon atoms

i.e. the degree of unsaturation of the links. Stable links are described as "saturated" whereas the more reactive links are described as "unsaturated" links. In this regard, fatty acids may be divided into three groups: -

i Saturated fatty acids, which are totally made up of saturated links (i.e no double bonds). Saturated fatty acids comprise a methyl group (CH_3-) at one end, a chain of methylene units (-CH_2-) in the middle and a carboxyl group (-COOH) at the other end. They usually contain an even number of carbon atoms and the term "fatty acid" is applied to those containing six or more carbon atoms

ii Mono unsaturated fatty acids, which contain only one unsaturated link (one double bond); a typical example being oleic acid, 18:1 (eighteen carbon atoms, one double bond)

iii Polyunsaturated fatty acids (often abbreviated PUFA), which contain two or more unsaturated links; the most common PUFA being linoleic acid, 18:2

2.2.1 Carbon Chain Lengths

The carbon chain length in fish oil fatty acids commonly exceeds C-18, and a considerable proportion of fatty acids contain 20, 22 and to a limited extent, 24 carbon atoms. Fish oils also contain more fatty acids of odd carbon chain length (C-15, C-17, C-19) than most other oils or fats. The usual total proportion of odd carbon chain fatty acids is 1-3% but at least one species, the mullet, contains as much as 10% or more (3).

Two fatty acids, palmitic ($C_{16:0}$) and oleic ($C_{18:1}$), ordinarily total 30% or more of the total fatty acids in nearly all fish oils. They may make up half or more of the fatty acid content in some fish oils, and in only a few oils do they amount to less than 20% of the total (3).

Other fatty acids that are often contained in considerable amounts include three monoenes ($C_{16:1}$ $C_{20:1}$ and $C_{22:1}$) one other saturated fatty acid, myristic ($C_{14:0}$), and two polyunsaturates ($C_{20:5}$ and $C_{22:6}$). The latter two compounds are characteristic of fish oils and ordinarily do not occur in other oils in more than trace amounts (3).

Most of the PUFA of fish oils of chain length (C18-C22) occur as the omega-3 (w-3) type, which are of the linolenic acid family, as contrasted to the more usual linoleic acid family (omega-6 (w-6) type) fatty acids occurring in most other oils. The proportion of w-6 fatty acids in fish oil is very small; under 10% and often below 5%. The oils of freshwater fish usually have somewhat higher proportions (around 10%) of W-6 fatty acids than those of marine fish.

2.2.2 Essential Fatty Acid

The w-3 family of PUFA comprises α- linolenic acid and it's metabolic conversion products found in animal tissues and blood. The chemical structures of linoleic and α- linolenic acid are shown in Figure 1.

The designation "w-3" means that in these fatty acids the first double-bond is situated between carbon 3 and 4, counted from the methyl end of the fatty acid chain (7).

The parent PUFA, linoleic acid linolenic acids, can undergo alternating desaturation and chain elongation in animals, thus giving rise to the PUFA families(7).

Linoleicacid: $CH_3\ (CH_2)_4\ CH{:}\ CHCH_2\ CH{:}CH\ (CH_2)_7\ COOH$
α- Linolenic acid: $CH_3\ CH_2CH{:}CH\ CH_2\ CH{:}CH\ CH_2\ CH{:}CH(CH_2)_7\ COOH$

Fig 1 Chemical Structures of linoleic and α- linolenic acids

The essentiality of linolenic acid has been abundantly documented in numerous animal species and normal growth and reproduction can be sustained over several generations in both rats and guinea pigs, using linoleic acid as the sole dietary PUFA. However, evidence for an absolute requirement for α- linolenic acid, which is not met by linoleic acid, has been scarce, at least until recently (7). Essential fatty acids are discussed in more detail in Section 1.6.

2.2.3 Fatty Acid Variations

For many years there has been a prevailing belief that oil made from any particular species of fish has a fatty acid pattern that will vary only a little from one sample to another. Actually, the correlation between fatty acid composition and the species of fish from which the oil is made is a very loose one. Many species of fish tend to modify the fatty acids that they consume in their feed so as to lay down, in some cases, fatty acids different from those in the food they eat (3).

The feed available to fish differs considerably according to the place and the season of the year. Furthermore, the type and amount of available feed may change from year to year. These various factors tend to result in fish of the same species containing oil with highly variable fatty acid content (3).

2.3 LIPIDS AND THEIR CLASSES

Scientists use the term "lipid" to describe what the Layman knows as a 'fat' or an 'oil'. This term covers a wide range of chemical compounds which are generally sparingly soluble in water, but soluble in solvents such as ether or chloroform. Lipids, therefore, are the group of food components which are insoluble in water (e.g. fats, oils, waxes, lipoproteins and sterols). It is only recently that lipids contained in plant and animals from the marine and fresh water bodies of the world have been considered important to human nutrition.

The classes of lipids most commonly found in fish oils are triglycerides, phospholipids, hydrocarbons, wax esters and ether linked compounds. Sterols, vitamins and pigments are also usually present as minor components of fish oil(13). However in most cases, fish oils occur as triglycerides, and less frequently as phospholipids.

2.3.1 Triglycerides

Triglycerides are generally the principal sources of fatty acids in fish oils. It seems that the fatty acids in the triglycerides of marine species, with the probable exception of most mammals, obey a certain rule: that is, the characteristic polyenic acids are preferentially bound at the 2-position of glycerol (14).

The polyenic fatty acids in fish body and liver oils are preferentially located in the β-position, yet in marine mammals the triglycerides of the blubber have the polyunsaturates primarily in the α- position (15).

2.3.2 Phospholipids

All fish have a small amount of their lipid occurring at the cellular level in the form of phospholipids. Most of these phospholipids in marine fish occur as either phosphatidyl cholines (lecithins) or as phosphatidyl ethanol-amines (cephalin). In most fish about half of the phospholipids are lecithins and about one-quarter are cephalin. To a lesser extent fish phospholipids occur in other

forms including inositol phosphatises, cerebrosides, and sphingomyelins (8).

Several well-executed studies on the composition and positional distribution of the fatty acids in individual phospholipids have been undertaken. In extensive studies with two species of tuna, for example, the characteristic C-20 and C-22 polyunsaturated acids, particularly docosahexaenoic acid, were present in relatively large amounts (16, 17). The predominant phospholipids occurring in these species and probably in fish in general are lecithin (about half of the phospholipids) and cephalin [about one fourth] (1).

2.3.3 Hydrocarbons

Hydrocarbons present in fish oils are readily separated by chromatography (e.g. columns of silicic acid eluted with light petroleum) of the original oil or of the non-saponifiable fraction. Evidence so far suggests that a wide variety of saturated and unsaturated straight-chain and branched-chain hydrocarbons are present (13).

Some marine oils contain less than 0.1% hydrocarbons, others contain as much as 90%. Hydrocarbons occur in high quantities in the liver oil of several species of shark such as Centrophorus nyato, which contains up to 90% squalene (18). This hydrocarbon generally predominates but smaller quantities of pristane and Zamene are also present in such liver oils (19).

2.3.4 Ether - Linked Compounds

Previous work suggests that the ether-containing lipids of fish occur primarily as diacyl glyceryl ether in which the 1-and 2-positions of glycerol are esterified with fatty acid (20).

Several shark species such as the common dog fish (squalus acanthias) contain diacyl glyceryl ethers (9, 10).

The fatty acids have high proportions of polyenic C-20 and C-22 fatty acids when the glycerol ether occurs in the flesh; but if it resides in the liver, instead of a high proportion of the long chain polyenic fatty acid, the corresponding C-20 and C-22 monoenes are present (3).

The presence in shark of alkoxydiglycerides yielding upon hydrolysis such glyceryl ethers as selachyl chimyl and batyl alcohols has been known for a long time (21). Later studies demonstrate the presence of high percentages of glyceryl ethers in the nonsaponifiable fractions of the liver and body oils (22).

The isolation of diacyl glyceryl ethers from dogfish flesh and liver oils, and subsequent analysis of the fatty acids determined that the fatty acid content in both the ester- and ether-linked portion of dogfish flesh were characterised by high percentages of the typical C-20 and C-22 polyenic acid while the same ethers from the liver contained remarkably low percentages of these acids and high percentages of C-20 and C-22 monoenoic acids (9).

A rather complete review of both the chemistry and nutritional properties of such ether-linked compounds has been made (23).

2.3.5 Wax Esters

In a few species of fish, fish oil occurs as wax esters. These compounds have been found in the liver of cod [Lotella phycis (11)]. and in both the flesh and liver lipids of the castor oil fish (12)

These compounds, which presumably serve as an energy reserve and are often found in high concentrations, comprise a fatty alcohol (usually hexadecanol and octadic-9-enol) and a fatty acid usually of low degree of unsaturation. Research has revealed that for example the muscle of the gempylid fish contained 91.5% and the liver 3.9% of wax esters (12).

2.3.6 Other Lipid Components

Other Lipid components include sterols, vitamins and pigments. These substances are usually present as minor components of fish oils. Sterols are perhaps the most important.

The sterols that are present in clams, scallops, and oysters include a C_{26} sterol, two different C_{29} sterols (one not present in oysters), cholesterol, 22 dehydro-cholesterol, 24 methylene cholesterol and brassicasteral (24).

Of these, cholesterol was found to occur in the greatest quantity and it is also present in other fish and shellfish. However, its quantity varies between species as shown in Table 1, with lower amounts present in fish than in shellfish.

Table 1 Quantity of Cholesterol in certain species of Fish and Shellfish

Species	Cholesterol Content mg/100g
Fish	
Haddock	90
Pollock	75
Salmon	95
Shellfish and Crustaceans	
Clam	190
Crab	140
Lobster	170
Oyster	150
Scallop	175
Shrimp	200

Vitamins A and D constitute other components of fish lipids which occur in the liver and body oils of fish in widely varying amounts ranging from high values of up to 700,000 units of vitamin A / gram in halibut liver oil and up to 250,000 units of vitamin D / gram in certain tuna liver oils, down to values of under 100 units / gram (25).

It is appropriate now to examine triglyceride compounds in more detail, as they constitute the major source of fatty acids in fish oils.

2.4 TRIGLYCERIDES AND FATTY ACIDS

Both the fish body oils and liver oils are mainly composed of triglycerides which are three fatty acids (FA) attached to a glycerol molecule as shown in Figure 2, whereby the acidity of the fatty acids is counterbalanced by the alkaline properties of the glycerol producing a natural oil (26).

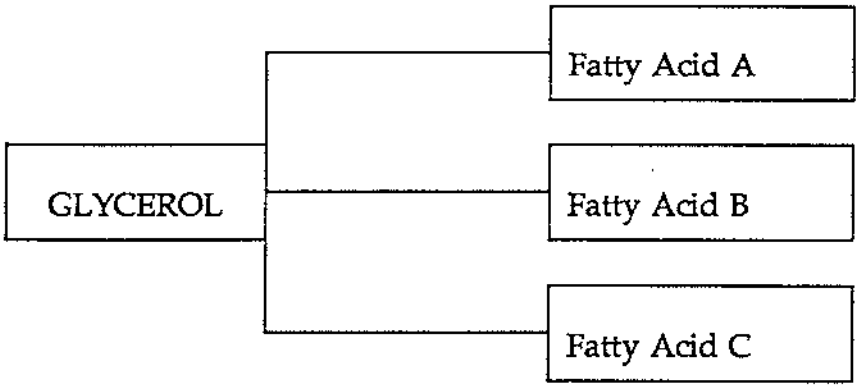

Fig 2 Diagrammatic Structure of Triglycerides

This attachment between the glycerol and fatty acids is important and should be maintained since:

a Its presence in the form shown produces a neutral oil in which the acidity of the fatty acid is counterbalanced by the alkalinity of the glycerol

b Its splitting releases free fatty acids whose presence in an oil is commercially undesirable

As previously stated, fatty acid content in fish oil may be highly variable, even in the same species of fish.

Geographical influences are important even in restricted areas such as the English channel/North sea. Sprats from the Moray Firth - Inverness area deposit a certain type of Fatty acid ($C_{22:1}$) freely. Mackerel, like herring, is a species that also shows marked seasonal changes in fat content on both sides of the Atlantic (6).

The physical state of an oil or fat is dependent on its fatty acid composition. A high level of unsaturated fatty acids, particularly polyunsaturated fatty acids (PUFA), which confer liquidity on an oil, is also responsible for the early development of off-flavours and odours.

Marine oils are highly unsaturated but become fairly stable on hydrogenation. In general the species of fish do not have a major effect on the overall composition of fish oil in terms of its content of triglycerides, free fatty acids, moisture, etc. These factors are mainly determined by the method of storage of fish and processing. However, the triglycerides in fish oil from different species of fish are normally characterized by different fatty acid composition (6).

2.5 OXIDATION

Two forms of deteriorative change can occur in fish oils, viz hydrolysis of the glycerides leading to the production of free fatty acids, and union of the unsaturated compounds of the glycerides with oxygen to produce reactive molecules and rancid flavours. These changes can seriously affect the suitability of fish oils for certain purposes and thus their marketability (26).

Fish oils, although differing chemically to a considerable extent from animal and vegetable oils, oxidize by the same general mechanism as most lipids, the theoretical basis for which was developed during the 1940's (27, 28). Fish oil fatty acids, however, have up to six double bonds where oxidation can take place.

Compared to linoleic acid with only two double bonds or linolenic acid with three, many of the fish oil fatty acids are far more vulnerable to oxidation, and their rate of oxidation is far in excess of that of the fatty acids in most other oils (29).

With most polyunsaturates of fish oils of the omega-3 type, the kind of oxidation products may vary from those obtained from the more usual omega-6 variety (29).

2.6 ESSENTIAL FATTY ACIDS AND VITAMINS

The fatty acid spectrum of fish oils is very complex and the use of fish oils in experimental diets result in a very complicated fatty acid picture in the animal tissues, where in vivo conversions are known to take place i.e. chain elongation and destruction especially of C-16, C-18 and C-20 - mono, di, and trienoic acids (31). Furthermore, partial hydrogenation of fish oil which is necessary for commercial purposes, results in a most complex mixture of unsaturated fatty acids including positional and geometrical isomers (30).

Therefore, it is necessary to clarify the meaning of essential fatty acids for the purpose of a certain work and/or discussion.

The criteria for a polyenic acid belonging to the group of essential fatty acids (EFA) are: a long chain with C-15 - double bonds in divinyl methane arrangement, and the first double bond in position 6 counted from the methyl end of the molecule [w-6 position]. This type of fatty acid is now described as belonging to the "Linoleic acid family" (31).

EFAs restore growth and cure the characteristic dermal symptoms in EFA deficient animals. They prevent damage to kidney and reproductive tissues and prevent a piling up of eicosatrienoic acids in tissues of experimental animals fed on EFA-free or EFA-deficient diets.

A study which put EFA-deficient rats on diets containing 10% of tuna, menhaden, or herring oil, respectively for 12 weeks, showed that all three oils cured the dermal symptoms and restored growth (32). The same researcher showed that the oils were relatively ineffective at lower concentrations. The amount of linoleic acid family of fatty acids was estimated in these experiments to be about 2% in these fish oils.

A study on the effect of feeding menhaden oil to EFA-deficient chicks showed that the addition of 4% menhaden oil to the essentially fat-free basal diet improved the growth rate significantly compared to that of the chicks on the basal diet alone (33).

Most recently, two long-chain "w-3" fatty acids namely 18:3w-3 EFA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), have been recognised as EFA (26, 27). The DHA is necessary for brain and retinal function (18, 20) but may be bio synthesized in situ from 18:3w-3 (26, 27) or be taken up from performed DHA absorbed from the diet and is included in fatty acids circulation in the blood lipids of normal humans (29).

2.7 MAIN NUTRITIONAL PROPERTIES OF FISH OIL

Fish oils as dietary fats are of great general interest, not only as a source of calories and to some extent of certain fat soluble vitamins, but as interesting components containing large amounts of many different types of polyenic acids, including minor quantities of EFA.

Analysis of the fatty acid pattern of fish oil has revealed a most complex picture. Polyenic acids with EFA activity occur in fish oils in minor amounts only. Besides being of interest as EFA's, polyenic acids are of importance in connection with several other aspects of the nutritive effects of fish oils.

The fat in fish is composed mostly of triglycerides [or wax esters, as in New Zealand orange roughy] (35). Generally, fish lipids are characterised by a relatively high content of PUFA mostly of the w-3 family (w-3 PUFA) (34). This type of oil has been shown to be effective in lowering blood cholesterol (30). Such oils are effective even when included in the diet with larger quantities of saturated fatty acids.

The high degree of polyunsaturation found in fish oils added to the low sodium content of many species of fish make them especially useful in therapeutic diets.

The polyunsaturated Fatty acid components of fish lipids can be effective in reducing plasma lipids, but it is unknown whether the amount ingested as components of fish or the concomitant reduction in fat intake has the greater effect when fish are consumed. The results of research in Japan and Netherlands indicate that even low (about 30g/day) but frequent consumption of fish may have beneficial effects in reducing heart disease (36). Consumption of fish in medium (100g/day) to large quantities (400 - 700g/day) was reported to effectively reduce plasma lipids (especially triglycerides), prevent thrombosis and ameliorate ischemic heart disease (37, 38).

The consumption of fish -and especially fish lipids - may provide significant health benefits (35). For example it may provide prophylactic effects in minimizing the development of a number of chronic degenerative disease or pathophysiologies and may exert therapeutic-effects in certain cases, e.g. arthritis, atherosclerosis, and vasospasm. These findings suggest that increased consumption of certain lipids is beneficial, and indicate that issues concerning the nutritional role and inter-relationships between different dietary fatty acids still need to be clarified (35).

A result from clinical trials showed that consumption of relatively large amounts of fatty fish (mackerel or salmon; 200-400g/day) or fish oil (10-50g/day) improve symptoms and/or cause remission of angina pectoris, asthma, atherosclerosis, arthritis, inflammation, psoriasis, thrombosis, tumour growth, and vasospasm and a number of immune and autoimmune diseases (34, 39).

Research has established that the w-3 polyunsaturated fatty acids (w-3 PUFA), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are the principal biologically active components of fish lipids (39). The content of these w-3 PUFA in seafood or fish oils varies considerably between species of fish and marine mammals (6, 34), and largely determines the efficacy and dose required for particular treatments.Table 2 shows a list of disorders that may be ameliorated by dietary w-3 PUFA (35).

Table 2 Disorders that may be ameliorated by dietary w-3

Arthritis	Hyperlipidaemia
Asthma	Inflammatory Diseases
Atherogenesis	Ischemic Heart Diseases
Atherosclerosis	Psoriasis
Automimmune Diseases	Thrombosis
Blood Pressure	Tumour Growth
Burns	Vasospasm

Fish oils have also been incorporated into animal feeds because they have growth-promoting effects, they contain Vitamins A and D and are a cheap source of energy. Considerable work has been done on growth effects of fish oils on various farm animals. In almost all such tests, fish oils have been shown to act as good growth promoters (40). But unless proper care is taken either to limit the amount of fish oil in the diet or to eliminate the fish oil near the end of the feeding period, the possibility exists that the meat of the animals or poultry may acquire a fishy flavour (3).

Vitamin A is required for vision, epithelial membrane integrity, and perhaps, as an anti-cancer retinoid (35). It may also function in an anti-oxidant capacity as a free radical quencher, but it is toxic when consumed in large amounts. Vitamin A (totally biologically available) is concentrated in fish liver oils with small amounts occurring in fish muscle [the concentration depends on factors such as species and season] (35).

It has been reported that fish do not constitute a major source of vitamin A for consumers. Fish Liver oils contain concentrated amounts of vitamin A but these are not consumed as such, and the oils currently available are usually stripped of their vitamin A. On the other hand fatty fish, in contrast to lean fish, contain modest amounts of this vitamin (35).

Vitamin D has also been found in fish liver oils (45). Vitamin D in its active form promotes the syntheses of the protein involved in the transport of calcium in the body. The fattier species of fish such as herring, mackerel, salmon, and lake trout contain varying amount of vitamin D in their tissues (35).

CHAPTER 3

MANUFACTURE AND PROCESSING OF FISH OIL

3.1 CURRENT PRODUCTION OF FISH OIL

Fish oils are produced as a valuable by - product of fish meal from two sources of raw material: The offal (remains after fish-filleting) and the industrial fish. The FAO (Food and Agriculture Organization)statistics show that an increasing proportion of the total catch of fish harvested in the world is reduced to meal and oil. Approximately one third of fish harvested in the world is reduced to meal and oil (41) resulting in some 1.3 million metric tons per year. These fish, commonly known as "industrial fish" include such high-oil species as herring, menhaden, anchovy, sardines, and mackerel (42). The meal, containing high-quality protein is used for animal feed whereas the by-product oil is sold on the industrial market. Around 1.5 million metric tons (mmt) of fish oil is produced annually worldwide (43).

While the production of fish oils is small compared to that of many other oils, its consumption in certain countries is such that it is an important factor in the national diet. For example, in 1979, fish oil accounted for 56% of the total oils and fats consumed in Peru, 26% of the refined, deodorised oils and fats production in the U.K. and 10% of oils and fats used in the EEC (44).

In general the overall composition of fish oil in terms of its content of triglycerides, free fatty acid, moisture, etc, is not species specific (44). Also, a wide variation exists in the oil contents of different fish species and within individual species with the latter occurring with the changing seasons and the age of fish (43).

Based on oil content, fish may be categorised into "lean" fish which is usually considered as having less than 2-2.5% fat and oily fish containing over 2.5% oil.

The equipment necessary for processing lean fish is rather simple since the cooking and pressing operations are greatly minimized or even eliminated. However, oily fish require processing that will reduce the oil content in the meal to a level acceptable to the market.

The most important factor in the production of a high quality crude fish oil is the condition of the raw material at the start of processing. So far as is possible the fish should be undamaged and held under chilled conditions so as to minimise the effect of microbial and enzymatic attack on the fish tissue. Such spoilage is responsible for increased free fatty acid content by liposes, increased oxidative breakdown by peroxidases, increased gum levels by phosphorylases and increased nitrogen and sulphur contents in the oil by breakdown of protein (44).

The present source of commercial fish oil is primarily as a by-product from

fish meal plants. All of the techniques in use on any production scale involve cooking, pressing, and centrifuging to recover the oil from the micella [the liquid portion] (41).

3.2 FISH OIL RENDERING METHODS

Most fish oils (at least 95%) are produced via the so-called wet reduction process (45) under inert gas or in closed containers to reduce chances of deterioration in quality from oxidation by atmospheric oxygen. Fish should be preserved or processed as soon as possible to minimise microbial spoilage.

After curing fish the wet rendering procedure consists of (41):

a Cooking the fish by direct steam injection or indirect steam heating, in order to partially sterilise the oil. Cooking temperature and cooking times are varied depending on fish species, their size and oil content (45). Undercooking of fish leads to incomplete coagulation, denaturation and inefficient separation of protein and oil, while overcooking makes it hard to remove the micella by pressing since much of the homogenized mass will pass through the screens.

Cooking is generally regarded as the most critical step in fish reduction. Typical cooking conditions are a residence time in the cooker of 15 minutes during which the temperature is raised to 90°c (45).

b Dewatering (pressing) with screw presses where the sludge from cooking is mechanically decanted and pressed and crude oil is collected.

c Drying the meal in a rotary vacuum or air dryer. Centrifugation is now used in preference to settling tanks for recovery of oil from the micella.

The liquid portion, known as micella, is composed of water, water solubles, suspended solids, and oil. These materials are separated by centrifuging and screening to give wet solids (usually cycled to the meal dryer), a water phase ("press liquor") laden with water solubles, and crude oil.

The press liquor is treated as wastewater, although future developments should make it possible to recover the soluble solids by chemical and physical means. This could result in a valuable by-product and cleaner wastewater for disposal.

The final oil from a conventional meal plant is separated by centrifuging. Since the quality control of a meal plant is based on producing a high-quality fish meal, the oil does not receive much attention other than being centrifuged and polished to remove most solids and water. Such oil is the raw material that must be further refined if it is going to be used for human consumption. A major improvement that can be made in separating the oil resulting from conventional meal operations is to cool it immediately after cooking and pressing. This retards the oxidation and triglyceride deterioration that makes much of the present crudely extracted oil rancid and high in free fatty acids

(41).

Besides the conventional wet-rendering process which accounts for most of the meal and oil produced in the world, other processing methods normally used for the manufacture of crude oil include the following:

i Dry rendering Process

This process is employed primarily for raw material which is both relatively low in oil content and available in relatively small quantities (45) (46). The process is nearly always a batch type of operation rather than a continuous process and involves a combined cooking and drying step (45).

ii Enzymatic Digestion

This technique and a solvent liquid extraction process have been developed originally to produce high-quality fish protein from edible portions of the flesh. Although there are many different techniques being tried, the basic approach is to mince or homogenize the fish and treat it with about 0.25 to 0.5% enzymes based upon the weight of the whole fish. Following digestion, the reactive material is pressed and filtered. Oil that is liberated from this type of process will float to the surface and can be skimmed or centrifuged in a manner similar to that of reclaiming oil from stick water or press cakes in the conventional precess (45). Another enzymatic technique uses a protease. Fish are incubated with protease at 0.001-0.1% by weight at 45°-75° for 40-50 minutes. The slurry formed is separated into solid and liquid fractions in a continuous decanter to produce fish meal and fish oil (48).

iii Solvent Process

This processing technique has been used in the past when fish oil was the product of choice such as in the preparation of vitamin oils from fish liver (46). This process can be further broken into two basic procedures, one employing a standard cycling of a solvent through homogenized fish and the other employing a solvent in an azeotropic distillation-solvent extraction technique (45).

iv Silage Process

This process involves mincing the fish followed by the addition of the selected acid for preservation (43). The enzymes in the fish hydrolyse the endogenous proteins into smaller soluble units (peptide components). Fish oil is obtained by the centrifugation of the silage (43).

3.3 PROCESSING OF FISH OIL

Generally, processing of fats and oils aims at the removal of impurities which cause the original products to have an unattractive colour or taste or which cause harmful metabolic effects (51).

The processing steps of fats and oils, in order to reduce or remove the impurities may be summarised as follows (49):

a Crude oil storage - insoluble impurities

b Degumming - phospholipids, sugars, resins, proteinaceous compounds, trace metals, and others

c Neutralization - free fatty acids, pigments, phospholipids, oil insolubles, water solubles, and trace metals

d Water washing - soaps

e Drying - moisture

f Bleaching and filtration - pigment, oxidation products, trace metals, sulphur compounds, and trace soaps

g Deodorization - free fatty acids, mono-acid diglycerides aldehydes and Ketones, chlorinated hydrocarbons, and pigment decomposition products

h Polishing

The processing of fish oil for industrial products usually consists of winterization, refining, and bleaching. However, some steps may be added or eliminated depending upon the quality of the oil required.

Figure 3 shows a typical flow diagram for the processing of fish oil (43).

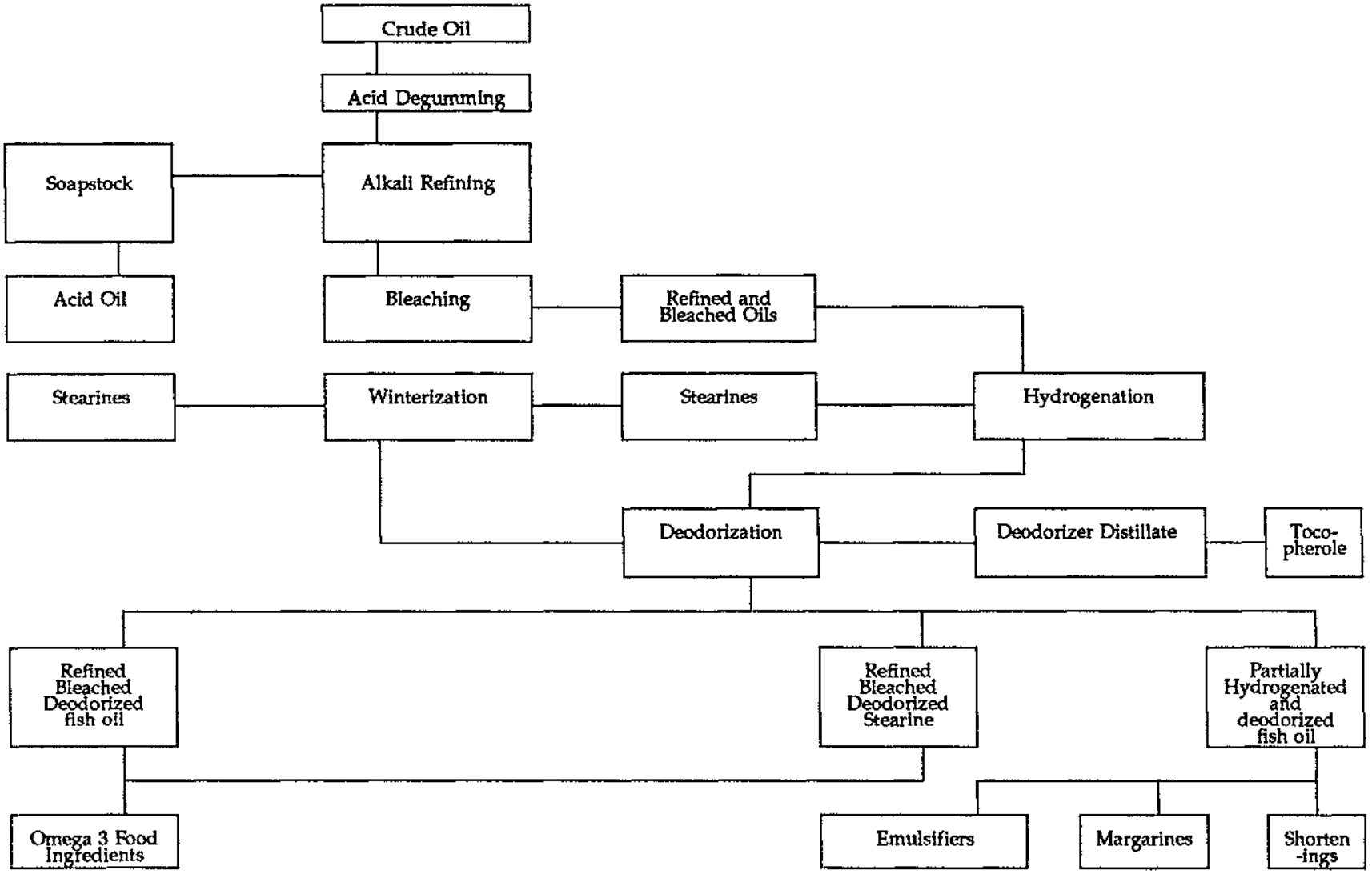

Fig 3 Flow diagram of the processing of fish oil

3.3.1 Fractionation or Winterization

Crude fish oil is usually settled and filtered before further processing. It may also be "winterized" or "cold cleared" by chilling until the higher melting and less soluble saturated glycerides precipitate. After filtration to remove the precipitate solids, an oil is produced that has much improved drying properties (46 (51).

Winterization is a thermomechanical separation process where solid fats are crystallized from a melt.

Nowadays oils are winterized for the following reasons:

a To remove waxes and other nontriglyceride constituents

b To remove naturally occurring high-melting triglycerides

c To remove high-melting triglycerides formed during partial hydrogenation or interesterification

Fat crystallization occurs in two steps:

- the first step involves a crystal formation process called nucleation

- the second step is crystal growth. Technically, the winterization process involves two component fractional crystallizations in terms of solid and liquid fractions

The equipment and technique employed in winterization of oils are rather simple. However such a process produces relatively low-yield that requires a large amount of space and takes a great deal of time. The relatively large molecules of triglycerides are reluctant to precipitate out as well-formed crystals in a media as viscous as oil at low temperatures. The winterization may be terminated when the temperature falls below the lowest temperature which had been attained immediately preceding the rise in temperature. The mixture is then filtered in a room refrigerated to 2°-3°C with a plate and frame filter press (51).

3.3.2 Refining

Crude fish oil also has undesirable substances present in varying amounts. These are removed by refining or processing to increase its usefulness as a starting material for the manufacture of industrial products. These undesirable substances may be classed as follows (46):

a suspended matter, mucilaginous, colloidal, and resinous or polymeric

b free fatty acids present or produced from the natural oil prior to or during the processing of fish

c naturally occurring oil-soluble colouring matter

d volatile odoriferous and flavour compounds dissolved in the oil

e saturated glycerides

The refining of oil begins in the crude oil storage tank, because both quality and yield are affected by storage conditions. Very dirty or wet oil can be allowed to settle and good oil drawn off the top but losses are high when the bottom oil is refined (44).

Degumming refers to the general removal of mucilage by treatment of crude oils with 2-3% of water, or with an aqueous solution of boric acid or a salt such as sodium chloride or pyrophosphate at 30° to 50°C. Degumming may be conducted either by batch process in tank or by continuous process mixer and centrifuge (51).

There are today two methods of refining, the conventional caustic soda or chemical method and the physical refining method. Physical refining requires a thorough degumming treatment for the oil prior to distillative removal of the fatty acids, heat degradable pigments and other impurities at temperatures of the order of 250°c and 2-5 mm Hg absolute pressure with open steam injection.

It has been suggested that the breakeven point for using physical refining over alkali refining is 0.4 - 0.7% ffa. Above 0.7% ffa physical refining becomes more attractive. However, it appears fish oils are not normally physically refined because they are too unstable. The highly unsaturated triglycerides would tend to polymerize during the distillation and produce a rapid flavour reversion after refining (54).

A process of physical refining of fish oil without damaging the long-chain w-3 fatty acids has been described.

Alkali Refining (Neutralization) involves the addition of an alkali solution crude oil which results in both chemical reactions and physical changes (43):

i The alkali combines with the free fatty acids present in the oil to form soaps

ii The gums absorb the alkali and are coagulated by hydration

iii Much of the colouring matter is degraded, absorbed on the gums, or made water soluble by the alkali

iv The insoluble matter is entrained with the other coagulated material

In such a process, a solution of caustic soda is gradually mixed with warm fish oil and then heated to about 100°C. A slight excess of alkali above that necessary to neutralize all of the free fatty acids is used.

The caustic soda method can be carried out in batch, semi-continuous and fully continuous equipment. Of these the most favoured is the centrifugal continuous, refining line (43).

Oils of poor quality are then given a second caustic soda treatment primarily to remove more sulphur, phosphorus and colour, followed by phase separation. The oil is then washed with water to remove soap and centrifuged before being dried. To ensure removal of the soap from the oil, phosphoric or citric acids are often added to the final wash water. Soap reduces the effect of the subsequent bleaching earth treatment and is a hydrogenation catalyst poison (43).

Other refining methods include a complete process that has been described for producing a relatively odourless, refined fish oil containing a high level of w-3 PUFA's. According to the results any fish oil can be used (56).

3.3.3 Bleaching

The natural colouring compounds found in fish oils vary from species to species (46). Bleaching is used to improve the colour, flavour, and oxidative stability of the oil, and to remove impurities, such as traces of soap, that interfere with the hydrogenation process (43). To decolorize fish oils, adsorptive bleaching techniques are most common. Chemical methods of bleaching have been less successful with fish oils than with other natural fats and oils probably due to the greater degree of unsaturation common to commercial fish oils.

The bleaching step is now recognised to be something of a misnomer in that the activated clays used adsorb not only pigments but are also effective in the reduction of oxidation products, trace metals, phosphorus and, to a lesser extent, sulphur compounds.

There are two methods of bleaching, batch and continuous, and batch bleaching can be further broken down into atmospheric and vacuum bleaching (43).

3.3.4 Hydrogenation

Hydrogenation of an oil consists of the direct addition of hydrogen at double bonds in the fatty acid chains of glycerides. The degree of hydrogenation in an oil is directly related to its iodine value. Primarily, hydrogen is a means of converting liquid oils to semisolid plastic fats suitable for shortening and margarine manufacture. Hydrogenation also accomplishes various other desirable results including enhancement of the stability and improvement of the colour and taste of crude oils (51).

Neutralised and bleached oil is the starting material for the hydrogenation process. For ease of hydrogenation and production of high quality product, it has been recommended that prerefined feed stock for hydrogenation have the following characteristics:

FFA-0.15% maximum
Soap-trace
Phosphorous-4ppm maximum
Sulphur-15ppm maximum

On completion of the reaction the oil is cooled to 90°C and filtered.

3.3.5 Deodorization

Deodorization is the removal by vacuum steam distillation of small quantities of the more volatile components which are responsible for any odour or taste in fats and oils. The object is to yield a bland product (51).

Deodorization of fish oils may be effectively accomplished by steam distillation of oil at relatively high temperature. It is important in storage of the deodorized oils to exclude air because of the great tendency for such refined fish oils to revert or become rancid. This process finds its usefulness in improving the flavour of hydrogenated fish oils for use in shortening and margarine (43).

Hydrogenation of fish oils free from non-oil fishy material is another method for reducing fish odour (57).

CHAPTER 4

APPLICATIONS OF FISH OIL

4.1 USAGE OF FISH OIL IN FOOD INDUSTRY

In recent years between 1.1. and 1.6 million tons of fish oil has been produced per annum, virtually all of which has been used for human foods. This tonnage amounts to between 2 and 3% of the world oils and fats supply for food use (58). The predominant part of the world's marine oil production is used in Europe, South America, and Japan. It is used for the production of salad oils, frying fats, table margarine, low-calorie spreads, and industrial margarine and shortening used to make bread, pastries, cakes, cookies, biscuits, imitation creams, and emulsifiers (59, 60, 61). Other uses include feed for livestock, pets, and aquaculture species (62) as well as numerous industrial products (63).

Hardened fish oil is almost entirely used in margarines and shortening. Hardened fish oil is mainly used in the harder packet margarines and does not find much use in the tub margarines. In certain countries the use of hardened fish oil in table margarine is limited because of the presence of a so-called "hardening flavour" (25).

Fish oil, because of its content of highly unsaturated fatty acids, can only be used in the hydrogenated form. However PHFO (Partially hydrogrogenated fish oil) plays an important part in the formulation of fats for edible purposes. PHFO has a particularly wide spread of a crystal stability in the cooled fat which is of value in all edible fats, but particularly so in industrial shortenings and margarine. Cake margarine and shortenings made primarily from PHFO also have better creaming capability than the vegetable counterparts. PHFO is also used in biscuit dough fats. PHFO of higher melting point, in the 46° to 52°c range, is particularly useful for the production of puff or flaky pastry margarine or fats (64).

These products are also valuable for the formulation of bread fats for use in high speed mixing bowls. Lightly hydrogenated fish oil is also used in salad and cooking oil blends.

4.2 FISH OIL AS ANIMAL FEED

For many years fish oil has been incorporated into animal feeds since it:

- is a cheap source of energy.
- has growth - promoting effect.
- often contains significant amounts of vitamins A and D.
- contains a broad spectrum of fatty acids that are well utilised by animals (65).

All animals can utilize good quality fish oils for energy and for growth when

the oils are included in a balanced diet adequately fortified with vitamins.

Although many species of fish store large amounts of vitamins A and D in their livers, the vitamin E requirement for most animals is increased when fish oils are added to their diet. Fish oil is also added to change the fatty acid composition of the fat in edible products. However, when fish oil is added to the diet of animals which are to be used for food, care should be taken to adjust the amount of fish oil in order to avoid the occurrence of fishy flavours in the flesh of the animal (65).

4.3 MEDICAL APPLICATION

4.3.1 Early Medical Applications

Fish oils may contain a unique combination of compounds necessary for human health and longevity (25). Although much of the work, especially that relating to effects of w-3 fatty acids in fish, is relatively new, a vast amount of research has been going on for many decades on the value of fish oil to reduce the incidence of certain diseases. Perhaps the first usage of fish oil which was tested and reported on the basis of its value for treatment of a disease was the work in 1772 in England based on a 10-year study of the use of cod-liver oil to cure arthritis. The use of fish or fish oil in the diet to minimize the chance of acquiring cardiac heart failures awaited the late 1940's and early 1950's before being studied. In the late 1940's, it was found that high serum cholesterol levels, which were known to be associated with increased risk or heart failure, could be reduced by consumption of polyunsaturated fat or oil.

Two 18 to 20 year studies were conducted separately in U.S.A and Holland on the effects of fish oils in the diet on heart attack fatalities. Each of these investigations showed clearly that with increased consumption of fish the risk of fatal heart attacks was decreased (66).

Later, shorter-term research found that in addition to the consumption of fish oil resulting in decreased serum cholesterol levels, some of the highly polyunsaturated long-chain fatty acids, unique to fish oils, were built up to higher that normal levels in certain tissues such as the heart (66).

Fish liver oils are mainly sold for medicinal or veterinary purposes. They are particularly prized for their content of vitamins A and D, and most contracts for fish liver oil produce a better sheen to the coat of the animal (25).

4.3.2 Recent Medical and Pharmaceutical Application

Many studies in different parts of the world have reinforced the view that fish has a dietary role to play in alleviating the effects of coronary heart disease. Further studies have revealed that the main factors within the fish oil responsible for the apparently beneficial effects were found to be two particular long-chain PUFA called eicosapentaenoic acid (EPA; C20:5n-3) and docosahexaenoic acid [DHA; C22: 6n-3] (67).

Research on the beneficial effects of w-3 fatty acids on heart disease is now so well documented that there can be very little doubt that such a relationship exists. There are many different diseases that may be affected by w-3 fatty acids but the amount of research for any one of these many diseases is very small compared to that done on heart diseases (68).

These fatty acids were found to produce changes in the balance of short-lived hormone-type compounds called prostaglandins and Leukotrienes. Such changes have been shown to result in remarkable effects in the treatment of two main classes of disease, namely those affecting blood vessels and those affecting inflammatory diseases (67). Long-chain w-3 fatty acid in fish oils have been shown to cause a dramatic decrease in plasma triglyceride levels in patients suffering from different types of hyperlipoproteinemia. w-3 fatty acid causes a decrease in the production of icosanoids derived from W-6 fatty acid, which play important roles in several thrombotic and immune-inflammatory disorders. Encouraging results have been obtained by dietary w-3 fatty acid in the attenuation of platelet and Lenkocyte function, and decrease of blood pressure (7).

Probably the most important medical use of fish oils is the serum cholesterol depressant effect which is brought about by the highly polyunsaturated fatty acids contained in fish oils. During the early 1960's one fish oil manufacturing concern put up on a trial basis produced capsules containing fish oil and fish oil fatty acid concentrates for use by heart patients (3). Fish oil in the diet was found to produce a very important class of recently discovered lipids called the prostaglandins. The prostaglandins are powerful metabolic and physiological regulators which play a role in preventing excessive fat deposition in the arteries (25).

Other pharmaceutical preparations include the commercially available omega-3 fatty acids from fish oil which are primarily marketed in 1g gelatine capsules (69) (70).

w-3 fatty acid, vitamin A and vitamin D concentrates may also be prepared from fish oil.

Further fish oils and derivatives obtained from them are sometimes also used in cosmetics. The most commonly used substance of this kind is squalene (1).

4.4 OTHER INDUSTRIAL APPLICATIONS

Commercial fish oils are used by industry in a variety of ways including protective coating, lubricants, leather treatment, fire retardants and printing inks. A partial list of these industrial uses is shown in Table (3) (43).

Table 3 Some industrial uses of Menhaden fish oil

Fatty Acids	Fatty Chemicals	Refractory Compounds
Soaps	Leather tanning	Cutting Oils
Protective coatings	Lubricants and greases	Plasticizers
Rubber compounds	Ore floatation	Printing inks
Caulking compounds	Insecticidal cds	Linoleum
Glazing compounds	Fermentation substrates	Presswood fibre boards
Automotive gaskets	Illuminating oils	Oiled fabrics
Core oils	Fuel Oils	Ceramic deflocculants
Tin plating oils	Mushroom culture	Attractants
Rust proofing	Fire retardants	Polyurethane foams

4.5 RECENT FOOD USES OF FISH OIL

Despite considerable doubts that it would be possible to introduce fish oils into food products without making them taste fishy (58), producers have been collaborating to develop a number of non-fish food products which contain refined and deodorized fish oil rich in w-3 long-chain PUFA and which do not taste fishy (67). More details are given in section 6.2.

CHAPTER 5

CHEESE AN OVERVIEW

The idea of this project basically involves incorporating fish oil in cheese which would be the major constituent of the proposed product. Therefore, it is necessary to provide some background on various aspects of cheese and its making that could influence the proposed idea.

This chapter serves the purpose of providing information on cheese that is relevant to the research. The classes of cheese and their nutritional value are discussed first followed by a description of stages of cheese making. Special attention is given to the two forms of cheese which are proposed to incorporate fish oil; processed and spread cheese.

5.1 DEFINITION OF CHEESE

Cheese is the natural and oldest way of preserving the nutrients of milk. The expansion of the numbers of types of cheese make a simple definition of cheese difficult. The simple definition of cheese is the curd of milk produced by enzyme activity and subsequent separation of the whey from the coagulum to give a more solid curd which is the "cheese". However this definition does not cover whey cheese, lactic cheese, cream cheese and some of the cheese produced by newer techniques.

The Food and Agricultural Organization (FAO) defines cheese as the fresh or matured product obtained by the drainage after the coagulation of milk, cream, skimmed or partly skimmed milk, butter milk or a combination of some or all of these products (71).

Processed cheeses and products made from whey, strictly belong to a separate category, as their manufacture does not follow this definition.

Once the "cheese" is formed according to the FAO defined process, it can either be marketed as fresh cheese or be ripened for a shorter or longer period, and sold as matured cheese. This type is often called "natural cheese", in order to distinguish it from processed cheese (72).

5.2 CLASSES OF CHEESE

The classification of different types of cheese is complicated. Within each variety, there are added variations due to place of manufacture, type of milk, packing and coating, shape and size (71).

Although there are probably not more than eighteen distinct types of natural cheese, the handbook Cheese Varieties and Descriptions lists more than 800 different names of cheeses (73).

Cheese may be classified according to various characteristics such as:

- the species that produced the milk
- size
- shape
- weight
- colour
- external appearance
- moisture content
- salt content
- fat content

However there is often a great deal of overlap, such as when the same variety of cheese is produced with milk from different animal species (72).

A variety of systems of classifying cheese are based on these characteristics as follows:

1- Classification based on composition

A very broad classification is as shown in Table 4. This classification ignores other factors such as ripeness, size, shape, external appearance and ripening methods (71).

Table 4 Classification of cheese in respect of composition

Cheese Type	Water in Fat Free Substance (%)	Fat in Dry Matter (%)	Descriptive Class
Extra hard	< 51	> 60	High fat cheese
Hard	49-55	> 45 - < 60	Whole milk cheese
Half fat	53-63	> 25 - < 45	Half fat cheese
Semi-soft	61-68	> 10 - < 25	Low fat cheese
Soft	>61	> 10	Skim milk cheese

2- Classification based on fat content

Because cheese with the same fat content may show completely different characteristics, this method of classification is also not entirely satisfactory.

3- Classification based on ripening characteristics

In internal ripening, micro-organisms within the cheese cause the cheese to mature. For surface ripening, maturing is caused by micro-organisms on the surface of the cheese.

4- Classification based on consistency

Table 5 shows the classifications of cheese based on consistency; giving the product grades of hard, semi-hard and soft. However, this classification still gives rise to an overlap of varieties.

Table 5 Classification of natural cheese, based on consistency

Source : Reference 72

Category	Description
Hard Cheese	Mainly sliceable cheese when little matured mainly grating cheese when fully matured
Semi Hard Cheese	Sliceable cheese at all stages of maturing
Soft Cheese	Sliceable or spreadable cheese according to variety and maturing stage

5.3 NUTRITIONAL VALUE OF CHEESE

Cheese is one of the most versatile and economical foods. Most kinds of cheese contain approximately the same ingredients but the actual composition of cheese varies according to the milk or cream from which it is made. Cheese is virtually solid milk without the lactose (which remains in the whey). The composition of two well known types of English cheese is shown in [Table 6] (74).

Table 6 Composition of two types of cheese

Nutrients	Grams per 100g	
	Cheddar Cheese	Cottage Cheese
Protein	26.0	13.6
Fat	33.5	4.0
Carbohydrate	trace	1.4
Minerals	3.4	1.4
Water	37.0	78.8
Kilo calories per 100g (kilojoules per 100g)	406 (1682)	96 (402)

The heat-treating of milk during the cheese-making process does not produce significant changes to nutritive values, because the milk is not heated above the temperature of pasteurization. Cheese is often also made from raw milk and retains the following valuable constituents of milk - protein, calcium, vitamin A and riboflavin. Thus it is an important element in the average diet.

More than 90 per cent of cheese is digestible material which may be used for energy growth and repair of body tissues. Its calorific value is high (74).

Cheese is the most concentrated form of nitrogenous food in common use and even if it is consumed in relatively small amounts it can provide a significant part of the daily intake of nitrogen. It is a concentrated food, but it does not contain all the nutritive constituents of milk since during manufacturing most of the lactose, lactalbumin and soluble mineral salts remain in the whey (71). Most of the fat in the milk is retained by the cheese thus leading to the fat-soluble vitamins being also retained. The content of water-soluble vitamins varies with the amount of whey retained by the cheese and the extent to which the curd is handled. The washing, cutting, and stirring of the curd removes or destroys practically all of the ascorbic acid that may have been present (73).

The nutritional advantages of cheese can be demonstrated by comparing it with other everyday foods. Table 7 serves this purpose and gives average figures of the nutrients in cheese as compared to other foods per 100g weight (71).

Table 7 Nutrients in cheese (including vitamins) and some other foods. Figures are quantities per 100g of food

Foods	Protein NX 6.26 (g)	Fat (g)	Calcium (mg)	Iron (mg)	Thiamin (mg)	Retinol (Vitamin A) (mg)	Ribo-flavin (mg)	Ascorbic acid (vitamin C) (mg)	Ascorbic Acid (vitamin C) (mg)	Nicotinic Acid (mg)
Cheese										
Cheddar	26.0	33.5	800	0.5	0.04	310	0.5	0	0.5	406
Soft Cheese	22.8	25.5	150	0.4	0.06	155	0.4	0	0.4	285
Cottage	13.6	4.0	60	0.1	0.07	32	0.3	0	0.3	96
Cheese	5.0	1.0	180	0.09	0.09	8	0.26	0.4	0.15	180
Yoghurt										
Bread										
Wholemeal	8.8	2.7	23	2.5	0.26	-	0.06	0	2.5	216
Egg	12.3	10.9	52	2.0	0.09	140	0.47	0	0.07	147
Meat										
Chicken	20.5	4.3	10	0.7	0.1	0	0.16	0	6.0	121
Pork	13.6	31.5	8	0.9	0.58	0	0.19	0	5.0	338
Beef	15.8	24.3	7	1.9	0.07	0	0.20	0	5.0	283
Vegetables										
Potato	2.1	0.1	8	0.5	0.11	12	0.04	15	1.2	87
Cabbage	3.3	0.1	75	0.9	0.06	0	0.05	60	0.25	21
Butter	0.4	82.0	15	0.16	0	710	0.01	0	0	740
Orange Juice	0.8	0	41	0.3	0.1	0	0.03	50	0.2	35

Table composed of extracts from

(a) The Composition of Foods by A Paul and D.A.T Southgate HMSO, London, 1978; and by
(b) Dairy Foods, by JG Davis, Milk Industry, 1974 (3) 14-16

Nutritionally, most natural cheese contains micro-organisms which are responsible for flavour, texture and aroma. These micro-organisms do not usually survive the human digestion processes and are in any case, not injurious to health (71).

5.4 PRINCIPLES OF CHEESEMAKING

Cheesemaking appears to be almost as old as civilization itself and has traditionally been an 'art', handed down from generation to generation. It is only in recent years that precise scientific control has been applied to cheesemaking. The basic type of cheese developed in a given locality probably was of accidental origin. Factors affecting the end product were such things as the kind of milk used, the manner in which it was treated and ripened, the season of year in which the cheese was made, and the way in which it was coated or wrapped. Often a cheese was named for the locality in which it was made. Thus similar cheeses became known by many different names (73).

Despite the great diversity in cheese and its classification into hundreds of different varieties, most cheese is prepared by following a basic 5 step process.

This is:

- preparation of the milk;
- coagulation of the milk with acid or enzymes;
- separation of whey to obtain curd;
- processing of the curd;
- ripening of the cheese

Variations in these basic steps are responsible for the differences between the various cheese varieties. The essence of cheese is the transformation of milk into a concentrated, easily handled, and less perishable food.

Cheese retains most of the protein and fat in milk, but loses much of its milk sugar and soluble mineral matter, through the extraction of the whey. The yield of cheese depends upon the amount of casein, fat and water in the milk.

Hard and semi-hard cheese is usually made using raw milk though the use of pasteurized milk is increasing. Pasteurized milk tends to improve the uniform quality in the finished cheese. Most cottage cheese and cream cheese are made from pasteurized milk.

Organisms in the milk that would cause defects in the final cheese product are destroyed by Pasteurization. Pasteurization also affects the cheese ripening process by reducing enzyme activity and altering bacteria levels. Thus if pasteurized milk is used, more time must be allowed in the ripening process, and this may in turn sometimes affect the body and flavour of the cheese (73).

5.5 PROCESSED AND SPREAD CHEESES

Processed cheese, (or process cheese as it is called in North America), is a product prepared by grinding, mixing, melting and emulsifying one or more varieties of natural cheese. The mixture may be heated, and emulsifying agents and milk components may be added. Other food stuffs such as spices and herbs may be incorporated to alter flavour. [These additives need to be mentioned on packaging].

The advantage of processing is that use can be made of natural cheese with variable characteristics of ripeness, fat content, moisture content, flavour, consistency, etc. Processing gives a marketable product of uniform flavour and good keeping quality.

Cheddar cheese is the most commonly processed variety, but Swiss, Limburger, Brick, and Camembert varieties may also be processed.

The ingredients determine the quality of the final product. A good processed cheese has a smooth, compact body, which is uniform in composition and colour. It is either sliceable or spreadable. The spreadable product contains more water and its PH is 5.6-5.9, whereas that of the sliceable product is PH 5.4-5.6 . The emulsifying agents (phosphates, citrates or tartrates) are added to prevent fat separation and to control the texture of the product (72).

Process cheese spread differs from the processed cheese food (made from cheese and other food products) in moisture content. Process cheese contains 44 to 60% of moisture whereas that for processed cheese food is not more than 44% . In order to obtain a satisfactory body and texture, water-retaining ingredients may be used, but may not exceed 0.8% of the weight of the finished product. Sweetening agents such as sugar, dextrose, maltose, and corn syrup may also be included (73).

In the case of the sliceable product the warm cheese paste is put directly into foil-lined containers. The spreadable product is packaged in cups or other similar containers.

Certain standards govern processed cheese manufacture: the moisture content of processed cheese may not be more than 1% above the maximum permitted in the natural variety from which it is made. The fat content should be the same as that of the natural cheese. Processed cheese can be made entirely from fresh cheese, by adding the correct emulsifying salts. However a better product will be obtained if at least 20% of the material consists of matured cheese (72).

The organisms present in processed cheese are those that survive the time and the temperature used in processing. The non-cheese ingredients may increase the number of organisms present and provide more suitable media for their growth. This explains why processed cheese food and cheese spread may spoil more readily, once opened.

Processed cheese does not normally need to be refrigerated until opened. Its

flavours are usually mild, though there is loss of the natural cheese flavour of its ingredients. It is more expensive than natural cheese, and has similar nutritive value. Cheese spreads have been marketed in aerosol-type dispenser cans which require no refrigeration.

The above shows that there have been a number of successful attempts to add a variety of food products to cheese. The successful attempts lead to the belief that incorporating fish oil in cheese products would also be successful and acceptable to consumers.

The foregoing sections showed that processed cheese is made by mixing and grinding together different lots of cheese with the aid of heat and an emulsifying agent. Therefore fish oil that is to be incorporated in processed cheese can be added during that stage of cheese making which involves heating and adding an emulsifying agent.

CHAPTER 6

PROJECT PRELIMINARIES

6.1 BACKGROUND

The beneficial role of fish oil in the human diet can be divided into two main areas (67).

1. Sustenance of normal healthy life which can be subdivided further into:

   a development of the fetus and young child
   b dietary requirements of the normal adult

2. Correcting certain diseases which can also be subdivided into:

   a treatment of blood vessel diseases
   b treatment of inflammatory disease .

Until recently the use of refined and deodorised non-hydrogenated fish oils in food products was very rare. This is mainly due to the expected problem of these oils reverting, producing smelly and fishy food products . However, the beneficial effect of fish oil on a number of major diseases led many food companies to be interested in developing "healthy" foods containing refined and deodorised fish oils (75).

Recently in the western world, there has been a growth in the sales of capsules, taken as dietary supplements, containing fish oils with declared levels of w-3 PUFA. However to obtain the amount of these acids required to achieve beneficial effects makes buying too many capsules expensive and its consumption uninteresting.

Many people would prefer to obtain the w-3 fatty acids in the food they eat. This is possible by eating fish of course. However, many people do not like eating fish on a regular basis. Also fish vary considerably in both their oil content and the percentage of w-3 fatty acids in the oil (75).

6.2 PREVIOUS ATTEMPTS

The above has led to collaboration between oil producers to develop food products rich with w-3 Long-chain polyunsaturated fatty acids (LCPUFA) through the International Association of Fish Meal Manufacturer (IAFMM) using fish oil (75).

Oils were tried in six categories of food, some of which were strongly flavoured and therefore any flavour from the fish oil could be masked, and some of which were sensitive to off-flavours. These categories are shown in Table 8 together with the comments agreed on when they were tasted blind against a control of the same food without fish oil (67).

Table 8 Flavour assessment of food containing refined fish oils

Food Type	Food Made	Fat Content (g/kg)	Fish Oil Content (% of Food)	Main Ingredients	Flavour Assessment
Spreads and Pastes	Fish Spread Cheese Spread Peanut Butter	250 220 550	11 3.3 5	Fish, meat, oil, water, starch Milk products, cheese, water peanuts, oils, salt	Acceptable Good Acceptable
Margarine	Margarine	800	10/20	Oil, water, salt	Acceptable
Salad and Salad Dressings	Salad Cream Mayonnaise Coleslaw	250 750 50	2.5 - 7.5 3	Vinegar, egg, oil, water oil, egg vegetables, French dressing.	Acceptable Poor
Dairy Products	Yoghurt	40	0.3 - 1.5	Water, fat, protein, sugar	Poor
Oils and Oil Blends	French Dressing Canned Fish Oil	520 1000	31 100	Vinegar, oil, water	Good Good
Sausages, Smoked and Spiced Foods	Salami Pork Sausages	230 300	2 3	Beef, Pork Meats Water Pork Meat and Fat, Water, Fibre	Good Good

The results obtained from phase 1 of IAFMM trials were satisfactory and led to the next development phase where the targeted types of food included French dressing, salad cream, frankfurters and salami. The trial was successful in that in all cases it proved possible to produce foods containing fish oil with acceptable flavours and to indicate a maximum level for each food. The results were promising showing that the target of 2-3g per day of the w-3 LCPUFA can be achieved through the production of food incorporating fish oil (75). The range of food used for the above-mentioned trials included only one type of cheese; spread cheese. When tasting this type of food blindly against a control of the same food without fish oil its flavour assessment was good.

This result was considered encouraging and it has led to the development of the present research project to investigate the level of acceptance of both spread and processed cheese, when incorporating fish oil.

6.3 AIM

The aim of the present study is to investigate the potential development of a non-fish food product which contains refined and deodorized fish oil rich in w-3 LCPUFA and which does not taste fishy. The idea requires that fish oil be incorporated into food recipes to replace part of the customary oil or fat in the product. The nutritional requirements of humans of LCPUFA was reported to range between 1 and 3 g/day (67). Therefore, it is desirable that the fish oil content in the food must enable people to obtain 1-3 gm/day of w-3 LCPUFA.

6.4 OBJECTIVES

* To research current usage of fish and fish oil
* To research the kind of dairy food product suited to incorporate fish oil
* To research current processed cheese products on the New Zealand market and its usage
* To determine the potential acceptability of the product
* To screen packaging methods
* To identify a suitable market and determine the size of the market

6.5 POTENTIAL BENEFITS OF FISH OIL

Research work together with the latest biochemical and nutritional information obtained with animal and human volunteer experiment, suggests that long chain polyunsaturated fatty acids present in fish and fish oil might play a beneficial role in the diet of people in western cultures (76). Epidemiological and experimental evidence (77) suggests that a modest intake of oily fish confers some protection against ischaemic heart disease although the mode of action of fish oil is still uncertain. In addition fish oil was reported to have a favourable effect on serum triglyceride levels, blood pressure, clotting mechanisms and heart rhythm. Further studies (78) have shown that fish oil can ease the itching and scaling of psoriasis, dampen the pain of migraine headache and rheumatoid arthritis, and help prevent coronary artery disease by reducing blood clotting and the level of fat that circulates in the blood.

Thus according to a growing body of evidence, fish oil would appear to be the elixir of the late 20th century. In most experimental situations, the minimum amount of fish oil required does far exceed the amount that would be provided by a typical amount of dietary fish. Further work is needed, particularly on human subjects, to explain the observed protective effects (77).

6.6 POSSIBLE PROBLEMS RELATED TO FISH OIL

Recently considerable interest is being shown in scientific circles about the beneficial health effects of long-chain polyunsaturated fatty acids present in fish oil. As a result, supermarkets, drugstores and health food shops in the USA have devoted a considerable amount of shelf space to fish oil supplements. Some food manufacturers have also begun to market fish products as a healthy option (79). Undoubtly, there is a scientific basis for some claims of the health benefits of fish and fish oil but there is much disagreement concerning the relative advantages and disadvantages of dietary fish and fish oil. Unfortunately, it has been suggested that less than a third of studies of the effects of fish and fish oil on blood lipids, blood pressure and haemostasis have had an adequate control group (80).

In view of the lack of adequate support by scientific evidence for some of the claims, the US Food and Drug Administration (FDA) is not convinced of the oils efficacy and has recently disallowed all health claims for the capsules.

The problem with the scientific study of dietary fish and fish oil and the incidence of cardiovascular disease derives from the fact that many of the data have been obtained from epidemiology studies, implying association rather than causality. Interpretation of the results of such studies is complicated by factors such as genetics and aspects of lifestyle. For example the characteristic plasma fatty acid profiles seen in Eskimos and Canadian Indians although related to high intakes of w-3 fatty acids may be partially attributable to genetic differences in the activity of Δ 5 and Δ 6 desaturases, respectively (80).

There are good reasons for caution. In the rush to acknowledge the positive effects of fish oil, some of the negatives have been overlooked. FDA has focused on the possible hazards of consumption of fish and fish oil (81) which may include:

* Increased susceptibility of cell membranes to lipid pre-oxidation (which in individuals with low antioxidant (e.g.vitamin E) status may be associated with the development of atherosclerosis (82).

* Vitamin E deficiency;

* Depressed immune system response to infection;

* Ingestion of chlorinated hydrocarbons, which may be found in relatively high concentration in the oil of fish from coastal waters.

Many of these problems can be overcome by adding adequate amounts of vitamin E to the oil and by refining to remove undesirable constituents. On balance a moderate intake of oily fish as part of a well-planned diet is probably a healthy choice (79).

A recent study by researchers at the American Human Nutrition Research Centre suggests that the level of vitamin E in most fish oil available in todays

market "may not be enough to maintain a balance between the highly unsaturated fats in fish oil and vitamin E level in the human blood" (78).

Fish oil capsules seem to be effective in relieving some inflammatory diseases, but the fish oil supplement also depresses the immune system's response to stimulated infection. These immune functions normally decline with age leading to the beneficial anti-inflammatory effect of fish oil being weighed against its effect on T-cell mediated immune response. So fish oil should be used with care and with awareness of possible side effects.

The excellent nutritional balance of fish oil and the marked prophylactic properties of w-3 PUFA of fish lipids are expected to boost fish consumption from its current level. However a number of problems or obstacles must be solved or minimized before widespread consumption is possible. These include:

- Supply
- Cost
- Quality (flavour and odour)
- Safety
- Convenience
- Aesthetics

Finally, many would argue that dietary supplements are unnecessary and that a balanced diet is the most appropriate means of ensuring adequate nutrition. However, there are many individuals who dislike the taste of fish. Thus capsules containing fish oil or the addition of fish oil to some food products (e.g. bread, cheese, salad dressing) provide an alternative for such individuals, provided that the oil intake is moderate and that vitamin E intake is adequate (88).

These reasons, added to the encouraging results obtained by IAFMM trials, have led to the development of our product idea. The response of consumers to the proposed idea was investigated through a field survey and the results are discussed in the following chapter.

CHAPTER 7

SURVEY AND RESULTS

7.1 INTRODUCTION

Product innovation has become a vital element in corporate strategy for such reasons as changes in consumer and competitor behaviour, technology and government policy [Rothberg 1918].

The commercial success of new products is dependent on selection of a product with a high level of consumer demand or with minimum potential opposition from competitors. Another factors is the development of a product with characteristics acceptable to the consumer.

It was previously mentioned that fish oil and particularly w-3 fatty acids have unquestionable health benefits. This study was therefore conducted to obtain a highly nutritive product with improved w-3 fatty acid content through the addition of fish oil.

Based on the literature and in view of the success of IAFMM trials where fish oil was incorporated in a number of food products, two product ideas were retained where fish oil could be added to improve w-3 fatty acid content:

- processed cheese
- spread cheese

A critical part of a product development process is measuring the consumer response and testing his acceptance. This will indicate whether the proposed product can be marketed as it is or improvement is needed.

Therefore, a consumer survey was carried out to check the acceptability of the new product ideas and identify the market preferences.

The issues investigated in the survey include the frequency of fish and cheese consumption, the consumers awareness of the nutritional value and health benefits of fish oil and the technological and marketing aspects of the products which make them acceptable to the consumer.

Following sections present the aim and the methodology of the survey and discuss the results obtained.

7.2 AIM OF SURVEY

The aim of the consumer survey was to obtain information regarding the recent consumer behaviour relating to fish oil and cheese products and to determine consumer attitude towards the new product ideas incorporating fish oil.

This is to establish the market potentials and target market.

7.3 OBJECTIVES

The survey aimed at obtaining information to achieve the following objectives:

- to determine the present frequency of purchase of fish products.
- to determine the present frequency of consumption of cheese and what kind of cheese are most popular.
- to determine consumer acceptability about the proposed product ideas and their preferences in packaging, price and information they would like to see on the product.
- to determine market potential and the target market segment.
- to determine the most acceptable product idea for further development.

7.4 METHODOLOGY

It is acknowledge that the most practical way of predicting consumer response to a new product is through the use of a sensory panel.However the consumer, who may not have the level of skill for a specialized sensory taste, can provide unbiased information not obtainable from trained panellists.

Questionnaires with prepaid postage envelopes were distributed in Wellington and Palmerston North. One hundred questionnaires were distributed to potential consumers in Wellington and two hundred in Palmerston North.

The method of distribution was designed to approximate a random survey where the questionnaires were handed to customers at major supermarkets during different times of the day. Those customers are considered to be the persons in charge of household shopping and/or determining the family menu.

The participants were asked to return the questionnaire within three days.This method enabled more questions to be asked and allowed the respondents enough time to answer the questionnaire included in Appendix 1.

The questionnaire was designed to obtain information needed to achieve the objectives. Classification of incomes was set at $10,000 increments with those consumers of income over $40,000 being grouped in one class. Such a classification aimed at serving people of relatively low income.

All data was input to the computer and analysed using Minitab program. The analysis produced one dimensional and two dimensional cross tabulation.

7.5 OVERALL RESULTS

7.5.1 Characteristics of Respondent

Of the total 300 questionnaires distributed 120 questionnaires were returned producing a response rate of 40% in both cities .However the response rate of 49% from Wellington is higher than that of Palmerston North with only 36% rate.This may indicate that the citizens of Wellington areas where the questionnaires were distributed are more health oriented and possibly more educated with higher level of income than those of Palmerston North .The various characteristics of respondents including gender, age, income, and occupation are given in tables 9 and 10.

Table 9 Sex and age of total respondents

	Number	%
Sex		
male	39	33.0
female	79	67.0
Ages (Years)		
<15	3	2.6
16-20	10	8.7
21-25	9	7.8
26-30	22	19.1
31-35	19	16.5
36-40	17	14.8
41-45	13	11.3
46-50	12	10.4
51-55	7	6.1
56-60	2	1.7
>60	1	0.9

Note: The totals are less than 120 due to missing data as a result of incomplete questionnaires

Table 10 Income and occupation of total respondents

	Number	%
Income		
< $10,000	13	11.9
$10,000-$20,000	14	12.8
$20,000-$30,000	23	21.1
$30,000-$40,000	4	3.7
> $40,000	55	50.5
Occupation		
Unemployed & retired	7	6.1
Housewife	13	11.3
Student	17	14.8
Civil servant < 30,000	26	22.6
Civil servant > 30,000	50	43.5
Private sector	2	1.7

Note: Totals are not the same due to incomplete questionnaires

Table 11 Consumption frequency of fish and cheese

Frequency % respondents	Product				Total monthly consumption	
	Fish		Cheese		Fish	Cheese
	No.	%	No.	%		
>twice/week	21	17.5	38	31.7	252	456
once/week	41	34.2	61	50.8	164	244
once/fortnight	27	22.5	10	8.3	54	20
once/month	16	13.3	5	4.2	16	5
<once/month	10	8.3	4	3.3	5	2
None	5	4.2	2	1.7	0	0
Total Monthly consumption	491		727		491	727

It can be seen that two thirds of respondents participating in the survey are female. Approximately half of respondents are aged 25-40 years and about 87% aged between 20 and 55 years . Most respondents are in the high income group (>$40000) which may be considered a sign of their high education thus reflected in their relatively high response. More than 65% of respondents are civil servants of which two thirds are with income > $30,000 which supports the previous conclusion in that the respondents acquire relatively high level of education.

7.5.2 Consumption Frequency

Consumption frequency of fish and cheese products is shown in Table 11. The monthly consumption is calculated by assuming the month to consist of four weeks. Average values of three times per week is taken for respondents consuming products more than twice per week and half time per month for those consuming products less than once a month. The monthly consumption of cheese was found to be about 60% higher than that of fish.

The results of the survey showed that, as expected, the respondents consume cheese more often than fish. Approximately 82% of respondents reported to consume cheese at least once a week compared with a corresponding value of 51% for fish. Those respondents consuming cheese once a month or less constitute only 9% compared with over 25% as related to fish consumption. Only 1.7% of respondents did not consume cheese at all with a corresponding figure of 4.2% for fish consumption.

The above results indicate a low level of fish consumption and relatively high cheese consumption among respondents. The consumption of fish oil in capsules was found to be even lower. Less than 6% use fish oil capsules most of whom use it occasionally i.e < once a week.

Among cheese products, processed cheese seems to be most popular and is consumed most as shown in Table 12. More than 90% of all respondents reported consumption of processed cheese making it a better candidate for the product idea. This result added to that showing over 82% of respondents consuming cheese at least once a week gives more support to the idea of incorporating fish oil in processed cheese thus benefiting more people.

When investigating the awareness of respondents of the nutritional and health benefits of fish oil the results showed relatively high levels of awareness of these benefits with 54% reporting positively.

The above shows that although many people are aware of fish oil benefits to health, few of them consume it regularly. This finding dictates the need for and gives greater value to the present study with the aim of incorporating fish oil in cheese products. If successful, many people will benefit from fish oil qualities without significant change in their daily diet.

Table 12 Consumption of cheese

Cheese Type	Number	%
Processed	109	90.8
Spread	7	5.8
other	2	1.7
None	2	1.7

7.5.3 Knowledge of fish oil benefits

The results of the survey showed that more than half of respondents (56.7%) are aware of the nutritional values and health benefits of fish oil. Table 13 shows that the age of consumers seems to be a significant factor affecting the people awareness of fish oil benefits with the level of awareness being higher among older people.

The majority of those who are aware of the nutritional values and health benefits of fish oil belong to the middle-age group (between 21 and 50 years) which constitute a similar percentage of all respondents.

The young (< 21 years) constitute 11.3% of all respondents compared to only 3.2% of those with awareness. The old (> 50 years) seem to have a higher level of awareness since they constitute 8.7% of respondents compared to over 12.6% of those with awareness.

Table 14 shows that the frequency of fish consumption may be related to the awareness of fish oil benefits. More than half of the aware respondents consumed fish at least once a week. Those who consume fish least are also found to be least aware of fish oil benefits.

Table 13 Age respondents and their awareness of fish oil benefits

Age(year)	Number	%aware	%respondents
< 21	2	3.2	11.3
21-30	19	27.6	26.9
31-40	19	29.7	31.3
41-50	16	24.9	21.7
> 50	8	12.6	8.7
Total	64	100.0	100.0

Table 14 Awareness of fish oil benefits as related to fish consumption

Fish consumption	Aware of fish oil benefits	
	No.	%
> twice / week	14	20.5
once / week	24	35.3
once / fortnight	15	22.1
once / month	7	10.3
< once /month	4	5.9
None	4	5.9
Total	68	100.0

7.6 ANALYSIS OF RESPONDENTS TOWARD PRODUCT IDEAS

7.6.1 Product Acceptability

The results of the consumer survey were subjected to further analysis to investigate attitudes of respondents towards the product ideas. Table 15 shows this attitude and illustrates that more than half of the respondents think highly of the idea of incorporating fish oil in cheese. This is comparable to the percentage of respondents who reported awareness of fish oil benefits indicating a closer relationship between awareness of fish oil benefits and the acceptability of product ideas.

Respondents reported higher acceptability of the product idea of incorporating fish oil in processed cheese. This is not surprising since more people were found to consume processed cheese than spread cheese indicating that processed cheese could be a better candidate for the new product.

A low percentage (17%) of all respondents did not like the product ideas. Those respondents who ranked the ideas below average were 10% with only 7% describing the idea as poor.

Table 15 Product acceptability

Attitude	Product Ideas			
	Processed cheese		Spread cheese	
	No	%	No	%
Excellent	12	10.4	13	11.8
Good	48	41.8	40	36.0
Average	34	29.6	40	36.0
Below average	12	10.4	11	9.9
Poor	9	7.8	7	6.3

In order to decide which idea is more acceptable a point system was adopted and applied to the attitude of respondents as follows :

Excellent	5 points
Good	4 points
Average	3 points
Below average	2 points
Poor	1 points

Using these gradings Table 16 shows that although processed cheese scored slightly higher points than spread cheese the product ideas were equally acceptable by respondents. This becomes more evident by calculating the average score per respondent where a value of 3.37 points was obtained for both product ideas. However, if we accept that the stronger the response the higher the buying intention then a product incorporating processed cheese and fish oil would have a better potential market.

Table 16 Scores of respondents' attitude towards product ideas

Attitude	Product Ideas			
	Processed cheese		Spread cheese	
	No	Points	No	Points
Excellent	12	60	13	65
Good	48	192	40	160
Average	34	102	40	120
Below average	12	24	11	22
Poor	9	9	7	7
Grand Total	115	387	111	374

The distribution of the respondents' attitude towards the product ideas by gender, age, income and occupation reveals interesting results which would be beneficial for identifying target market segments. The distribution is shown in tables 10 through 17.

The survey results given in Table 17 show that the acceptability of the developed product of processed cheese incorporating fish oil can be affected by both the age and sex of respondents.

Male respondents were found to feel slightly more strongly about the product idea and seem to like the product more than females. This could be attributed to the nature of males being more adventurous.

When investigating the effect of age on acceptability the number of age groups was reduced due to the limited number of respondents. The results indicate that the product seems to be more acceptable to the younger consumers than older ones. Respondents less than 20 years of age were found to like the product idea most. No respondent in this age group ranked the idea as poor and only 8% ranked it below average. These figures are compared with corresponding figures of 3 and 12 % of the middle-aged group and 18 and 9% for the old group (>40 years) respondents.

In order to reach a more reliable conclusion, further investigation into the effect of sex and age on product acceptability was carried out using the point system as explained earlier. The results are given in Table 18 and illustrate more clearly that acceptability decreases with age of consumer where those of age under 20 years show much better acceptability to the product idea than those over 40 years. The average scores for all respondents in the various groups were 3.77, 3.88 and 3.15 for young(< 20), middle-aged(20-40) and old(>40) age groups respectively. As for age, the application of a point system

on sex reinforced the above conclusion in that the product idea seems to be more acceptable to males with average score 3.45 compared to 3.35 for females.

Table 17 Sex and age of respondents on the level of products' acceptability

	Level of Acceptability									
	Excellent		Good		Average		Below Average		Poor	
Sex										
	No	%	No	%	No	%	No	%	No	%
Male	4	10.5	18	47.4	10	26.3	3	7.9	3	7.9
Female	8	10.5	30	39.5	24	31.6	9	11.8	5	6.6
Age										
<20	2	15	7	54	3	23	1	8	0	0
20-40	7	11	23	35	25	39	8	12	2	3
>40	2	6	16	49	6	18	3	9	6	18

Table 18 Score of consumer acceptability by sex and age

	Average Score
Sex	
Male	3.45
Female	3.36
Age	
< 20	3.77
20-40	3.38
> 40	3.15

Further distribution of respondents' attitude towards the developed processed cheese by income and occupation is shown in Table 19. The analysis of results indicate that the product idea is more acceptable to consumers in the lower income groups.Those with income level below $ 30,000 were found more receptive to the idea.This conclusion was tested further using the point system to calculate the average score per respondent in each of the income categories and the results given in table 13 support the above, confirming better product acceptability among respondents with annual income between $10000 and $30000.

The distribution of respondents attitude by occupation is also given in table 19 while the average score of each category, calculated through the application

of point system, is given in Table 20. The results in both tables illustrate lower acceptability of the product by civil servants with income level over $ 30,000 while higher acceptability is reported by unemployed and retired, students and civil servants with income less than $ 30,000.The results for the private sector category is discarded due to very small sample size of respondents (only 2)making it statistically unreliable. However, the positive response obtained from this category warrants further investigation to confirm or deny the expectations. These findings combined with the fact that those categories who reported high acceptability of product idea have relatively low income further support the above conclusion that the acceptability of the product idea is influenced by income level and that those with lower income are more receptive to the idea .

Similar analysis was carried out on responses to the second product idea which involves incorporating fish oil in spread cheese.The effect of respondent characteristics on their attitude towards the product idea was investigated and the results are shown in Tables 21 through 24.

Table 19 Respondent acceptability of developed processed cheese by income and occupation

	Level of Acceptability									
	Excellent		Good		Average		<Average		Poor	
Income ($)	No.	%	No.	%	No.	%	No.	%	No	%
<10,000	2	16.7	4	33.3	3	25.0	2	16.7	1	8.3
10,000 - 20,000	0	0.0	10	76.9	2	15.4	0	0.0	1	7.7
20,000 - 30,000	5	21.7	9	39.1	7	30.4	1	4.4	1	4.4
30,000 - 40,000	0	0.0	1	25.0	3	75.0	0	0.0	0	0.0
>40,000	4	7.4	20	37.0	18	33.3	7	13.0	5	9.3
Occupation										
Unemployed and retired	1	14.3	4	57.1	1	14.3	0	0.0	1	14.3
House wife	1	8.3	3	25.0	5	41.7	3	25.0	0	0.0
Student	2	12.5	8	50.0	3	18.8	2	12.5	1	6.2
Civil Servant <30,000	3	12.0	11	44.0	8	32.0	2	8.0	1	4.0
>30,000	4	8.2	19	38.7	16	32.7	5	10.2	5	10.2
Private Sector	0	0.0	2	100	0	0.0	0	0.0	0	0.0

Table 20 Average score of consumer acceptability of the developed processed cheese by income

Income	Average Score
< 10,000	3.33
10,000 - 20,000	3.62
20,000 - 30,000	3.69
30,000 - 40,000	3.25
> 40,000	3.20
Occupation	
Unemployed	3.57
Housewives	3.17
Students	3.50
Civil servant < 30,000	3.60
Civil servant > 30,000	3.25
Private Sector	4.0

The results given in Table 21 show that sex does not have significant effect on product acceptability. The proportions of respondents who ranked the product idea as excellent and good were similar (47.4% of male and 48.6% of female) with similar average score per respondent. If this finding is combined with earlier results about the acceptability of processed cheese product we may deduce that the product idea acceptability is independent of sex.

The results in the same table indicate that the product idea seems to be much more acceptable to the consumer under 40 years of age.Calculating the average score per respondent in each of the age categories produced the results shown in Table 22. The results seem to support the above conclusion that the younger consumers (< 40 years) accept the product idea more than those in older age groups with average scores of 3.56 for the under 40 years age group and 2.95 for the older group.

The relation between product idea acceptability and the income and occupation of respondents was also investigated and the results are shown in Table 22 and indicate that consumers with lower income level accept the idea more than those of higher income (the proportion of respondents who ranked the product idea as excellent or good decreased systematically from 76.9% to 32% for income levels < $ 10,000 and > $ 40,000 respectively). This conclusion was reinforced when the point system was used to calculate the average score per respondent as shown in Table 24.

Distribution of respondents attitude towards the product idea by occupation is given in Table 23 which shows that lower acceptability is reported by higher income civil servants and higher acceptability by unemployed, retired, students and lower income civil servants (< $ 30,000).These findings give further support to the conclusion that income level has a significant effect on the product idea acceptability.

Table 21 Respondent attitude towards spread cheese by sex and age

Sex	Attitudes of Respondents (%)									
	Excellent		Good		Average		<Average		Poor	
	No.	%	No.	%	No.	%	No.	%	No	%
Male	7	18.4	11	29.0	13	34.2	4	10.5	3	7.9
Female	6	8.3	29	40.3	27	37.5	7	9.7	3	4.2
Age (years)										
< 21	2	15.4	6	46.2	5	38.4	0	0.0	0	0.0
21 - 30	3	9.7	10	32.3	11	35.4	6	19.4	1	3.2
31 - 40	5	15.1	15	45.5	10	30.3	3	9.1	0	0.0
41 - 50	0	0.0	6	28.6	10	47.6	2	9.5	3	14.3
> 50	1	11.2	2	22.2	4	44.0	0	0.0	2	22.2

Table 22 Score of consumer acceptability of the developed spread cheese by sex and age

	Average Score
Sex	
Male	3.40
Female	3.39
Age (years)	
< 21	3.77
21 - 30	3.26
31 - 40	3.67
41 - 50	2.90
> 50	3.00

Table 23 Respondent attitude towards the developed spread cheese by income and occupation

Income ($)	Attitude of Respondents (%)									
	Excellent		Good		Average		<Average		Poor	
	No.	%	No.	%	No.	%	No.	%	No	%
<10,000	3	23.1	7	53.8	2	15.4	1	7.7	0	0.0
10,000 - 20,000	2	15.4	6	46.1	3	23.1	1	7.7	1	7.7
20,000 - 30,000	4	18.2	9	40.9	9	40.9	0	0.0	0	0.0
30,000 - 40,000	0	0.0	2	50.0	2	50.0	0	0.0	0	0.0
>40,000	2	4.0	14	28.0	22	44.0	0	0.0	0	0.0
Occupation										
Unemployed and retired	3	42.8	1	14.3	2	28.6	0	0.0	1	14.3
House wife	1	8.3	3	25.0	5	41.7	3	25.0	0	0.0
Student	4	23.5	9	52.9	3	17.7	1	5.9	0	0.0
Civil Servant <30,000	1	4.2	10	41.7	11	45.8	2	8.3	0	0.0
>30,000	2	4.5	14	31.1	19	42.2	5	11.1	5	11.1
Private Sector	1	50.0	1	50.0	0	0.0	0	0.0	0	0.0

Table 24 Average score of consumer acceptability of the developed spread cheese by income and occupation

	Average Score
Income ($)	
< 10,000	3.92
10,000 - 20,000	3.53
20,000 - 30,000	4.18
30,000 - 40,000	3.50
> 40,000	3.02
Occupation	
Unemployed	3.71
Housewives	3.17
Student	3.94
Civil servant < 30,000	3.50
Civil servant > 30,000	3.07
Private sector	4.50

Table 25 Respondent preference of packaging, size and price of developed processed cheese

	No.	%
Packaging type		
Can	2	3.7
Plastic sealed package	90	79.7
Plastic sealed bag in cardboard box	7	6.2
Other	12	10.6
Size (gm)		
250	36	32.7
500	48	43.6
750	10	9.1
1000	16	14.6
Price / 250 gm ($)		
2.00 - 2.50	58	52.3
2.51 - 3.00	37	33.3
3.01 - 3.50	16	14.6
3.51 - 4.00	0	0.0

Table 26 Respondent preference of packaging, size and price of developed spread cheese

	No.	%
Packaging type		
Refrigerated plastic Container	60	
Glass jar	39	65.6
Other	7	36.8
Size (gm)		6.6
125	56	
300	38	53.9
400	10	36.5
Price / 125 gm ($)		9.6
2.00 - 2.50	71	
2.51 - 3.00	23	71.0
3.01 - 3.50	6	23.0
		6.0

7.6.2 Preference of Packaging Type, Size, and Price

In an attempt to identify other marketing tips, an analysis was carried out of respondents preference of the type of packaging, the size of the package and the price that they would be prepared to pay for the new products. The results are shown in Tables 25 and 26 for both processed cheese and spread cheese product ideas respectively. The majority of respondents (79.7%) preferred

plastic sealed type of package for the proposed processed cheese product while the least preferable type of packaging was found to be the can with only 3.5% of respondents preferring it. The most preferable size for this product is 500 gm with 43.6% of respondents reporting it as their preference followed by the 250 gm size (32.7%) while 750 gm was given the lowest preference with only 9.1%. When asked about the price that the consumer would be prepared to pay for 250 gm of this proposed product, more than half indicated that they would pay between $ 2.00 and $2.50. No one is prepared anything above $ 3.50 for the same size of the product.

Similar analysis of the respondents preferences for packaging, size and price of the developed spread cheese product (Table 26) revealed that the refrigerated plastic container is the most preferable type of packaging with about two thirds of respondents (65%) reporting this type as their preference. Glass jar was more preferable for 36.8% of respondents. The most preferable size of container was found to be 125 gm (more than half respondents) followed by 300 gm (36.5%). The majority of respondents (71%) reported that they would be prepared to pay between $2.00 and $2.50 for 125 gm of this proposed product and only 6% prepared to pay more than $3.0.

7.6.3 Market Potential and Target Market Segment

The aim of this part was to assess the selling potential on the market of the proposed product ideas.

The objectives were :

* To determine the price the consumer was prepared to pay
* To determine the target market
* To estimate the market potential of the developed products

The results of the consumer survey reveal as illustrated in Tables 25 and 26 that a total of 52.3% of respondents indicated that they would be prepared to pay between $2.00 and $2.50 for 250 gm of developed processed cheese. A total of 71% of respondents would pay the same price for 125 gm of developed spread cheese.

A cross tabulation was done to determine the buying trends of respondents in terms of demographic characteristics. The results are shown in Tables 27 through 30. The results of the analysis illustrate that the buying trend of respondents is independent of geographic location since the percentage of people reporting their intention to buy the proposed product were similar in both Wellington and Palmerston North.

However other consumer characteristics such as age, income and occupation were found to have distinct effects on the buying trend. Although both sexes show the same buying intention to the processed cheese product, females showed much less intention to buy the spread cheese product.

The majority of young with age < 20 years and the old with age > 50 years

(70%) would buy the proposed processed cheese product. This figure compares to less than half of respondents from all other age groups. Knowing the health benefits of fish oils both groups seem to realise that they need these benefits more than others. Similar results were obtained for response to the spread cheese idea with less enthusiasm to buying the proposed product by the old aged people.

The survey results also suggest that the income of consumers may have an important effect on their buying trend. Consumers of lower income groups intend to buy the product more than high income consumers (> $ 40,000). Among low income groups lower buying intention of those with income <$10,000 may be partly explained by their willingness to buy but realization that they would be unable to afford it. Another explanation could be related to their low level of awareness of health benefit of fish oil. The occupation of the consumer has a similar effect, being related to the income. Consumers with low income occupations reported that they would buy the proposed products more than high-income occupation groups. The proposed products seem to have a good market potential among students, unemployed and retired and low income civil servants.

The above results confirm the conclusions derived earlier that show consumers under 40 years of age and those with income less than $ 30,000 to have better acceptability of the potential products.

In general more positive response was given to the product idea incorporating fish oil in processed cheese than in spread cheese. The average percentage of consumers who expressed their willingness and intention to buy the processed cheese product was found to be about 55% compared with about 47% for spread cheese product idea. In particular students and housewives seem to prefer and are more prepared to buy the proposed processed cheese product than that of spread cheese.

Further cross tabulation was carried out in order to determine the frequency of buying intention and the target groups of consumers with the results shown in Table 31 for both the processed and spread cheese.The majority of those consumers who reported positive buying intention (those who answered " yes ") have reported that they would buy the developed product at least once a week.This proportion amounts to about two thirds (63%) of consumers with positive buying intention. Very few potential buyers would buy the proposed products once a month or less. However the results confirm that those consumers who intended to buy the proposed product would buy more often that product which incorporates fish oil in processed cheese than spread cheese. Table 31 illustrates that young consumers i.e teenagers and children would like the developed products least while adults would like them more. About two thirds of respondents reported that the proposed products would be consumed by the whole household.

Based on the above findings the products should be developed to target the consumer groups who have the characteristics identified i.e adults < 40 years of age, with < $ 30,000 income. Cross tabulation analysis showed that these

groups are expected to buy the products once a week or more.

Once the products are manufactured, market trials need to be carried out to establish if any modification could be made to improve the developed products.

Table 27 Buying intention of developed processed cheese by location, sex and age of respondents

	Buying Intention					
	Yes	%	No	%	Don't Know	%
Location						
Wellington	36	52.9	9	13.3	23	33.8
Palmerston North	23	51.1	6	13.3	16	35.6
Sex						
Male	19	52.8	6	16.7	11	30.5
Female	39	51.3	9	11.8	28	36.9
Age (years)						
< 20	9	69.2	1	7.7	3	23.1
21 - 30	14	44.2	5	16.1	12	38.7
31 - 40	17	48.6	2	5.7	16	45.7
41 - 50	9	45.0	5	25.0	6	30.0
> 50	7	70.0	2	20.0	1	10.0

Table 28 Buying intention developed of processed cheese by income and occupation of respondents

	Buying Intention					
	Yes	%	No	%	Don't Know	%
Income ($)						
< 10,000	6	46.1	2	15.4	5	38.5
10,000 - 20,000	10	71.4	2	14.3	2	14.3
20,000 - 30,000	13	56.5	3	13.4	7	30.4
30,000 - 40,000	2	50.0	0	0.0	2	50.0
> 40,000	22	44.0	8	16.0	20	40.0
Occupation						
Unemployed	3	42.9	1	14.2	3	42.9
Housewives	4	33.3	0	0.0	8	66.7
Student	11	64.8	3	17.6	3	17.6
Civil servant < 30,000	15	57.7	3	11.5	8	30.8
Civil servant > 30,000	22	47.8	8	17.4	16	34.8
Private sector	2	100.0	0	0.0	0	0.0

Table 29 Buying intention of developed spread cheese by location, sex and age of respondents

	Buying Intention					
	Yes	%	No	%	Don't know	%
Location						
Wellington	30	45.5	19	28.8	17	25.7
Palmerston N.	22	51.1	7	16.3	14	32.6
Sex						
Male	22	61.1	8	22.2	6	16.7
Female	19	30.7	18	29.0	25	403
Age (years)						
< 20	9	69.2	1	7.7	3	23.1
21 - 30	9	31.0	7	24.2	13	44.8
31 - 40	18	52.9	5	14.7	11	32.4
41 - 50	7	36.8	9	47.4	3	15.8
> 50	5	50.0	4	40.0	1	10.0

Table 30 Buying intention of developed spread cheese by income and occupation of respondents

	Buying Intention					
	Yes	%	No	%	Don't know	%
Income ($)						
< 10,000	6	46.2	0	0.0	7	53.8
10,000 - 20,000	8	61.5	3	23.1	2	15.4
20,000 - 30,000	13	56.6	5	21.7	5	21.7
30,000 - 40,000	3	75.0	0	0.0	1	25.0
> 40,000	16	34.0	16	34.0	15	32.0
Occupation						
Unemployed & retired	4	57.1	2	28.6	1	14.3
House wife	2	15.4	3	23.1	8	61.5
Student	9	52.9	1	5.9	7	41.2
Civil servant < 30,000	15	62.5	5	20.8	4	16.7
Civil servant > 30,000	18	41.9	14	32.5	11	25.6
Private sector	2	100.0	0	0.0	0	0.0

Table 31 Buying frequency of consumers who reported their willingness to buy the developed products

Frequency of intended buy	Processed cheese		Spread cheese	
	No.	%	No.	%
Twice / week	9	15.8	5	9.8
Twice / fortnight	27	47.4	27	53.0
Twice / month	18	31.6	12	23.5
< once / month	3	5.2	7	13.7
Household type				
Whole household	40	67.8	31	60.8
Adults	17	28.8	14	27.4
Teenagers & children	2	3.4	6	11.8

CHAPTER 8

STATISTICAL ANALYSIS

This chapter is concerned with the analysis of the frequency data that occurred in the previous section in the form of cross-classification or contingency tables.

8.1 DESCRIPTION OF DATA

The data obtained from the consumer survey in chapter 7 involve multiple classification. This classification, however, is exhaustive where sufficient categories are provided to accommodate all members of the population - a generic term denoting a well defined class of people or things - The categories are also mutually exclusive i.e each member of the population can be correctly allocated to one, and only one, category.

The data obtained from the questionnaire are qualitative since the population is classified into several categories and each cell contains a "count" of the number of individuals in each category. The sample drawn is a random one in which each member of the population in question has an equal chance of being included. The sample is classified with respect to two or more qualitative variables thus producing contingency tables with certain numbers of cells.

Although they may be transformed into proportions or percentages, the entries in the cells are originally frequencies or counts rather than continuous measurements.

The contingency tables produced from the data would be with rows, columns or both greater than 2 and the variables will have ordered categories.

8.2 THEORY

8.2.1 Independent Classification - Association

Having examined the type of data with which we are concerned, it is necessary to consider the questions of interest about such data. The most important question is whether the qualitative variables forming the contingency table are independent or not. The answer requires to clear what independence between the classifications would entail.

First suppose that, in the population from which the sample is taken, the probability of an observation belonging to the ith category of the row variable and the jth category of the column variable is represented by P_{ij}; consequently the expected frequency in the ijth cell of the table F_{ij} resulting from sampling N individuals is given by

$$F_{ij} = N\ P_{ij} \tag{1}$$

Let;

P_i represent the probability of an observation belonging to the ith category of the row variable

q_j represent the probability of an observation belonging to the jth category of the column variable

Then, using the multiplication law of probability, independence between the two variables implies that:

$$P_{ij} = P_i\ q_j \tag{2}$$

and in terms of expected frequencies

$$F_{ij} = N\ P_i\ q_j \tag{3}$$

The above probabilities may be simply estimated from the observed frequencies and the maximum likelihood estimates are based upon the relevant marginal totals of observed values, that is:

$$P_i = \frac{n_i}{N} \tag{4}$$

$$q_i = \frac{n_j}{N} \tag{5}$$

Thus, the frequencies to be expected in the ij - cells E_{ij} can be estimated as follows:

$$E_{ij} = N\ P_i\ q_j \tag{6}$$

$$E_{ij} = \frac{n_i\ n_j}{N} \tag{7}$$

When the two variables are independent then the observed and expected frequencies should differ by amounts attributable to chance factors only. Larger differences would arise if the two variables were not independent. Consequently, the size of this difference between n_{ij} and E_{ij} should be the base

for the test of independence of the two variables forming a two-dimensional contingency table.

8.2.2 Independence Testing of Variables

Independence of the two variables in a two-dimensional contingency table is tested by investigating the truth of the null hypothesis Ho:

$$P_{ij} = P_i \, q_j$$

The test, which is based on the differences between the expected frequencies when Ho is true and the observed frequencies, uses statistic chi-square (χ^2) whose magnitude depends on the values of the differences (n_{ij} - E_{ij}) and is given by:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(N_{ij} - E_{ij})^2}{E_{ij}} \qquad (8)$$

where r is the number of rows of the contingency table
c is the number of columns of the contingency table

The magnitude of this statistic will be smaller when Ho is true than when it is false.

By assuming that the observed frequencies have a particular distribution, namely the multinominal distribution, and that the expected frequencies are not too small, the statistic χ^2 was shown to have approximately a chi-square distribution. The test of the hypothesis of independence may now be performed by comparing the obtained values of χ^2 with the tabulated values of this distribution. Acceptance or rejection of the hypothesis is based upon the probability of the obtained χ^2 value; a "low" probability (taken to be a value of 0.05 or 0.01, and is referred to as the significance level of the test) leads to rejection of the hypothesis, others to its acceptance.

The degrees of freedom of the chi-square distribution which approximates the distribution of χ^2 when the hypothesis of independence is true, is simply the number of independent terms in equation 8, given that the row and column marginal totals of the table are fixed. The degrees of freedom of χ^2 is

$$d.f. = (r-1)(c-1) \qquad (9)$$

8.2.3 Log-Linear Analysis

The preceding sections have dealt with hypothesis testing technique for the analysis of contingency tables. An alternative approach considers fitting models and estimating the parameters in the models. The major advantages obtained from fitting long-linear models include providing a systematic approach to the analysis of complex multidimensional contingency tables and providing estimates of the magnitude of effects of interest. Estimates of the parameters in the model allows us to quantify the effects of various variables and of interactions between variables.

Equ. 2 specifies a particular model for the data: that is, the probability of an individual falling in the ijth cell of the table is simply the product of the marginal probabilities. However the model could be arranged to express Pij as the sum of the marginal probabilities (or some function of them) by taking the natural logarithms as follows:

$$\log P_{ij} = \log P_i + \log q_j \qquad (10)$$

Equ . 1 may be rewritten as:

$$\log F_{ij} = \log n_i + \log n_j - \log N \qquad (11)$$

Summing over i and j:

$$\sum_{i=1}^{r} \sum_{j=1}^{c} \log E_{ij} = c\sum_{i=1}^{r} \log n_i + r\sum_{j=1}^{r} \log n_j - rc \log N \qquad (12)$$

Fij refers to the theoretical frequencies but in practice it is necessary to estimate these and the model parameters and subsequently test the adequacy of the suggested model for the observed data.

Fitting particular log-linear models to the frequencies in a contingency table is equivalent to testing a particular hypothesis about the table. Consequently, the procedure used in hypothesis testing is the same as that used for assessing the adequacy of a suggested model, namely obtaining the values Eij and comparing these with the observed values by means of χ^2 statistic.

8.3 CONTINGENCY TABLES AND VARIABLE ASSOCIATION

Responses to product ideas will be analysed separately in this section. Contingency tables are prepared and the hypothesis testing is done by means of χ^2 statistic.

A total of 30 two-dimensional contingency tables were prepared to classify the respondents with respect to various qualitative variables. Three three-dimensional contingency tables were prepared to test its validity for the data

but it was found that such refinement with the small sample size in hand would produce tables with many cells having 'too small' frequencies. The derivation of the chi-square distribution as an approximation for the distribution of the statistic χ^2 is made under the assumption that the expected values are not "too small". This vague term has been generally interpreted as meaning that all expected values in the table should be greater than unity.

The association between the variables forming the contingency tables was tested using χ^2 statistic as follows:

The null hypothesis H_o is that the variables forming the contingency tables are independent. If the calculated χ^2 is greater than the tabulated values with certain degrees of freedom and at certain significance level, it indicates that the result obtained would be expected to occur by chance very rarely; consequently it is indicative of a real departure from independence, and hence leads to reject the null hypothesis.

The results of association tested at three levels of significance 90%, 95% and 99% for all contingency tables are shown in Table 32. A full description of variable names is given in Table 33.

Table 32 Results of chi-square test

No	Row	Column	d.f	x^2	Significance Level %		
					90	95	99
1	21	23	4	10.478	✓	✓	x
2	22	23	40	70.514	✓	✓	✓
3	23	24	20	172.050	✓	✓	✓
4	1	22	50	38.378	x	x	x
5	5	22	50	98.359	✓	✓	✓
6	5	20	20	12.102	x	x	x
7	7	21	4	1.048	x	x	x
8	7	22	40	53.479	✓	x	x
9	7	23	16	18.404	x	x	x
10	7	24	20	12.400	x	x	x
11	7	11	8	8.410	x	x	x
12	6	7	8	10.255	x	x	x
13	1	7	20	18.417	x	x	x
14	2	7	8	7.020	x	x	x
15	8	9	9	4.384	x	x	x

No	Row	Column	d.f	x^2	Significance Level %		
					90	95	99
16	10	11	4	2.467	x	x	x
17	5	13	20	28.716	✓	x	x
18	7	13	16	54.780	✓	✓	✓
19	13	23	16	24.949	✓	x	x
20	14	21	4	3.744	x	x	x
21	14	22	40	45.803	x	x	x
22	14	23	16	19.290	x	x	x
23	14	24	20	31.369	✓	✓	x
24	1	14	20	17.270	x	x	x
25	2	14	8	6.317	x	x	x
26	6	14	8	12.607	x	x	x
27	17	18	4	2.327	x	x	x
28	15	16	4	6.611	x	x	x
29	17	23	8	7.085	x	x	x
30	14	20	16	43.758	✓	✓	✓

Table 33 Description of Variable Names

Variable number (Row/Column)	Description
1	Frequency of fish consumption
2	Awareness of FO benefits
3	Required information
4	Use of FO capsules
5	Frequency of cheese consumption
6	Type of cheese consumed
7	Product one acceptability
8	Packaging type preferred
9	Packaging size preferred

Variable number (Row/Column)	Description
10	Price prepared to pay
11	Buying intention
12	Potential buyers
13	Buying frequency
14	Product two acceptability
15	Packaging type preferred
16	Packaging size preferred
17	Price prepared to pay
18	Buying intention
19	Potential buyers
20	Buying frequency
21	Sex of respondent
22	Age of respondent
23	Income of respondent
24	Profession of respondent

Using a chi-square test of independence for cross-tabulated data is a common response of researchers. This approach, however, usually does not result in a systematic evaluation of the relationship among the variables. In addition, the approach does not provide estimates of the effects of the variables on each other, and its application to tables with more than two variables is complicated (SPSS/PCT).

In view of the above discussion there is a need for the use of statistical models that summarize data and test hypotheses. The technique which is most appropriate for categorial data is log linear models.

8.4 LOG LINEAR MODELS

8.4.1 General Description

This is a special class of statistical techniques, which has been formulated for the analysis of categorial data. The models are useful for uncovering the potentially complex relationships among the variables in a multiway cross-tabulation. The test of the hypotheses that a particular model fits the observed data can be based on the familiar Pearson chi-square statistic or the likelihood-

ratio chi-square statistic. For large sample sizes these statistics are equivalent. If the observed significance level for the change in chi-square between the saturated and the derived models is small, the hypothesis is rejected indicating that the derived model does not fit well.

The SPSS/PC HILOGLINEAR (hierarchical log-linear) procedure automatically calculates tests of two types of hypotheses : the first that all Kth - and higher - order effects are zero. Small observed significance levels indicate that the hypothesis that terms of particular orders are zero should be rejected (SPSS/PCT).

8.4.1.1 *Backward Elimination*

The tests described above provide an indication of the collective importance of effects of various orders but does not test the individual terms. This means that if the overall hypotheses that say second-order terms are zero may be rejected, that does not mean that every second-order effect is present. Individual terms can be tested by fitting two differing only in the presence of the effect to be tested. The hypothesis that the effect is zero is then tested using the "partial" chi-square which is the difference between the likelihood - ratio chi-square values of the two models.

The 'best' model can be arrived at by using variable - selection technique. Forward selection adds effects to a model, while backward elimination starts with all effects in a model and then removes those that do not satisfy the criterion for remaining in the model.

8.4.2 Model Selection

Backward elimination variable - selection technique appears to be the better procedure for model selection (Benedetti and Brown, Strategies for the selection of log - linear models. Biometrics, 34 (1978), 680 - 686) and was therefore adopted in this study. The initial model need not be saturated but can be any hierarchical model.

At the first step of the model selection process, the effect whose removal results in the least - significant change in the likelihood - ratio chi-square is eligible for elimination, provided that the observed significance level is larger than the criterion for remaining in the model. Three criteria are used for the purpose of this study as follows:-

0.01	Highly significant
0.05	Significant
0.10	Trend

The process of elimination continues until the observed significance level for removal of any of the effects is smaller than the set criteria when no more effects are removed from the model.

8.4.3 Application and Results

The log-linear technique as described in the previous sections was applied using SPSS Computer package and the data collected from the responses of this study. The backward elimination process was used to remove from the model those effects which do not satisfy the criteria set in section 3.2.3.

The analysis focused on two main issues; the acceptability of the proposed products and the buying trends of the potential customers. Product 1 refers to the proposed product that incorporates fish oil in processed cheese while product 2 refers to that product that incorporates fish oil in spread cheese.

8.4.3.1 *Acceptability of Products*

The variables whose effect on acceptability was tested (the design) include awareness of fish oil benefits, sex, age and income of respondents. Elimination of the fourth-order interaction in the first step of analysis results in a chi-square change that has an associated significance level of 1. Since this level is greater than 0.1 (the highest criterion for remaining in the model), the effect is removed.

The "best" model has the generating class as shown in Table 34.

Table 34 Effect on acceptability of influencing factors

"Best Model"	Significant Level	
	Value	Description
Product 1		
Acceptability * Awareness * Sex	0.057	Trend
Acceptability * Age	0.036	Significant
Product 2		
Acceptability * Awareness * Sex	0.037	Significant
Acceptability * Age	0.065	Trend
Acceptability * Income	0.097	Trend

The results of the analysis therefore suggest that the respondents' age and sex, besides their awareness of fish oil benefit, affect the acceptability of both proposed products. A trend was also found for acceptability to depend on income of respondent. More information on trend of this effect may be obtained by referring to tables 10, 12, 14 and 16 in Chapter 6 where, for example, the very young and very old were found to seem slightly more inclined to favour product.

8.4.3.2 *Buying Trends*

The statistical analysis of this part investigated the effect of the same variables considered in the previous analysis of acceptability. These include sex, age and income of respondents and their awareness of FO benefits. The results showed that the best model has the generating class as below. (Table 35)

Table 35 Effect on buying trend of influency factors

"Best Model"	Significant Level	
	Value	Description
Product 1		
Buying * Awareness * Income	0.044	Significant
Buying * Sex * Income	0.037	Significant
Buying * Awareness * Sex	0.003	Highly Significant
Buying * Awareness * Age	0.023	Significant
Buying * Sex * Age	0.038	Significant
Product 2		
Buying * Sex	0.012	Significant
Buying * Income	0.012	Significant
Buying * Sex * Age	0.03	Significant

The variables tested were found to significantly affect the buying trends of both proposed products. The results, however, show greater association between these variables and the buying trend of product 1 than product 2. Again the results outlined in Chapter 6 shed more light on the trend of this association.

Further investigation was carried out to test the effects of these variables on the frequency of buying the proposed products and the results are given in Table 36.

Table 36 Effect on buying frequency of influencing factors

"Best Model"	Significant Level	
	Value	Description
Product 1		
Frequency * Age	00.01	Highly significant
Frequency * Awareness	0.001	Highly Significant
Frequency * Income	0.005	Highly Significant
Product 2		
Frequency * Sex * Age	0.024	Significant
Frequency * Income	0.065	Trend

The variables have shown more effect on buying frequency than buying trend. The results are similar to those of buying trend in that greater association is present between the variables and product 1 than product 2.

In conclusion the results of the statistical analysis have shown that both the acceptability of the proposed products as well as their buying trend depends on factors such as sex, income and age of respondents. The factors, however, have more significant association with buying trend and buying frequency than with acceptability.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

The work carried out in this research to investigate the acceptability of two new product ideas revealed interesting results.The product idea that incorporates fish oil into processed cheese appears to produce more encouraging results and has greater potential market as more people consume processed cheese than spread cheese.

The results of the study showed that the potential market for the new product is high. The market should target young consumers with more publicity and marketing efforts to attract other groups who did show resentment to product ideas.The market could be further widened by considering both ideas and produce two types of products. However, it is recommended to carry out an estimate of economic viability in the form of benefit cost analysis for example before a decision is made.

Product acceptability, buying trend and frequency were found to depend on a number of factors. These factors, whose effect have varying significance, include sex, income, age of respondents as well as their awareness of the benefits of fish oil. The target group should be the male, very young (<20 years) or very old (>40 years) and of limited income. There is a need to increase people's awareness of fish oil benefits in order to improve the buying potential of consumers.

A close relationship was found between income and product acceptability with lower income people being more receptive to the new product. Unemployed, students and lower income groups were found to like the idea much more than housewives and higher income groups. Price could be an important factor affecting the buying intention especially for the very low income group (<10,000).

Based on the results of this research, the following are recommended.

1. A larger scale study needs to be carried out in which the questionnaire is distributed to cover more than one market segment or cultural group. It is recommended that the potential market overseas be established and cover both developed and developing countries.

2. Developing a strategy to increase the awareness of people of fish oil benefits in order to improve the buying trend and buying frequency of potential customers. The strategies should target those groups identified as more receptive to the product ideas.

3. Trial production of the proposed foods using deodorised and refined fish oil and subject them to panel-testing before making it available commercially.

4. Monitoring the acceptability of the products and exposing them to wider evaluation.

5. Further investigation of the private sector group which showed positive response and could prove promising.

6. Setting a price of the product that enables very low income group (<$10,000) to buy the food and obtain the identified health benefits of fish oil.

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MASSEY UNIVERSITY
FOOD TECHNOLOGY DEPARTMENT
PALMERSTON NORTH

CONSUMER SURVEY

Dear Consumer

Good Morning/Afternoon. I am a Postgraduate Food Technology student at Massey University. Could the food buyer of the household please answer the following questions and return the questionnaire form in the Free Post envelope (**NO STAMP REQUIRED**) within the next three days. Any additional comments, both favourable and unfavourable, will be appreciated and may be written in the space provided.

Recent research has revealed many important nutritional values and health benefits of fish oil. At present I am involved in a work with the aim of developing a food product that incorporates Fish oil into chess without having a fishy taste/odour.

1 **How often do you include fish products of any king into your meals**

- [ ] 2 or more times week
- [ ] Once weekly
- [ ] Once fortnightly
- [ ] Once monthly
- [ ] Less than once monthly
- [ ] Don't buy

- [ ] Yes
- [ ] No
- [ ] Don't know

- [ ] Ingredients
- [ ] Nutritional Information
- [ ] Health Information

- [ ] Yes, How often?.....capsules/week
- [ ] No

- [ ] Every day
- [ ] Twice weekly
- [ ] Once weekly
- [ ] Once fortnightly
- [ ] Once monthly
- [ ] Less than once weekly

- [ ] Cheddar Cheese
- [ ] Mild Cheese
- [ ] Colby Cheese
- [ ] Spread Cheese
- [ ] None

PART ONE

In developing the new product I am considering two ideas.
The first inlcudes **FISH OIL IN PROCESSED CHEESE.**

7 What do you think of the product idea?

- [ ] Excellent
- [ ] Good
- [ ] Average
- [ ] Below average
- [ ] Poor

- [ ] Can
- [ ] Plastic sealed package
- [ ] Plastic sealed bag in a cardboard box
- [ ] Other. Please specify _____

- [ ] 250 grams
- [ ] 500 grams
- [ ] 750 grams
- [ ] 1000 grams

- [ ] $200 - $2.50
- [ ] $2.51 - $3.00
- [ ] $3.01 - $3.50
- [ ] $3.51 - $4.00

- [ ] Yes
- [ ] No, Why? _____
- [ ] Don't know

- [ ] Whole household
- [ ] Adults
- [ ] Teenagers
- [ ] Children

- [ ] 1 - 2 times per week
- [ ] 1 - 2 times per fortnight
- [ ] 1 - 2 times per month
- [ ] Less than once per month
- [ ] Not buying