Enhanced usage of contemporary scientific findings on health benefits of seafood to promote fresh seafood consumption.

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Non-technical summary

Eat fish and you'll live longer and healthier. Everyone knows this - or do they? Where did this common understanding of the benefits of fish arise and what is the scientific basis for these claims. What are the "best bets" for nutrition-based fish promotion in Australia?

Need

Considerable scientific information on the health benefits of eating seafood is accumulating, yet relatively little of this information has been effectively communicated to the general public or translated into opportunities to promote fresh seafood consumption. There is a need for this to be done, since the FRDC-funded Sydney asthma study demonstrated clearly the commercial potential of communicating research findings to the mass market.

Results

This project has looked at the scientific evidence and translated complex nutrition research findings into a form upon which marketing and promotional material on fresh fish can be based.

Studies on the relationship between fish or fish oil consumption and the following conditions have been analysed and distilled into a series of research summaries: coronary heart disease, rheumatoid arthritis, diabetes mellitus, glucose intolerance, obesity, hypertension, hypertriglyceridaemia, asthma, infant neural development, Crohn's disease, colon cancer, inflammation, psoriasis, inflammatory bowel disease, atopic dermatitis, aggression, dysmenorroea, dyslexia, dementia, atopic dermatitis, multiple sclerosis, autoimmune disorders such as systemic lupus erythematosus, laryngeal cancer, stroke, multiple sclerosis, dementia, and pancreatic cancer. This collection of conditions is comprehensive, and identifies many opportunities to promote the consumption of fresh seafood to the Australian population. It also identifies the many ways in which the Fishing Industry can lead Australians to better health.

How do we know if the results of a scientific study are meaningful or significant? This report includes a guide on how research evidence can be judged, providing an indication of the level of evidence for claims about health benefits.

The advertising and promotion of food in Australia is regulated by the Food Standards Code which is administered by the Australia-New Zealand Food Authority (ANZFA). Strict guidelines determine what marketers can and cannot say about their products. This project has summarised relevant sections of the Food Standards Code to guide those who wish to use the research summaries from this project in the marketing and promotion of fish. The Food Standards Code is not a static document, but is constantly under review. Access by fish marketers to information on the most current version of this code, and on its interpretation by local State health authorities is essential.

Conclusions

This report responds to the need by fish marketers for information on the relationship between fish consumption and health. Specifically, it has collated and distilled results of a broad collection of scientific research to produce a stand-alone resource which can then be used to produce a range of marketing and promotion tools. Since specific messages about seafood consumption vary depending on the target market, the scientific reviews are pitched at a level which allows for flexibility in the development of promotional material. The key to effective and responsible nutrition communication is to maintain an audit trail back to the original scientific source, which this report endeavours to achieve.

This report also responds to the need by health professionals and consumers for a summary of scientific findings on the relationship between fish consumption and health in a single source.

Further work

An important step in the effective and sustained (long-term) promotion of fresh fish requires a global planning mechanism for nutrition promotion, which considers the nutrition situation in Australia in its broadest context. A key outcome of this report is the identification of a comprehensive set of nutrition issues upon which such a planning mechanism can be based. At an operational level, collaboration between marketing and nutrition specialists to act on the issues raised in this report is essential, to target specific groups of consumers.

For example, there are many opportunities for fish to contribute to the health and well-being of mothers and infants in Australia. However, further specific research on the nutritional status and dietary habits of Australians is required so that fish-related nutrition messages can be targeted to appropriate groups. Early introduction of foods to infants is the best way to encourage consumption over the entire lifespan, a clear marketing opportunity.

Much of this report refers to health issues related to the oil composition of fish. Previous FRDC-funded research (FRDC Project 95/122) looking at oil contents in Australian fish species provides significant insight into the relationship between fish consumption and health in Australia. We know very little about other nutrients (vitamins, minerals, amino acids) in Australian fish species, and more extensive compositional information would provide further insight into the relationship between fish consumption and health.

Background

A substantial volume of scientific findings has emerged linking fish of fish oil consumption to health benefits. Much of this information is shrouded in scientific jargon or is in such a form that requires significant skill and specialised knowledge to interpret. This makes it difficult for marketers of fish to access health information - information which could be used as a promotional tool to sell fresh seafood. Indeed, in 1996 the results from an FRDC-funded asthma study in Sydney demonstrated how such information can increase fresh fish sales (NSW Master Fish Merchants Association).

The seafood industry is actively seeking further information on seafood and health. They know that the general public has a vague understanding that seafood is good for health, but the general public doesn't understand important specific information such as; what quantities to eat, which varieties and for which diseases seafood may be beneficial. We intend that this project will answer many of these questions and present these answers in a form that can be accessed easily by all.

A preliminary seeding project preceding this main project reviewed a small proportion of the scientific literature on seafood and health, and contacted three FRDC-funded research groups working on health-related topics to obtain some general background on research in Australia linking nutrition/health to fish consumption. The general findings of this work were that information on the health benefits of seafood is available in the scientific literature but is clearly not in a form that is readily amenable for use by marketers for the promotion of fresh seafood consumption.

The breadth of health issues which are linked to fish consumption is extensive. The large intercountry epidemiological studies over the past two decades have indicated that there are general health benefits from eating fish on a regular basis. More specialised studies show that fish consumption is important in diseases such as cardiovascular disease, diabetes, rheumatoid arthritis, cancer, psoriasis, obesity and a range of other ailments.

Many of the studies linking health with fish focus on the effects of feeding fish oil capsules to people. We need to be able to transform this information into the context of fresh fish consumption, so that marketers and the general public can make better use of this information. A useful tool in this process is food composition information, which explains this content of particular oils found in various fish species.

In the short term, the FRDC-funded fish composition study coordinated by Dr Peter Nichols (CSIRO, Hobart) will provide an important tool to express the results of the many studies made to date on the effects of fish oil supplementation. This is important, considering the large proportion of studies linking fish to health which concentrate specifically on fish oil consumption.

Key features of Australian fish are that they are generally low in fat, rich in omega-3 fatty acids (like the northern hemisphere produce), but differ from their northern counterparts in that docosahexaenoic acid (DHA) is the omega-3 fatty acid which predominates. Pre-existing scientific information on the effects of northern hemisphere fish needs extensive interpretation to convert into an Australian context, and the composition information generated by CSIRO is of enormous value.

A particularly innovative aspect of the work of Nichols et al is the investigation of various lipid classes (eg. polar compounds, wax esters, free fatty acids, triacylglycerides) which goes far beyond the traditional analytes such as ratios of polyunsaturated, monounsaturated and saturated fats. The nutritional implications of these lipid classes are still not known, but this compositional information will prove invaluable as new information on the roles of such compounds emerges in the scientific literature. At that time, such information can then be transformed into the perspective of the consumption of whole fish using the fish composition data generated by Nichols et al.

A primary concern raised by nutrition researchers and the food industry alike is the long lag time between the emergence of such results and changes in public health policy. The same could also be said for the lag time between scientific discovery and acquisition of knowledge by health professionals and the general public. An active scientific communication program, such as that presented in this project, will help shorten this lag time. By basing such communication programs on well-established scientific principles, the technical integrity of these activities will be maintained.

Research results are produced for communication in specialised scientific journals to be read only by highly trained professionals. Rarely, and often only by chance, do these results reach the community in a form which is accurate and understood by the general public. The recent media interest and subsequent increase in fresh fish sales in response to the Sydney study (Hodge and others, Royal Prince Alfred Hospital) linking asthma prevention with fish consumption is a graphic indication of the commercial potential of communicating health research results to the general public. This present proposal outlines an organised plan to make complex scientific findings more accessible to the seafood industry and to the Australian public at large.

Need

Considerable scientific information on the health benefits of eating seafood is accumulating, yet relatively little of this information has been effectively communicated to the general public or translated into opportunities to promote fresh seafood consumption. There is a need for this to be done, since the FRDC-funded Sydney asthma study demonstrated clearly the commercial potential of communicating research findings to the mass market.

The seafood industry and the general public need an organised mechanism to identify important health issues, to seek out scientific findings and to translate these into a format that can be used by the seafood industry marketers and others to promote the consumption of fresh seafood in a responsible, accurate and safe manner.

There is a need also for the general public to become more aware of the health benefits of seafood.

Objectives

To translate the complex findings of nutrition science research into a format (ie. in the form of research summaries) that make such findings accessible to marketers of seafood and the general community (by: compiling health research findings, summarising the results of those findings, and translating them into a format that can be readily adopted by marketers of seafood, health workers and others to communicate to the general public).

Develop guidelines for the selection and communication of nutrition information to be used for marketing and promotion to ensure an image of health scientific integrity for the fishing industry.

Outline food standards code section A1(19) relating to health claims made about food etc. to ensure that usage of research summaries complies with Australian food regulations.

Section A: Australian food regulations: opportunities for health claims.

Food composition, labelling and advertising are governed by the NH&MRC Australian Food Standards Code. This code is directed largely at prepared food rather than fresh commodities ('primary foods' is the term used in the Food Standards Code). However, precedents have been set, eg. omega-3 eggs and AMLC promotion of beef, which indicate that such foods must also abide by this code. For the purposes of promotion of nutritional properties of fresh fish, Standards A1 and A9 are the most relevant. Further, all food retailing is governed by the more potent Trade Practices Act which protects the public against false or misleading claims about food.

> **Nothing in the Food Standards Code permits claims which state or imply that vitamins and minerals have or may have a therapeutic or prophylactic effect. In the absence of an express permission, therapeutic or prophylactic claims are prohibited by clause (19) of Standard A1.**

Relevant clauses in Standard A1 include:

Clause 19

a. Save where otherwise expressly prescribed by this Code, any label on or attached to a package containing or any advertisement for food shall not include a claim for therapeutic or prophylactic action or a claim described by words of similar import.

b. Any label on or attached to a package containing or an advertisement for a food shall not include the word 'health' or any word or words of similar import as a part of or in conjunction with the name of the food.

c. Save where otherwise expressly prescribed by this Code, any label on or attached to a package containing or any advertisement for food shall not contain any word, statement, claim, express or implied, or design that directly or by implication could be interpreted as advice of a medical nature from any person.

d. Save where otherwise expressly prescribed by this Code, the label on or attached to a package containing or any advertisement for food shall not contain the name of or a reference to any disease or physiological condition.

[Note: Section A1(19) is particularly important in relation to promoting food on the basis of nutritional features]

Clause 6 *It shall not be stated or implied in any statement, label or advertisement in relation to food that the food is a food for specific dietary use unless the food is labelled and sold in accordance with the requirements of Standard R1 (Special Purpose Foods).*

Clause 12 *a. Food, or an ingredient or nutrient in a food, must not be described as 'unsaturated', 'polyunsaturated' or 'monounsaturated', or by any term that is suggestive of those words, unless such description is expressly permitted by this code.*

b. The fatty acid content of a food may be described as 'polyunsaturated' or 'monounsaturated' if the total fatty acids present in the food contain-

i. not less than 400 g/kg of cis-monounsaturated fatty acids or of cis-methylene interrupted polyunsaturated fatty acids as the case may be; and

ii. not more than 200 g/kg of saturated fatty acids

[Note: Clause 12 of Standard A1 is specifically targeted towards fats and oils, and manufactured foods. The amounts prescribed in this clause far exceed the levels found in any fresh fish. Clause 12 therefore precludes the direct labelling of any fresh fish as polyunsaturated, even if fish oil in isolation could be labelled as such]

c. The label on or attached to a package containing a food must not include a statement relating to or a claim based on the fatty acid content of the food or of an ingredient or nutrient in the food unless -

i. the label includes a nutrition information panel in accordance with clause (13) of this Standard, except that no entry specifically for fatty acid content is required as a result of the statement of claim;

ii. any food referred to as 'polyunsaturated' or monounsaturated' complies with the standard for that food;

iii. the statement or claim, or the entry for fat in the left hand column of the nutrition information panel, is accompanied by a statement to the effect of -

SATURATED FATTY ACIDS (here insert the maximum percentage of saturated fatty acids present in the food on a total fatty acid basis)

POLYUNSATURATED FATTY ACIDS (here insert the maximum percentage of cis-methylene interrupted polyunsaturated fatty acids present in the food on a total fatty acid basis)

MONOUNSATURATED FATTY ACIDS (here insert the maximum percentage of cis-monounsaturated fatty acids present in the food on a total fatty acid basis); and

iv. the words 'polyunsaturated' and 'monounsaturated', wherever they appear in the label, are not qualified by any other word or expression.

Standard A9

Clause 2. *A claim that a food is a good source of a vitamin or mineral can only be made if a reference quantity of the food contains at least 25% of the RDI for that vitamin or mineral derived from those ingredients in the food which are primary foods or foods listed in the Table to clause 3.*

Health and related claims

In February 1996 the National Food Authority (now the Australia New Zealand Food Authority) released a document entitled 'Review of the food standards code. Concept paper on health and related claims'. This paper was released to seek public comment on the complex polemic of the inclusion of health and related claims on food labels, as a sequela to the 1993 NLEA (Nutrition Labelling and Education Act) in the USA which allowed seven specific claims to be made on food labels (depending on the nature of the food in question). These allowable claims are:

- Low-fat diets rich in fiber-containing grain products, fruits and vegetables may reduce the risk of some types of cancer, a disease associated with many factors.
- Diets low in saturated fat and cholesterol and rich in fruits, vegetables, and grain products that contain some types of dietary fibre may reduce the risk of heart disease, a disease associated with many factors.
- Regular exercise and a healthy diet with enough calcium helps teens and young adult white and Asian women maintain good bone health and may reduce their high risk of osteoporosis later in life.

- Development of cancer depends on many factors. A diet low in total fat may reduce the risk of some cancers.

- While many factors affect heart disease, diets low in saturated fat and cholesterol may reduce the risk of this disease.

- Low fat diets risk in fruits and vegetables (foods that are low in fat and contain dietary fibre, vitamin A, or vitamin C) may reduce the risk of some types of cancer, a disease associated with many factors.

- Diets low in sodium may reduce the risk of high blood pressure, a disease associated with many factors.

Responses to the National Food Authority on this issue indicates a predominantly conservative approach to the adoption of a similar system in Australia. In any case, the claims outlined above provide little opportunity for exploitation by the fishing industry.

Conclusion

The Food Standards Code makes it difficult to include information outlining potential health benefits of fresh fish in either labelling or direct advertising. An effective low risk strategy is to distribute such information in the form of point of sale consumer education material, or via indirect media advertorial and press communiques which discuss the effects of fish in general but not about specific (eg. brand name) fish products. The material contained in this section is intended as a guide only. Since it is the health departments in each state which administer the Food Standards Code, the relevant sections within those departments should be consulted at the appropriate stage of any promotional or labelling initiative.

References

Review of the Food Standards Code. Concept paper on heath and related claims. National Food Authority, February 1996. Canberra.

The Australian Food Standards Code. April 1996 - up to Amendment No 29. AGPS, Canberra.

Shapiro R (ed.) Nutrition labelling handbook. Marcel Dekker, Inc, New York, 1995.

Section B. Guidelines for the communication of nutrition information, with particular reference to reporting recent scientific findings.

Nutrition Communication

The maintenance of credibility with the general public and the scientific community is a fundamental consideration in nutrition communication. This section is intended as a set of overriding principles which guide nutrition-based food promotion, and help to maintain the Fishing industry's reputation as a source of reliable information and a good corporate citizen. It is specifically written for the stage of food promotion which involves nutrition and marketing specialists working collaboratively to produce effective and sustained marketing outcomes.

Nutrition information related to food marketing falls into 3 categories:

Nutrition labelling:	the inclusions of nutrient composition data on a label
Nutrition claims:	declaration of amounts of nutrient(s), eg. "low fat", "cholesterol-free"
Health claims:	suggestions that food/nutrient is good for health or can prevent/treat/cure a disease

Irresponsible, inaccurate claims about food may generate short-term gains in terms of sales and public interest and attention. However, in the longer-term there is likely to be a negative impact on corporate credibility which then requires substantial re-investment in time and money to restore.

Nutrition communication guidelines

Some fundamental points are highly relevant to nutrition communication [1]:

* Keep advice simple to understand and implement
* Avoid confusing the public by being too quick to push the latest nutrition theory
* Avoid jargon
* React continually and consistently to misinformation
* Messages should be positive
* Stay current with the latest literature
* Consensus is important. Messages should always be tied to current lifestyle trends
* Avoid alarmist strategies. These lose potency after awhile
* Acknowledge possible ethical conflicts
* Avoid arguments which have been debated extensively without conclusive

resolution
* Stay within area of expertise
* Know subject area
* Be brief

Further, a recent Editorial in Nutrition Reviews[2] expands upon many of the above important principles as follows:

1. Protect consumers from harm

* Cause no harm to consumers who rely on the information
* Include all information essential to achieving the beneficial effect, including the importance of a healthful total diet
* Do not mischaracterise or overstate either the risks or the benefits involved
* Provide realistic expectations to individuals who have a disease (or who are at high risk) about the effectiveness of the impact of diet alone on the disease.
* Consider the risks to significant subpopulations that may have unique characteristics or vulnerabilities

2. Empower consumers to choose foods that contribute to a healthful diet

* Provide information at an appropriate depth to enable the audience to take an informed position on the topic
* Provide understandable information in a user-friendly format
* Disseminate information in ways that will reach and have a maximal impact on the desired audiences
* Ensure that the public and/or any interest group has equal access to information to allow broad participation in the debate
* Ensure that consumers can distinguish between an emerging science message and an authorised health claim, especially when the new information is similar to a claim that has already been approved
* Do not undermine the credibility of reliable dietary guidance

3. Preserve scientific accuracy

* Accurately represent the underlying science
* Present information in a way that is accurate on its face and that does not mislead the audience by unfairly omitting opposing points of view
* Disclose the level of scientific agreement applicable to the underlying science, (eg. type of study, authors, inherent biases)
* Disclose areas of scientific contention, stating facts in the context of known relevant data on this or related topics, and areas where further research is needed
* Avoid undue disparagement of food products on the basis of preliminary or

unsubstantiated information

* Avoid making emerging science messages so compelling as to provide disincentives to further research that would lead to an authorised health claim

With appropriate attention to quality, the above aims can be achieved in tandem with the short- and long-term commercial objectives of promoting particular products. Nutrition communication is judged by critical experts and by lay public. In general, the following features influence the credibility of nutrition messages [2]:

Scientific Credentials

The Scientist/Expert
Appropriate educational background
Personal experience in the specific field
History of publication through peer review process
Record of credible media liaison

The Research Institution
Appropriate laboratory accreditation standards
Recognised by authorities in the particular scientific field

Experimental Design

Adequate Subject Composition
Sufficient Subject Composition
Subject numbers generate statistically significant results
Results unaffected by health status of subjects
Age and sex balance

Unbiased design
Double-blind design
Cross-over design
Sufficient duration

Repetition
At least 2 separate studies
Outside laboratory corroboration

Evaluation

Consistency
Analysis to discount confounders

Statistics
Statistical significance (likelihood that null hypothesis is correct)

Consensus
Are results consistent with current thinking*

Interpreting the scientific literature

Marketers of fish and the general public generally do not have the specific skills to analyse the primary scientific literature to determine the exact nature of potential health benefits of fish consumption. Nor do they have ready access to such sources of primary information. They rely heavily on secondary information sources, such as the popular press, the quality and accuracy of which are highly variable and often poor.

It is difficult to provide a standard approach to analysis and interpretation of primary scientific information, since it often incorporates a large degree of personal experience and specific expertise. However, with the move towards "evidence-based practice" in the health sciences, some generic guidelines for interpretation of scientific research are emerging.

This section collates some of the tools for standardisation that have emerged recently. These tools provide a useful basis upon which an expert reference panel can build.

The first stage of the communication process is to gather a wide selection of the most recent publications on the subject of interest. Technical experts will usually monitor several key periodicals on a regular basis. This yields specific information of a high quality but provides only a narrow perspective of the total body of scientific evidence. Secondary literature sources such as Medline and Current Contents are very useful in providing a broader view of international research. Medline searches databases retrospectively, whereas Current Contents focuses on information to be published imminently. A standardised approach to Medline searching will result in a comprehensive summary of international research on a particular health-related subject.

Standardised method for Medline searches on randomly controlled trials

The Cochrane collaboration is an initiative to strengthen evidence-based practice in medicine[3]. One of the aims is to collate information from good quality trials investigating how to prevent or treat disease. The Cochrane Collaboration has outlined the following as an optimal search strategy for identifying randomised controlled trials (RCTs)[a] using Medline:

#1 RANDOMIZED-CONTROLLED-TRIAL in PT

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[a] *Randomised Controlled Trial: A study investigating a preventive or therapeutic regimen where subjects are allocated randomly to treatment and control groups, and the results assessed by comparison of outcomes between the groups.*

#2 CONTROLLED-CLINICAL-TRIAL in PT
#3 RANDOMIZED-CONTROLLED-TRIALS
#4 RANDOM-ALLOCATION
#5 DOUBLE-BLIND-METHOD
#6 SINGLE-BLIND-METHOD
#7 #1 or #2 or #3 or #4 or #5 or #6
#8 TG=ANIMAL not (TG=HUMAN and TG=ANIMAL)
#9 #7 not #8

#10 CLINICAL-TRIAL in PT
#11 explode CLINICAL-TRIALS
#12 (clin* near trial*) in TI
#13 (clin* near trial*) in AB
#14 (singl* or doubl* or trebl* or tripl*) near (blind* or mask*)
#15 (#14 in TI) or (#14 in AB)
#16 PLACEBOS

#17 placebo* in TI
#18 placebo* in AB
#19 random* in TI
#20 random* in AB
#21 RESEARCH-DESIGN
#22 #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21
#23 TG=ANIMAL not (TG=HUMAN and TG=ANIMAL)
#24 #22 not #23
#25 #24 not #9

#26 TG=COMPARATIVE-STUDY
#27 explode EVALUATION-STUDIES
#28 FOLLOW-UP-STUDIES
#29 PROSPECTIVE-STUDIES
#30 control* or prospectiv* or volunteer*
#31 (#30 in TI) or (#30 in AB)
#32 #26 or #27 or #28 or #29 or #31
#33 TG=ANIMAL not (TG=HUMAN and TG=ANIMAL)
#34 #32 not #33
#35 #34 not (#9 or #25

#36 #9 or #25 or #35

This approach is comprehensive but not fool-proof and may not detect all RCTs. For example Lefebvre 1994 [4] found 400 RCTs in a 6-month term in Medline which were not listed as such.

Suggested other search topics:

For the purposes of this particular project, a number of other key words/phrases were used as search tools:

Fish: [all studies specifically related to the effects of fish and fish oil]
Fish consumption: [focuses more on the consumption of fresh fish rather than fish oil supplementation]
Dietary intake: [General dietary studies which may discuss fish intake as part of the overall diet]
Nutrition education ± fish: [General nutrition communication, but applicable to fish]

Once a comprehensive collection of research papers has been assembled, the next task is to prioritise them according to the significance of the results and the degree of international expert consensus for support of conclusions. The following information provides some guidelines. There is also an opportunity for an expert reference panel to play a role in this process.

Ranking/grading of scientific evidence

Bias (systemic error) is a major source of weakness in a scientific study. Bias occurs because it is difficult to control study participants, unlike the situation in laboratory experiments. Also, it is difficult to obtain representative samples of the human population. Adequate experimental design is important in minimising bias. In order of increasing vulnerability to bias [4] are:

1. Randomised allocation
2. Cohort studies
3. Case-control studies
4. Case series and registries
5. Case reports and expert opinion

The challenge then is to rank studies on the strength of their conclusions. The following is a list of 7 levels (from strongest to weakest) which can be used for such a purpose [4]:

Level 1. Supportive evidence from well-conducted randomised controlled trials that included 100 patients or more

a. Evidence from a well-conducted multicenter trial

b. Evidence from a meta-analysis that incorporated quality ratings in the analysis and included a total of 100 patients in its estimate of effect size and confidence internals

Level 2. Supportive evidence from well-conducted randomised controlled trials that included fewer than 100 patients

a. Evidence from a well-conducted trial at one or more institutions

b. Evidence from a meta-analysis that incorporated quality ratings and included fewer than 100 patients in its estimate of effect size and confidence intervals

Level 3. Supportive evidence from well-conducted cohort studies

a. Evidence from a well-conducted prospective cohort study or registry

b. Evidence from a well-conducted retrospective cohort study

c. Evidence from a well-conducted meta-analysis of cohort studies

Level 4. Supportive evidence from a well-conducted case-control study

Level 5. Supportive evidence from poorly controlled or uncontrolled studies

a. Evidence from randomised clinical trials with one or more major or three or more minor methodological flaws that could invalidate the results

b.Evidence from observational studies with high potential for bias (such as case series with comparison to historical controls)

c. Evidence from case series or case reports

Level 6. Conflicting evidence with the weight of evidence supporting the recommendation

Level 7. Expert opinion

[Note: Expert opinion is listed as the lowest level and should only be used as an adjunct to evidence at higher levels in the above list. ie. a nutrition "expert" should not be engaged for the task of nutrition "testimonials" in isolation. The evidence should be strong enough to speak for itself]

There is still a large degree of subjectivity in this guide which again emphasises the importance of an expert reference group. Key influencing factors to look for which will influence study validity include:

* Selection of patients
* Allocation of patients to treatment groups
* Therapeutic regimens
* Study administration
* Withdrawals from the study
* Patient blinding (randomised clinical trials only)
* Outcome measurement
* Statistical analysis

A simpler four-point rating system was developed by the US Preventive Services Taskforce (1989) to provide recommendations for health practitioners to apply to patient management. The categories are as follows:

Level A: Evidence obtained from a sound systematic review of all relevant randomised controlled trials, providing that it includes at least two properly designed trials of moderate size (or a systematic review that does not include trials which it could be reasonably argued could not affect the findings of the review).

Level B: Evidence obtained from at least one properly designed randomised trial.

Level C: Evidence obtained from well-designed controlled trials without randomisation, from well-designed cohort or case-control analytic studies, preferably from more than one centre or research group, or from multiple time series with or without the intervention.

Level D: Opinions of respected authorities, based on clinical experience, descriptive studies or reports of expert committees.

Both grading systems are useful in providing an indication of the strength of evidence supporting recommendations on fish consumption. For example, the literature on the relationship between fish consumption and coronary heart disease is sufficiently developed to derive recommendations supported by extensive Level A or Level 1 evidence, whereas the relationship between asthma and fish consumption relies more on limited Level B or Level 3 evidence.

References

1. Position of the American Dietetic Association: Food and nutrition misinformation. JADA 1995;95:705-707

2. Editorial. Communicating emerging scientific information. Nutr Rev 1996;54:153-157.

3. Lefebvre C. The Cochrane Collaboration: the role of the UK Cochrane Centre in identifying the evidence. Health Libr Rev 1994;11:235-242.

4. Hadorn DC et al Rating the quality of evidence for clinical practice guidelines. J Clin Epidemiol 1996;49:749-754

Section C. Preliminary consultations with key Australian experts

This section is a summary of preliminary interviews and literature reviews to identify human health issues associated with fish consumption.

The FRDC fish composition study coordinated by Dr Peter Nichols (CSIRO, Hobart) provides a cornerstone to link fish consumption to health benefits. The majority of clinical trials have concentrated on components of fish (eg fish oils). The compositional data generated by Nichols et al will be useful in interpreting such clinical trials from the perspective of the consumption of whole fish, in the absence of studies made directly on whole fish consumption. A key factor is that Australian fish are generally low in fat, rich in omega-3 fatty acids (like the northern hemisphere produce), but differ in that DHA is the omega-3 fatty acid which predominates.

Some findings are just starting to emerge, supporting the idea that DHA is at least as active and important as EPA in terms of disease prevention. As more of this information comes to light, a comprehensive database outlining the fatty acid profiles of Australian fish will be invaluable in making dietary recommendations to lower disease risk. In any case, data collected on the effects of northern hemisphere fish will need extensive interpretation to convert into an Australian context.

A particularly innovative aspect of the work by Nichols et al is the investigation of various lipid classes (eg. polar compounds, wax esters, free fatty acids, triglycerides) which goes far beyond the traditional analytes such as the polyunsaturated:saturated ratios. The nutritional implications of many of these lipid classes still has not been elucidated, but this compositional information will prove invaluable as new information on the roles of such compounds emerges in the scientific literature. At that time it will be reasonably straightforward to place these new findings into the perspective of the consumption of whole fish.

One common theme regarding the relationship between fish consumption and health is the issue of inflammatory processes and the n-3/n-6 ratio. The work of Professor Les Cleland and Dr Mick James focuses on this ratio in relation to rheumatology. They believe that there is a need for the Australian population to decrease n-6 intake and simultanously increase n-3 intake, a trend which would be achieved by increasing fish intake. This concept was also verified by discussions with Professor Len Storlien (University of Wollongong) who indicated that a change in this ratio has an impact on obesity, insulin efficacy and the management and prevention of diabetes.

Cleland and James have looked at biochemical changes in response to eating as few as two fish meals per week. The biochemical changes seen were consistent with a lowering in the propensity for inflammation, which has important implications for a range of diseases including rheumatoid arthritis, coronary heart disease, stroke, asthma and inflammatory bowel disease.

In an unpublished study by James and Cleland, 60 healthy males were fed 9g encapsulated fish oil (1.6g EPA) daily for 4 weeks. Inhibition (75 to 80%) of TNF-alpha and IL-1 beta were seen.

A primary concern raised by Cleland and James, and others is the long lag time between the emergence of such results and changes in public health policy. The same could also be said for the lag time between scientific discovery and aquisition of knowledge by health professionals and the general public. An active scientific communication program will help streamline this process.

The Sydney asthma study led by dietitian Linda Hodge provided some interesting preliminary results on a possible influence of fish consumption on asthma risk. The media attention resulting from this study raised an important need in scientific communication: FRDC needs transparent protocols to ensure that facts are correctly conveyed to the general public. If results are promoted too early and without substantiation and/or some degree of consensus, then there is substantial risk that the industry will lose credibility. Therefore, guidelines need to be established for the selection and communication of such information.

Key issues identified in preliminary survey of the research literature

Cardiovascular disease (CVD)

CVD presents the most opportunities to promote fresh fish consumption at this point in time. This is reflected by the shear volume of relevant studies published in the past 3 years. Coronary heart disease (CHD) has by far the most significant body of evidence. The etiology of CHD is far from straightforward, with a number of different processes contributing to progression of the disease. The first is plaque formation in the arteries, largely due to blood lipid (including cholesterol) imbalances. The second is via haemostatic factors including components which affect the bloods ability to clot. The third comprises the complex process of LDL oxidation. Studies can be found which deal with any of these mechanisms.

In addition, there are results from very large (tens of thousands of subjects) prospective trials which look at general consumption trends (eg average fish consumption) and long term health outcomes. On a more conservative note, some recent studies (one by Ascherio et al) have shown that 2 fish meals per week seems to be the optimal intake, with no advantage seen beyond this number, and a possible disadvantage of excessive levels of intake. This still represents an opportunity for fish marketers since many Australians are consuming less than 2 fish meals per week.

Other aspects of CVD pale into insignificance in comparison. Of the remainder, the most prominent is the issue of hypertension. Knowledge seems only to be at a stage of a possible link between fish or fish oil consumption and better blood pressure management.

Stroke is another area of CVD for which fish consumption may have some role to play. The literature in this area is still relatively sparse. However, there are two recent papers, one which implies a role for black males and females, and white females, and the other showing no association.

Metabolic disorders

Diabetes has just been added to the priority issues of the Commonwealth government, the others being mental illness, cardiovascular disease, cancer and injury. Thus, diabetes is recognised as a major health problem in this country. There are particular opportunities to promote fish consumption with respect to non-insulin dependant diabetes. A high n-6/n-3 ratio has been found to be deleterious for insulin action (Storlien et al. Skeletal muscle membrane lipids and insulin resistance. Lipids 1996;31:S261-S265). Higher levels of unsaturated fatty acids in muscle membrane phospholipids is associated with improved insulin action.

People with diabetes are often overweight, and even obese in many cases. Increases in obesity incidence are a major concern for Australia, as in many other developed countries. Some studies looking at the caloric load of various food components have indicated that n-3 fats may be less calorific (ie. not put on as much weight as other fats), representing a major opportunity for the promotion of fresh fish.

People with diabetes also have a higher risk of developing CHD, intensifying the importance of an appropriate diet, including fresh fish.

Inflammation

The disease which has the most supportive evidence for fish consumption is rheumatoid arthritis. We are fortunate to have world leaders in this field (Cleland and James) currently funded by the FRDC. Again, advantages seem to centre upon the n-6:n-3 ratio in the diet. Vegetable oils which are high in n-3 and low in n-6 can be incorporated into diets to suppress excessive pro-inflammatory cytokine production (Caughey et al. The effect on human tumor necrosis factor alpha and interleukin 1beta production of diets enriched in n-3 fatty acids from vegetable oil or fish oil. AJCN 1996;63:116-122). Similar results (unpublished by Cleland and James) have also been found in healthy volunteers consuming Australian fish for 8 weeks.

At least 11 studies with either control groups or cross-over design have been published on the relationship between n-3 intake and improvement in RA symptoms (Cleland et al Diet and arthritis. In Brooks and Furst, Eds. Bailliere's Clinical Rhematology. London 1995; Ballier Tindall). In these studies, daily dosages varied from 0.4 to 6.0 g. Overall, n-3 fatty acid consumption seems to provide a modest therapeutic benefit. How does this translate into consumption of fresh fish?

Asthma is a risky issue to pursue at the communication level currently. Much more supportive evidence needs to accumulate before making too much of these preliminary results.

Recent studies on both inflammatory bowel disease and Crohn's disease show some preventive and/or therapeutic potential for fish and fish oils.

General issues

Some workers emphasise the importance of the n-6:n-3 ratio as a general dietary consideration. Fish oils are of course one of the very few significant sources of n-3 fatty acids and fish marketing could benefit greatly from a augmentation of this debate.

Focus on the deleterious effects of other foods (eg. red meat) on health could also be considered. For example, red meat is often overcooked, resulting in the formation of carcinogenic substances. In contrast, fish is not often intentionally cooked to excess and may represent a benefit purely through habitual preparation practises.

Conclusions

During this preliminary phase of the project incorporating discussions with selected Australian experts and consultation with the scientific literature, it was concluded that the most promising issues through which fish consumption can be promoted are in the following order of priority:

- Coronary heart disease
- Non-insulin dependant diabetes
- Obesity
- Rheumatoid arthritis
- Crohn's disease

The information presented in this section was collated after preliminary consultation with the literature. As the main part of the project unfolded, a clearer picture of the value of many of these issues to promote the consumption of fresh fish emerged, and other issues were added.

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Hodge L et al. Increased consumption of polyunsaturated oils may be a cause of increased prevalence of childhood asthma. Aust NZ J Med 1994;24:727.

Hodge L et al. Consumption of oily fish and childhood asthma risk. Med J Aust 1996;164:137-140.

Hodgson HJ. Keeping Crohn's disease quiet. N Engl J Med 334:1599-1560 (1996)

Makrides M et al. Effect of maternal docosahexaenoic acid (DHA) supplementation on breast milk composition. Eur J Clin Nutr 1996;50:352-357.

Nichols PD et al. Orange roughy and other marine oils: characterisation and commercial applications. FRDC Final Report for Grant 91/77. January 1992 to December 1993.

Pan DA et al. Dietary fats, membrane phospholipids and obesity. J Nutr 1994;124:1555-1565.

Prichard BNC et al. Fish oils and cardiovascular disease. Br Med J 1995;310:819-820.

Shoda R et al. Epidemiologic analysis of Crohn disease in Japan: increased dietary intake of n-6 polynsaturated fatty acids and animal protein relates to the increased incidence of Crohn's disease in Japan. Am J Clin Nutr 1996;63:741-745.

Storlien LH et al. Role of storage and membrane lipids in skeletal muscle metabolism: relation to obesity. In Angel A et al (eds), Prog Obes Res 94, John Libbey & Co, London 1996.

Section D: Relevant government reports as at January 1997.

Acting on Australia's weight: A strategy for the prevention of overweight and obesity. NHMRC, July 1996.

Health Australia. Promoting health in Australia. Discussion paper. NHMRC December 1995.

Guidelines for preventive interventions in primary health care. Cardiovascular disease and cancer. NHMRC, July 1996.

Draft National Men's Health Policy. Commonwealth Department of Human Services and Health. January 1996.

Evaluation of the implementation of the national food and nutrition policy. Final report. Commonwealth Department of Human Services and Health. November, 1995.

Report on Aboriginal and Torres Strait Islander nutrition. NHMRC, December 1996.

Infant feeding guidelines for health workers. NHMRC, 1996.

Draft nutrient criteria for the registration of foods in school canteens. Federation of Canteens in Schools. 1996

Section E: Research Summaries

1. One or two fish meals per week optimal: Two fish meals per week are better than none

People who live in Greenland and Japan have very low rates of coronary heart disease. Fish is a very important part of the diet in these two countries and may be a key factor in preventing coronary heart disease. Fish oils could exert this protective effect in a number of ways, including reduction of VLDL cholesterol, making blood vessels less constricted (thus enhancing the ease of blood flow) and decreasing platelet stickiness (making platelets less likely to cause blood clotting).

A recent study from the Harvard School of Public Health reported on the progress of a group of 44 895 initially healthy male volunteers between 40 and 75 years of age who had been monitored since 1986. Over that time, there had been 1543 patients who had either a heart attack or heart surgery. Dietary habits of these patients and of the other volunteers were assessed and compared for fish intake.

Those men who never ate fish were more likely to be in the group of 1543 heart patients than those who ate fish. Increasing fish intake from one or two meals per week to five or six times per week seemed not to decrease risk of heart problems further.

For this American study, one to two fish meals translates into 150 to 240 mg/day of long-chain omega-3 fatty acids.

Ascherio A et al. Dietary intake of marine n-3 fatty acids, fish intake, and the risk of coronary disease among men. N Engl J Med 1996;332:977-982.

2. Protection against heart arrhythmia.

Omega-3 oils are a particular class of polyunsaturated oils which have a range of important effects on the human body. Research over the past two decades has found that omega-3 oils may protect against ischaemic heart disease, the major cause of heart attacks. Fish are a rich source of omega-3 oils, specifically DHA and EPA.

Although fish consumption seems to protect against heart attacks, the reasons why this is so are not clear and are the subject of much scientific research. Many scientists suspect that the ability omega-3 oils from fish to prevent disruptions to the rhythm of the heart (ie. ventricular arrhythmia) is important.

In a recent Danish research study, 55 patients who had recently suffered a heart attack were given 5.2 grams per day of either fish oil or olive oil for 12 weeks. The heart rates of these patients were examined for variability, since such variability protects against ventricular arrhythmia.

The 5.2 grams per day of fish oil (containing 4.3 grams of the omega-3 oils DHA and EPA) significantly increased heart rate variations in these patients. This important effect could contribute to the possible protective role that fish oils have against subsequent heart attacks in those who have already had one.

Christensen JH et al. Effect of fish oil on heart rate variability in survivors of myocardial infarction: a double blind randomised controlled trial. Br Med J 1996;312:677-678

Katan MB. Fish and heart disease: what is the real story? Nutrition Reviews 1995;53:228-229.

Katan MB. Fish and heart disease. New Engl J Med 1995;332:1024-1025.

3. How the oil from fish is processed by the body

Fish are a very rich source of long-chain omega-3 oils. When these oils are ingested, they are transported rapidly into both the blood plasma and blood cells. The levels of omega-3 oils in blood cells tell scientists approximately how much fish a person has eaten. When these fish oils are consumed as part of a meal, eg. in the form of fresh fish, they are absorbed much more efficiently than when taken as fish oil alone. This is important because fish oils are thought to play a major part in protecting against coronary heart disease.

Exactly how fish oils exert this protective effect is not known, but there are several basic ways in which fish oils could act. Firstly, when fish oils accumulate in blood platelets, it makes them less sticky. Therefore, they are less likely to clot and block vessels.

Secondly, polyunsaturated oils such as the omega-3 oils found in fish can affect blood cholesterol levels. One recent Western Australian study found that adding fish to a moderately low fat diet (30% energy as fat) led to increases in total and HDL (good) cholesterol levels, but importantly decreased LDL (bad) cholesterol and triglyceride levels.

Thirdly, fish oils seem to prevent disruptions to the rhythm of the heart (ie. ventricular arrhythmia). Consumption of fish oils increases heart rate variations which, surprisingly, makes the heart more resistant to ventricular arrhythmia.

Fourthly, the essential fatty acid linoleic acid is the primary building block from which the body makes chemicals such as prostaglandins and leukotrienes. These compounds contribute to inflammation reactions in the body. Omega-3 oils are converted by the body to compounds which are very similar to these inflammatory chemicals, but instead of increasing inflammation, they compete with the inflammatory compounds leading to a less severe inflammatory reaction. Inflammation is an important component of coronary heart disease and a reduction in this type of reaction may reduce the risk of heart attack. Aspirin is used for similar reasons.

Prisco's study found that the increase in omega-3 content of blood cells caused by eating fish oils disappears within 3 months of stopping. Therefore, it seems that to gain the benefits of eating fish, consumption should be regular.

Prisco D et al. Effect of n-3 polyunsaturated fatty acid intake on phospholipid fatty acid composition in plasma and erythrocytes. Am J Clin Nutr 1996;63:925-932.
Christensen JH et al. Effect of fish oil on heart rate variability in survivors of myocardial infarction: a double blind randomised controlled trial. Br Med J 1996;312:677-678.
Mori et al. Effects of varying dietary fat, fish, and fish oils on blood lipids in a randomized controlled trial in men at risk of heart disease. Am J Clin Nutr 1996;59:1060-1068.

4. Fish is an important part of a healthy diet

Imagine if particular foods protected against specific diseases. We could take foods the way we take medicine and everyone would stay healthy. Unfortunately, there are no magical foods. The benefits gained from eating specific foods depend heavily on the rest of the diet. Many previous studies on the effects of fish consumption have often overlooked other foods which might interfere with the beneficial effects of fish oil.

One recent Western Australian study compares two diets, one relatively high in fat (40% energy as fat) and the other close to the general recommendation for a healthy diet (30% energy as fat). In addition, the first diet had a saturated to unsaturated ration of 1:1, whereas the second diet had a ratio of 2:1. The effects of adding one fish meal per day to these diets was studied for 12 weeks in a group of 120 men with high blood cholesterol. Each fish meal contributed 3.2 to 4.1 g of omega-3 oils.

Adding fish to the high (40%) fat diet raised total cholesterol, LDL (bad) cholesterol, and HDL (good) cholesterol levels. However, adding fish to the 30% fat diet similarly led to increases in total and HDL (good) cholesterol levels, but importantly decreased LDL (bad) cholesterol and triglyceride levels.

The results of adding fish to the moderately low (30%) fat diet were therefore more effective in reducing risk factors for coronary heart disease. However, the important message from this study is that the benefits of eating fish are maximised by having a total diet which is relatively balanced and moderately low in fat.

Mori et al. Effects of varying dietary fat, fish, and fish oils on blood lipids in a randomized controlled trial in men at risk of heart disease. Am J Clin Nutr 1994;59:1060-1068.

5. 2.5g per day of fish oil does not make LDL more susceptible to oxidation

The generation of free radicals in the body plays an important role in the progression of diseases which develop over a long period of time, such as coronary heart disease and cancer. Free radicals enhance a chemical reaction called oxidation, which can ultimately facilitate tissue damage and inflammation. Compounds called antioxidants inhibit this process, and currently are recommended widely as a valuable component of a healthy diet. Commonly known antioxidants include vitamins E, C and beta-carotene.

Oxidised LDL is a potent enhancer of coronary heart disease. Polyunsaturated oils are oxidised easily, which is why fish starts to smell if it is not stored properly. When polyunsaturated oils are eaten, some are incoporated into LDL particles in the blood. Some scientists have suggested that if more polyunsaturated oil is incorporated into LDL (bad) cholesterol, then this LDL will be more susceptible to oxidation. This seems to be the case for linoleic acid, an omega-6 oil found in many vegetable oils.

However, recent studies (Bonanome et al 1996) indicate this is not the case for the omega-3 fish oils at moderate intake levels (eg. 2.5g per day). For example, a 1996 Italian study of 12 patients with severe kidney failure showed that 2.5 g of omega-3 fatty acids per day did not render LDL more readily oxidised. These patients were particularly interesting because their disease (end stage kidney failure) usually increases coronary heart disease risk by decreasing HDL (good) cholesterol levels. An added advantage of the fish oil intake for these patients was triglyceride lowering.

After this study, one of the omega-3 oils eicosapentaenoic acid (EPA) disappeared from LDL particles reasonably quickly. However, levels of DHA (docosahexaenoic acid, another omega-3 fatty acid) persisted at least 2 months after supplementation with fish oils stopped. Many Australian fish species are rich in DHA.

Amounts of fish containing 2.5 grams of the omega-3 oils DHA and EPA.

Fish	Amount in grams
John Dory	1330
Gemfish	570
Sea Mullet	840
Golden Trevally	1800

Bonanome A et al. n-3 fatty acids do not enhance LDL susceptibility to oxidation in hypertriacylglycerolemic hemodialyzed subjects. Am J Clin Nutr 1996;63:261-266.
Nichols PD et al. Seafood, the good food. The oil content and composition of Australian commercial fishes, shellfishes and crustaceans. FRDC Project 95/122
Palozza P et al. n-3 Fatty acids induce oxidative modifications in human erythrocytes depending on dose and duration of dietary supplementation. Am J Clin Nutr 1996;64:297-304.
Louheranta AM et al. Linoleic acid intake and susceptibility of very-low-density and low-density lipoproteins to oxidation in men. Am J Clin Nutr 1996;63:698-703.

6. Lower omega-6 oils and higher omega-3 oils for an optimal diet

One of the most important risk factors for coronary heart disease is elevated blood LDL (bad) cholesterol. Low-density lipoprotein (LDL) is one of several classes of proteins which attach to cholesterol and fats, transporting them around the body. Cholesterol-laden LDL accumulates in part of the coronary artery wall called the intima, where tissue damage proceeds until the artery becomes completely blocked, resulting in a heart attack. Oxidation makes LDL even more potent in this process.

LDL oxidation seems to be influenced by the types of oils we eat. Recently, a Finish study by Louheranta found that consumption of the omega-6 oil linoleic acid was most closely associated with an increase in LDL oxidation in a group of 393 men. Linoleic acid is an essential omega-6 polyunsaturated oil which can lower serum cholesterol levels when it replaces saturated fats. This effect is thought to counteract the possibly negative increase in LDL oxidation, so that replacing saturated fat with linoleic acid is still a healthy strategy. However, a healthier strategy would be to reduce the amount of dietary saturated fat and linoleic acid in the diet (remembering that linoleic acid is an essential fatty acid, so we still need some), replacing some of these with omega-3 oils from fish.

Foods such as vegetable oils and many margarines are rich in the omega-6 oil linoleic acid. The following table outlines some major sources of linoleic acid.

Food	Linoleic acid content (w/w)
Safflower oil	77%
Sunflower oil	66%
Cottonseed oil	58%
Canola oil	20%
Palm oil	10%
Olive oil	10%

Louheranta AM et al. Linoleic acid intake and susceptibility of very-low-density and low-density lipoproteins to oxidation in men. Am J Clin Nutr 1996;63:698-703.
Reaven P et al. Effects of oleate-enriched and linoleate-enriched diets on the susceptibility of low density lipoprotein to oxidative modification in hypercholesterolemic subjects. J Clin Invest 1993;91:668-676
Renaud S. Linoleic acid, platelet aggregation and myocardial infarction. Atherosclerosis 1990;80:255-256.

7. Protective foods vs pathogenic foods

In the early days of research into coronary heart disease, the main indicator of disease was the heart attack. There was a major disadvantage with this primitive technology: heart attacks are often the result of years of unsuitable diet and lifestyle, so that experiments to find the best preventive diet took years to complete. Modern science has provided a range of techniques where we can assess the condition of the coronary artery walls long before the heart attack stage.

One such technique is quantitative coronary angiography which uses ultrasound to look at the coronary artery. This technology allows conclusions about various dietary strategies to be made much more quickly than was previously possible. Recently, a West Australian team used this technology to assess a group of 90 men who had presented with chest pains or myocardial infarction, and who had blood cholesterol levels of 6.1 to 10.00 mmol/L.

These patients were monitored for 39 months. Narrowing of the coronary arteries correlated with intakes of long-chain saturated oils such as myristic, palmitic and stearic acids, as well as trans-fatty acids derived from ruminant animal foods. Although myristic and palmitic acids raise plasma total cholesterol, stearic acid and trans-fatty acids do not. It is thought that these two types of fats increase risk by means other than raising cholesterol levels (eg. LDL oxidation, cardiac arhythmia).

Building on this and other studies, Connor has recently compiled two lists of foods according to their effect on the risk for CHD.

Pathogenic dietary factors	**Protective dietary factors**
Dietary cholesterol	Polyunsaturated fats
Saturated fat	omega-6 rich vegetable oils
Trans-fatty acids	omega-3 oils from fish
Animal fats	monounsaturated fats
	antioxidants (vitamin E)

Recent studies have shown that Australian fish are very low in saturated fat, cholesterol, trans-fatty acids and animal fats in general, but contain significant amounts of polyunsaturated omega-3 oils and vitamin E. Therefore, Australian fish stands up to the scrutiny of this classification system.

Watts GF et al. Dietary fatty acids and progression of coronary artery disease in men. Am J Clin Nutr 1996;64:202-209.

Connor WE. The decisive influence of diet on the progression and reversibility of coronary heart disease. Am J Clin Nutr 1996;64:253-254.
Australian Government Analytical Laboratory. Seafood Fact Sheet: Analysis of NSW fish and shellfish. Fish Marketing Authority 1989 Sydney.
Sinclair et al. The lipid content and fatty acid composition of commercial marine and freshwater fish and molluscs from temperate Australian waters. Aust J Nutr Diet 1992;49:77-83.

8. Fish good for seniors

Studies from three countries with relatively low intakes of fish (Sweden, the Netherlands and USA) indicate that fish intake reduces risk of death from coronary heart disease (CHD). Of particular note are the benefits of even small levels of fish intake, with middle-aged men who ate no fish at a much higher risk than those who ate fish once or twice per week. Such effects in fish intakes have not been detected in cultures with high fish intakes such as Norway and Hawaii.

A Dutch team conducted a 17-year study on a group of 272 people born in 1907 to see if fish consumption reduced CHD risk in older people. Those who reported eating fish (60% of the group) had about half the chance of dying from CHD as those who ate no fish. Those in the group who reported eating fish had an average intake of 24g of fish (mostly lean fish such as cod and plaice) per day. This translates into 127 mg omega-3 oils per day.

Amounts of popular Australian fish containing 127 mg of the omega-3 oils DHA and EPA.

Kromhout D et al. The protective effect of a small amount of fish on coronary heart disease mortality in an elderly population. Int J Epidemiol 1995;24:340-345.

9. Fish as part of a healthy, cholesterol-lowering diet

The National Cholesterol Education Program (NCEP) is a national US organisation which sets standards about the ways Americans should eat to avoid coronary heart disease. The NCEP provides several standard diets which vary in severity, corresponding to patient needs.

For example, a NCEP step 2 diet has ≤30% energy as fat, < 7% energy as saturated fat, and < 200 mg cholesterol, and is recommended for patients with moderately high blood cholesterol levels. Americans on average eat 35% energy as fat, 14% energy as saturated fat and 280- 560mg cholesterol per day.

The NCEP step 2 diet was used recently (Schaefer et al) as a standard diet to which fish (1.8g omega-3 oils per day) was added. After 24 weeks, the NCEP step 2 diet with or without fish decreased total cholesterol, LDL cholesterol and HDL cholesterol, the diet with fish showing the greater reductions. Only the NCEP step 2 diet with the added fish reduced triglyceride levels.

This study vindicates the NCEP approach to lowering blood cholesterol: ie. reduce total fat, reduce saturated fat to the levels of the NCEP step 2 diet, and shows that moderate amounts of fish are an important part of this strategy.

Example of NCEP step 2 with fish

Breakfast	Tea/coffee with skim milk Cereal with skim milk Orange juice
	Apple
Lunch	Salad Chicken breast or tuna sandwich Low fat yoghurt Orange juice
	Orange
Dinner	Fish fillet/chicken breast/lean meat Salad Bread with polyunsaturated margarine Low fat cake
	Walnuts Pear

Schaefer EJ et al. Effects of National Cholesterol Education Program step 2 diets relatively high or relatively low in fish-derived fatty acids on plasma lipoproteins in middle-aged and elderly subjects. Am J Clin Nutr 1996;63:234-241.

10. The Mediterranean diet

Ever since the *Seven Countries Study* in 1970 found that coronary heart disease rates were 2 to 3 times lower in southern Europe than in the United States or northern Europe, attention has focussed on the so-called "Mediterranean" diet for the prevention of coronary heart disease. In particular, Crete was identified as having the lowest incidence of coronary heart disease, despite blood cholesterol levels being similar to other southern European countries.

The results of the *Seven Countries Study*, which compared disease rates and lifestyle factors in Finland, Greece, Italy, Japan, the Netherlands, USA, and Yugoslavia, relate to diets of 3 decades ago. With changes in lifestyle, the protective effects of the Cretan diet are diminishing rapidly, whilst coronary heart disease rates are increasing. What were Cretans eating in the 1960s? At that time, high levels of legumes and fruit were consumed. In addition, the primary oil source was olive oil and only a comparatively small amount of meat was eaten. Moderate amounts of fish and alcohol (mainly red wine) also were consumed.

The following table outlines the disease rates in men for various diseases in the 1960s for three of the seven countries studied.

Disease	USA	Greece
Coronary heart disease	***189***	***33***
Stroke	***30***	***26***
Stomach cancer	***6***	***10***
Colorectal cancer	***11***	***3***
Total cancer	***102***	***83***

It was obvious that the Greeks (ie Cretans) were doing something right. There were marked differences between Greek and western diets, as outlined in this table:

Dietary component (g/day)	***USA***	***Greece***
Vegetables	***171***	***191***
Fruits	***233***	***463***
Legumes	***1***	***30***
Breads/cereals	***123***	***453***
Potatoes	***124***	***170***
Meat	***273***	***35***
Fish	***3***	***39***
Eggs	***40***	***15***
Alcohol	***6***	***23***

Renaud et al have compared the effects of a Mediterranean diet with a standard low fat diet in a group of 605 people recovering from a heart attack. Their recommendations for the Mediterranean diet were as follows:

- More bread
- More vegetables and legumes
- More fish
- Less meat (beef, lamb, pork), to be replaced by poultry
- No day without fruit
- No butter or cream, to be replaced by a special (canola-based) margarine

After 27 months, the group following the Cretan Mediterranean diet had a 70% lower rate of heart problems than the group following the low fat strategy. The Mediterranean diet includes a recommendation for eating 'moderate' amounts of fish.

Renaud S et al. Cretan Mediterranean diet for prevention of coronary heart disease. Am J Clin Nutr 1995;61(suppl):1360S-1367S.

Keys A. Coronary heart disease in seven countries. Circulation 1970;41(suppl 1):1-211.

de Lorgeril M et al. Effect of a Mediterranean type of diet on the rate of cardiovascular complications in patients with coronary artery disease. J Am Coll Cardiol 1996;28:1103-1108.

Willett WC. Diet and Health: What should we eat? Science 1994;264:532-537.

Kushi LH et al. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats, and oils. Am J Clin Nutr 1995;61(suppl):1416S-1427S.

Nestle M. Mediterranean diets: historical and research overview. Am J Clin Nutr 1995;61(Suppl):1313S-1320S.

Australian Government Analytical Laboratory. Seafood Fact Sheet: Analysis of NSW fish and shellfish. Fish Marketing Authority 1989 Sydney.

Sinclair et al. The lipid content and fatty acid composition of commercial marine and freshwater fish and molluscs from temperate Australian waters. Aust J Nutr Diet 1992;49:77-83.

11. "Secondary" prevention of coronary heart disease

It is particularly important to prevent further damage in those individuals who have previously suffered a heart attack. This so-called "secondary" prevention in these patients has been particularly challenging, since many trials have failed to demonstrate improved survival, even when diets were high in polyunsaturated oils and low in saturates. It was only when the DART study increased the intake of omega-3 fish oils specifically did the survival rates improve.

Studies by Renaud and others have shown that simply increasing the dietary polyunsaturate:saturate ratio is not enough to reduce heart attack risk, even if a reduction in serum cholesterol levels is achieved. This is supported by studies which show that high intakes of linoleic acid can increase lipid peroxidation and platelet aggregation, both of which contribute to the initiation of heart attacks.

De Lorgeril et al, in the Lyon Diet and Heart Study, recently tested the ability of the Mediterranean diet to reduce the recurrence of heart attack in 302 heart attack patients. In this study, the Mediterranean diet (including 47g of fish per day) was compared with a low fat "prudent" diet. The general dietary recommendations for the Mediterranean diet were to eat more bread, root vegetables, green vegetables, and fish, and less meat (beef, lamb and pork substituted with poultry), no day without fruit, and butter and cream to be replaced by a canola-based margarine. Those on the Mediterranean diet consumed less fat, saturated fat, cholesterol and linoleic acid, but significantly more oleic acid and alpha-linolenic acid (a plant omega-3 oil). This diet led to far lower heart attack rates and death rates in the 5 year follow-up period. In fact the trial had to be stopped early at 27 months because the results were so striking.

Alpha-linolenic acid (ALA) can be converted by the body into EPA (an omega-3 oil found in abundance in fish). However, this conversion is not very efficient and consuming fish is a much more effective way of obtaining EPA. Fish oil as a source of DHA (another omega-3 oil from fish) is even more important since very little is produced by the body. DHA is a key component of eye, nerve and brain tissue. In addition, ALA has not been shown to lower blood pressure, triglyceride levels, or platelet stickiness to the extent that has been demonstrated for oils from fish.

de Lorgeril M et al. Mediterranean alpha-linoleic acid-rich diet in secondary prevention of coronary heart disease. The Lancet 1994;343:454-459.

de Lorgeril M et al. Effect of a Mediterranean type of diet on the rate of cardiovascular complications in patients with coronary artery disease. J Am Coll Cardiol 1996;28:1103-1108.

Burr ML et al. Effects of changes in fat, fish, and fibre intakes on death and myocardial reinfarction: diet and reinfarction trial (DART). The Lancet 1989;334:757-761.

Renaud S. Linoleic acid, platelet aggregation and myocardial infarction. Atherosclerosis 1990;80:255-256.

Dyerberg J et al. alpha-Linolenic acid and eicosapentaenoic acid. The Lancet 1980;i:199.
Renaud S, Norday A. Small is beautiful: alpha-linolenic acid and eicosapentaenoic acid in man. The Lancet 1983;ii:1169.
Connor WE. w-3 Fatty acids and heart disease. In Kritchevsky D, Carroll KK, eds. Nutrition and disease update: heart disease. Champaign, Illinois: AOCS, 1994:1-139.

12. Fish versus fish oil

Research over the past two decades has shown that omega-3 oils, DHA and EPA in particular, are important factors in the prevention of heart disease and cancer. Balance has always been an important concept in nutrition, and omega-3 oils are no different. Increased consumption of fish oils leads to a higher proportion of polyunsaturated oils in cell membranes. In theory, this change could make cell membranes more susceptible to oxidation, which is an important process in degenerative diseases such as coronary heart disease and cancer. The amounts required for this to occur are usually only achieved by taking large amounts of omega-3 supplements. The amounts of fish commonly consumed would normally not reach levels of intake required to generate these negative effects.

Palozza et al have looked at the effects of high doses of fish oil on oxidation of red blood cell membranes in 40 healthy volunteers. After feeding this group of people doses of 2.5, 5.1, or 7.7 grams per day of a mixture of EPA and DHA for 30 days, the alpha-tocopherol concentrations in the red blood cell membranes increased significantly. This made the membranes less readily oxidised.

However, after 180 days of supplementation, the alpha-tocopherol concentrations had returned to normal and the red blood cell membranes were more susceptible to oxidation than from those people who had received no fish oil supplement. These dosages are far in excess of what would usually be taken in through the diet, as indicated in the following table.

Amounts fish containing 2.5, 5.1 and 7.7 g of the omega-3 oils DHA and EPA.

Fish	Amount of fish in grams (containing to 2.5, 5.1 and 7.7 g omega-3 oils)
John Dory	1330, 2710, 4100
Gemfish	570, 1160, 1750
Mullet, sea	840, 1710, 2590
Trevally, golden	1800, 3670, 5540

Consuming omega-3 oils by eating fish seems to afford the benefits from these oils while avoiding the problems of overconsumption that are sometimes seen with oil supplementation.

Palozza P et al. n-3 Fatty acids induce oxidative modifications in human erythrocytes depending on dose and duration of dietary supplementation. Am J Clin Nutr 1996;64:297-304.
Kushi LH et al. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats, and oils. Am J Clin Nutr 1995;61(Suppl):1416S-1427S.
Nichols PD et al. Seafood, the good food. The oil content and composition of Australian commercial fishes, shellfishes and crustaceans. FRDC Project 95/122

13. Fish and women's health

Blood cholesterol levels are an important indicator of risk for coronary heart disease. However, some specific nutrients or particular foods appear to affect the risk of coronary heart disease (CHD) independantly of cholesterol levels. For example, fibre and vegetable intakes have strong protective effects against CHD.

Much of the research on coronary heart disease has concentrated on men, since they have a higher risk of developing this disease. Early studies by Kromhout from the Netherlands in 1985 indicated that fish consumption reduced CHD by 50% in a group of 852 middle-aged men.

However, women can also develop coronary heart disease. A recent Italian study by Gramenzi et al investigated a group of 287 women between 22 and 69 years for the effects of various foods on the risk of CHD.

This study found that consumption of foods such as meat, salami, butter and coffee increased CHD risk, whereas the consumption of foods such as carrots, fresh fruit, green vegetables, fish and alcohol (moderate) reduced risk. In addition, the results showed that those who ate fish more than once per week had a 40% less chance of developing CHD than those who consumed fish less than once per week. Levels of the omega-3 fish oil docosahexaenoic acid (DHA) persist for at least 2 months after intake, indicating that the potential benefits of fish oil intake endure for some time.

Gramenzi's study focussed on elderly women. However, other age groups also can benefit from an adequate fish intake. For example, the levels of DHA in breastmilk are affected by omega-3 oil intake. Why is this important? Various studies have shown that DHA is required to achieve optimal neural development in infants under 30 weeks of age. As little as one or two fish meals per week can ensure adequate DHA levels in breastmilk.

The following table outlines the rates in women for various common diseases in the 1960s for USA and Greece from the Seven Countries Study.

Disease	USA	Greece
Coronary heart disease	54	14
Stroke	24	23
Breast cancer	22	8
Stomach cancer	3	6
Colorectal cancer	10	3
Total cancer	87	61

It was obvious from this study that the Greeks (ie Cretans) were doing something right. There were marked differences in the diets of these two countries reported in the Seven Countries Study. The next study looks at food consumption in diets from the early 1960s. Compared to the US diet, the Greeks ate more vegetables, fruit, legumes, cereals, alcohol, potatoes and fish, but ate less meat and eggs.

Dietary component (g/day)	USA	Greece
Vegetables	171	191
Fruits	233	463
Legumes	1	30
Breads/cereals	123	453
Potatoes	124	170
Meat	273	35
Fish	3	39
Eggs	40	15
Alcohol	6	23

Gramenzi A et al. Association between certain foods and risk of acute myocardial infarction in women. Br Med J 1990;300:771-773

Bonanome A et al. n-3 fatty acids do not enhance LDL susceptibility to oxidation in hypertriacylglycerolemic hemodialyzed subjects. Am J Clin Nutr 1996;63:261-266.

Kromhout D et al. The inverse relation between fish consumption and 20-year mortality from coronary heart disease. N Engl J Med 1985;312:1205-1209.

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Kushi LH et al. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats, and oils. Am J Clin Nutr 1995;61(suppl):1416S-1427S.

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14. Sources of omega-3 oils in the diet

The omega-3 family of polyunsaturated oils are essential components of the cell membranes in brain, retina and spermatozoa. One member of this family, DHA, is particularly prominent in these tissues. DHA is either taken in by eating fish or fish oils, or it is made in the body by converting dietary alpha-linolenic acid (ALA), a plant omega-3 oil. Sources of ALA include linseed oil, canola oil, walnut oil, wheat germ oil and soybean oil. The conversion of ALA to eicosapentaenoic acid (EPA) and DHA is relatively slow in humans and ingestion of ALA results in only low concentrations of blood EPA.

Humans, especially infants, have only a limited ability to convert sufficient amounts of ALA into DHA. This is perhaps the reason why human breast milk contains small, but significant, amounts of DHA. A range of studies has shown that both pre-term and full-term infants fed artificial formulae containing ALA have lower tissue DHA levels than those fed either breast milk or formulae containing DHA.

Makrides et al recently found that the amount of DHA in breast milk is proportional to the amount consumed in the diet. Even an intake of as little as 200mg per day significantly increases DHA content in breast milk. One way to ensure adequate amounts of DHA in breast milk is for lactating mothers to eat fish regularly.

Clark KJ et al Determination of the optimal ratio of linoleic acid to alpha-linolenic acid in infant formulas. J Pediatr 1992;120:S151-158.

Foreman-van Drongelen MMHP et al. Influence of feeding artificial formula milks containing docosahexaenoic acid and arachadonic acid on the postnatal long-chain polyunsaturated fatty acid status of healthy preterm infants. Br J Nutr 1996;76:649-667.

Hunter JE. n-3 Fatty acids from vegetable oils. Am J Clin Nutr 1990;51:809-814.

Dyerberg J et al. alpha-Linolenic acid and eicosapentaenoic acid. The Lancet 1980;i:199.

Renaud S, Norday A. Small is beautiful: alpha-linolenic acid and eicosapentaenoic acid in man. The Lancet 1983;ii:1169.

Makrides M et al. Effect of maternal docosahexaenoic acid (DHA) supplementation on breast milk composition. Eur J Clin Nutr 1996;50:352-357.

15. Fish intake and infant neural development

Various studies have indicated that breast-fed infants have a enhanced neural development compared with formula-fed infants. The omega-3 oil DHA (docosahexaenoic acid) is thought to be involved in this difference since breast milk contains this oil but, until recently, artificial formulae did not. Artificial formulae contain oils such as linoleic acid and alpha-linolenic acid from which the long-chain omega-3 oils such as DHA can be made. However, formula-fed infants are unable to make enough of these longer chained oils. In addition, linoleic acid competes with DHA in its metabolic activities, exacerbating this apparent shortfall of DHA.

A role for DHA in infant neural development is supported by studies which indicate that brain and erythrocyte DHA levels are higher in infants who have been breast-fed, than their bottle-fed counterparts. Australia has one of the world's leading research teams in this field. Their 1995 study (Makrides et al) builds on their previous discovery of the importance of DHA in neural development. This study found that infants fed either formula supplemented with 360 mg per 100g or fed breast milk had a higher visual acuity score at both 16 and 30 weeks of age than did those infants fed formula alone. Visual acuity (visual evoked potential acuity) is a way in which the neural response to visual stimuli can be measured. This measure provides an indication of neural development in young infants.

The DHA content of red blood cell membranes of the breast-fed and fish oil supplemented infants remained at the same levels as they were at birth, whereas the infants fed formula without fish oil showed a fall in DHA levels over the 30-week study period. Infants seem to need a continuous supply of DHA, since those infants breastfed for shorter periods (<16 weeks) showed poorer visual acuity scores than those consuming DHA (either via breastmilk or fish oil) for the duration of the study.

Makrides M et al. Are long-chain polyunsaturated fatty acids essential nutrients in infancy? The Lancet 1995;345:1463-1468.

Makrides M et al. Fatty acid composition of brain, retina and erythrocytes in breast- and formula-fed infants. Am J Clin Nutr 1994;60:189-194.

Clark KJ et al. Determination of the optimal ratio of linoleic acid to alpha-linolenic acid in infant formulas. J Pediatr 1992;120:S151-158.

Cleland LG et al. Linoleate inhibits EPA incorporation from dietary fish-oil supplements in human subjects. Am J Clin Nutr 1992;55:395 -399.

16. Fish intake and breastfeeding

Studies by Makrides et al from the Flinders Medical Centre in Adelaide have shown that the omega-3 oil DHA is important for the early neural development in infants. This important oil is found naturally in breastmilk and is another compelling reason for recommending breastfeeding.

DHA levels in breast milk are determined by how much fish a woman eats. In 1981, Gibson and Kneebone found that the average DHA content in breast milk was 0.32%. A decade later, the same laboratory found that the levels had fallen to 0.21%. Makrides et al have indicated that this lower level may not be sufficent for optimal neural development in young infants.

52 lactating mothers were fed 0-1300mg per day of DHA (in the form of fish oil) to determine the relationship between DHA intake and breast milk DHA content. This study showed that to achieve a DHA content in the diet of 0.35% of total fat, mothers had to consume an average of about 200 mg of DHA per day.

An intake of 400mg/day resulted in an average DHA level of 0.46%. The highest intake tested (1300mg/day) resulted in an average DHA content in breast milk of 1.13%.

Makrides M et al. Are long-chain polyunsaturated fatty acids essential nutrients in infancy? The Lancet 1995;345:1463-1468.

Makrides M et al. Effect of maternal docosahexaenoic acid (DHA) supplementation on breast milk composition. Eur J Clin Nutr 1996;50:352-357.

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17. Fish and health

Fish has long been recognised as an important part of the human diet. From the early days of nutrition science, fish has been acknowledged for being a high protein, low calorie food. In addition, fish protein is well known for its high biological value (nutritional quality).

Over recent years, the importance of fish in the diet has extended from its image as a cornerstone of a healthy diet, to more specialised roles in disease prevention. In surveying the literature, it is clear that a range of physiological conditions might benefit from adequate intakes of fish. Some conditions have been studied more extensively than others, leading to various levels of supporting evidence for the role of fish in the preservation of health.

The following is a summary of the physiological conditions which may benefit from optimal fish or fish oil intake, and the level of supporting evidence:

Definite health benefits

Coronary heart disease, rheumatoid arthritis, diabetes mellitus, glucose intolerance, obesity, hypertension, hypertriglyceridaemia

Promising preliminary results

Asthma, infant neural development, Crohn's disease, colon cancer, inflammation, psoriasis, inflammatory bowel disease, atopic dermatitis

Possible health benefits

Aggression, dysmenorroea, dyslexia, dementia, multiple sclerosis, autoimmune disorders such as systemic lupus erythematosus, laryngeal cancer, stroke, pancreatic cancer

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Gillum RF et al. The relationship between fish consumption and stroke incidence. The NHANES I epidemiologic follow-up study. Arch Intern Med 1996;156:537-542.

Gustafsson I-B et al. Moderate amounts of n-3 fatty acid enriched seafood products are effective in lowering serum triglycerides and blood pressure in healthy subjects. J Human Nutr Dietet 1996;9:135-145.
Hamazaki T et al. The effect of docosahexaenoic acid on aggression in young adults. J Clin Invest 1996;97:1129-1134.
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Hodge L, et al. Consumption of oily fish and childhood asthma risk. Med J Aust 1996;164:137-140.
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Kromhout D et al. The inverse relation between fish consumption and 20-year mortality from coronary heart disease. N Engl J Med 1985;312:1205-1209.
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Shoda R et al. Epidemiologic analysis of Crohn disease in Japan: increased dietary intake of n-6 polyunsaturated fatty acids and animal protein relates ot the increased incidence of Crohn disease in Japan. Am J Clin Nutr 1996;63:741-745.

18. Health effects of adding fish to the diet

Coronary heart disease impacts most significantly on affluent western economies. In contrast, population groups such as the Japanese and the Eskimos have relatively little coronary heart disease. In both of these populations, high intakes of fish have been proposed as one dietary factor which protects these people. This is a plausible explanation given that fish intake in western populations is generally much lower than that of the Japanese or Eskimos. Some studies have estimated fish intakes of around 18g per day in Britain and the USA, in addition to much larger intakes of red meat.

So, what happens when fish is substituted for red meat in such diets? A recent South African study by Wolmarans et al investigated this issue with the help of 28 volunteers. Participants were asked to either replace all the fish in their diet with red meat, or vice versa for a 6-week period. The fish diet equated to 280g and 216g of fish per day for men and women, respectively. This was compared with a daily red meat consumption of 300g and 225g, respectively. The fish-enriched diet resulted in significant decreases in plasma total cholesterol, LDL cholesterol, VLDL cholesterol and triglyceride levels. A range of factors could have been responsible for these favourable changes, including increased omega-3 (fish) oil intake, reduced saturated fat intake and a lower cholesterol intake, all achieved by substituting red meat with fish in the diet.

The importance of adequate fish intake is also supported by epidemiological studies. National survey data from Spain has shown that the Mediterranean regions of that country have the highest rates of coronary heart disease in Spain. Interestingly, these regions also report the lowest intakes of total and saturated fat in the country. Artalejo et al have analysed the Spanish national food intake data to determine possible reasons for this paradox. Moderate wine consumption, fish intake, chicken intake and vegetable consumption were all negatively correlated with regional coronary heart disease rates. Wine and fish consumption (70g/day) showed particularly strong correlations with reduced coronary heart disease risk in this study.

High cholesterol, high LDL and low HDL levels are established risk factors for coronary heart disease. Elevated triglycerides in combination with these factors compounds this risk further. Various studies have shown that fish oils rich in the omega-3 oils DHA and EPA can significantly decrease elevated triglyceride levels. However, some studies have indicated that fish oils can lead to an unfavourable increase in LDL levels. Interestingly, garlic supplementation has previously been shown to lower cholesterol levels. This led Adler and Holub to test whether garlic powder combined with fish oil supplementation could achieve the positive effects of fish oil on triglycerides whilst avoiding an associated increase in LDL cholesterol.

Groups of 50 men with elevated cholesterol levels were fed various combinations of garlic powder, fish oil and corresponding placebos. A combination of 900 mg of garlic powder with 12 g of fish oil (equivalent to 3.6 g omega-3 oils) led to a reduction of triglyceride levels of 34.3% and a reduction in LDL cholesterol of 9.5%. An important message arising from this study is that a focus on one dietary component is not sufficient to reduce disease risk. Fish is an important food for disease prevention, but it shouldn't be considered in isolation. It should be considered as one of many important components of a healthy diet.

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Wolmarans P et al. Plasma lipoprotein response to substituting fish for red meat in the diet. Am J Clin Nutr 1991;53:1171-1176.

19. Postprandial responses to fish

Low-fat, high-carbohydrate diets have over the past two decades been the treatment of choice for reduction of elevated coronary heart disease risk. The problem with this dietary strategy is that some undesirable effects such as increased blood sugar, triglyceride, and insulin levels, and decreased protective HDL levels may occur. Of particular importance is the intensity of blood triglyceride increase immediately after a meal (ie. postprandial triglyceridaemia). The intensity and length of this increase correlates strongly with increased risk of atherosclerosis.

Roche and Gibney have recently investigated the effect on coronary heart disease risk factors of adding fish to a low-fat, high-carbohydrate diet. Groups of 8 subjects received one of 4 diets over 16 weeks: low fat (with or without a fish oil supplement containing 800mg omega-3 oils, ie. 440 mg EPA and 360 mg DHA) and an average fat (35% energy as fat) diet (with or without a fish oil supplement containing 440 mg EPA and 360 mg DHA).

Some of the disadvantages of the low fat diet (ie. increased blood triglyceride levels and decreased levels of blood HDL) were averted by fish oil supplementation. The intensity of postprandial triglyceride levels was reduced by fish oil in those subjects following a moderately high fat diet. However, these levels were increased with the addition of fish oil to the low fat diet, indicating a possible negative effect of fish oil supplementation.

Until the early nineties, an emphasis was placed on measuring plasma cholesterol levels in fasting individuals as a way of assessing CHD risk. Studies by Sethi et al (1993) and others provided some evidence that serum lipid responses to a meal are also important. In an early study, Zampelas et al (1994) investigated the effects of meals containing 40g of various oils on postprandial blood lipid levels in 12 individuals with normal blood cholesterol levels. In comparison to meals containing saturated fat or corn oil (rich in omega-6 oils), the meal containing 40 g of fish oils significantly reduced postprandial plasma triglyceride responses.

Postprandial levels of other factors may also have an impact on health. In a second study, Zampelas looked at the effects of the same oils on postprandial levels of insulin, lipoprotein lipase and gastric inhibitory polypeptide. Lipoprotein lipase helps to remove triglyceride from the blood as a normal metabolic function. This second study showed that lipoprotein lipase activity increased significantly more after the meal with fish oil than for the other two oils. Thus, the reduction in postprandial triglyceridaemia caused by fish oil consumption may be in part due to an augmentation of the enzyme lipoprotein lipase.

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20. Fish as a source of Selenium

Selenium is increasingly being recognised as an important nutrient for humans. Selenium deficiency has a characteristic pathology which involves adverse changes to heart muscle. A high prevalence of a degenerative cardiomyopathy (Keshan disease) involving free-radical damage has been noted in some parts of China where selenium content of soils is low.

Apart from being an essential nutrient, Se plays a major role in the enzyme systems which control the accumulation of free radicals in the body. Adequate dietary selenium helps protect the body against situations which create substanital oxidative damage to DNA, such as exposure to various chemicals and radiation, as well as the factors in everyday life which contribute to aging.

In some areas of New Zealand the selenium intake of humans is extremely low. The selenium content of New Zealand cereals is extremely low. New Zealanders derive only 14% of Se intake from cereals compared to 75% in areas of China where Keshan disease is endemic. In these areas, Se intake is from 4-11 micrograms daily. The New Zealand intake is usually less than 30 micrograms per day and as low as 9-11 micrograms when no chicken or fish are eaten. Fish certainly is recognised as an important selenium source in regions with low soil selenium levels.

Some interesting findings have emerged from the Scottish population where their selenium intake may have decreased over recent years due to a fall in their consumption of locally grown wheat, previously a major selenium source. This change in food supply caused Barclay and MacPherson to investigate another rich selenium source (fish) for current selenium levels. General dietary survey results indicate that fish contributes 19% of the selenium intake in Scotland. Fish is also likely to be a noteworthy source of dietary selenium in Australia. The following table highlights the importance of fish as a selenium source as indicated by analysis data collected in 1992 by Tinggi et al.

Food	Selenium content (micrograms/100g)
Mackeral (raw)	31
Trevally (raw)	48
Morwong (raw)	63
Chicken (roasted)	25
Lamb chop	22
Beef steak	20
Eggs (scrambled)	21
Multigrain bread	11

Barclay MNI, MacPherson A. Contribution of selenium content of fish on dietary intake. Proc Nutr Soc 52:271A (1993)
Holland B et al. McCance and Widdowson's The composition of foods. Fifth Edition 1991.
Knizhnikov VA, Shandala NK, Komleva VA et al. The effect of dietary levels of selenium on radiation resistance and radiation-induced carcinogenesis. Nutr Res 1996;16:505-516
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21. The importance of fish for people with Crohn's disease.

The incidence of Crohn's disease has increased significantly over several decades. Environmental factors such as diet are thought to have played a major role in this increase since the genetic makeup of the Japanese population probably has remained reasonably homogenous over this period. One important change in the Japanese diet has been the increased consumption of "Western" foods, from countries where Crohn's disease is much more common. Shoda et al recently have analysed national dietary intake data to indentify which dietary factors in the Japanese diet are likely to have played a role in the increased incidence of Crohn's disease. Dietary intake information is based on an annual survey where up to 68 000 people are asked to submit a 5-day food record. In this study Crohn's disease was strongly correlated with increased dietary fat ($r = 0.919$), animal fat ($r = 0.880$), omega-6 fatty acids ($r = 0.883$), animal protein ($r = 0.908$), milk protein ($r = 0.924$) and the omega-6:omega-3 ratio ($r = 0.792$). This study's general conclusion was that the increase in animal protein as well as the increased omega-6 oil intake in combination with a corresponding decrease in omega-3 oil intake is strongly associated with increased rates of Crohn's disease.

Crohn's disease is characterised by bouts of illness interspersed with periods of remission. Inflammation is an important component of this disease, and it is the gastrointestinal tract which is most affected although inflammation of the liver, kidneys, joints, eyes and skin also can occur. It is thus thought by some that agents which can minimise the inflammatory processes (eg fish oil) may be beneficial in prolonging remission in patients with Crohn's disease.

Belluzzi et al fed a group of 78 Crohn's patients either fish oil (2.7 g/day omega-3 fatty acids) or a placebo for one year. A major consideration in the use of fish oil is that it is poorly tolerated by some patients because of its strong taste and its ability to cause gastrointestinal upsets. Capsules therefore were coated with a resistant surface to reduce unpleasant side-effects. Eleven patients had relapses in the fish oil group compared with 27 patients in the placebo group during the 12 months of the study. Compliance was assessed by monitoring blood phosphlipid profiles.

Hodgson's editorial associated with the study by Belluzzi et al draws attention to the drug strategies which have found some success in keeping Crohn's disease in remission. Such strategies centre around impairing the processes of inflammation, much akin to the approach taken by Belluzzi et al. Interestly, the patients used in this study had a high risk of relapse prior to the study, having had relapses within 2 years prior and having low grade disease upon initial examination, making the results of this dietary supplement study all the more impressive. Fish consumption is not a straightforward solution though since countries with high fish consumption (eg. Scandanavian countries) still have quite substantial incidences of Crohn's disease.

Belluzzi A, Brignola C, Campieri M et al.Effect of an enteric-coated fish-oil preparation on relapses in Crohn's disease. N Engl J Med 1996;334:1557-1560
Hodgson HJ. Keeping Crohn's disease quiet. N Engl J Med 1996;334:1599-1560
Kim Y. Can fish oil maintain Crohn's disease in remission? Nutr Rev 1996;54:248-257.
Shoda R et al. Epidemiologic analysis of Crohn disease in Japan: increased dietary intake of n-6 polyunsaturated fatty acids and animal protein relates to the increased incidence of Crohn disease in Japan. Am J Clin Nutr 1996;63:741-745.

22. Why is red meat consumption associated with colon cancer?

There is a strong correlation (r=0.85) between red meat consumption and colon cancer in international studies. It seems that chicken and fish consumption do not show such an association. The biochemical basis for this observation still remains to be solved. One hypothesis is that N-nitroso compounds are formed in the gut after red meat consumption and these compounds exert a mutagenic effect on colon cells. This theory was tested by feeding 8 human subjects either 60 or 600 g per day of beef, lamb or pork. The higher red meat intakes led to much higher N-nitroso compounds in faeces. This is certainly consistent with a potential role in colon cancer development. The methodology of this study was quite interesting. Meat was fried in 20 g of butter (3 min each side) at 180°C to "maximise mutagen content".

Earlier studies had found that groups with low red meat intake (eg. Seventh Day Adventists) have much lower colon cancer rates than the general population.

Willet et al (1990) have been studying a group of 88 751 female nurses over a period of 17 years to determine associations between various dietary factors and disease risk. They found that in this group of women, those who ate chicken and fish the most had half the risk of developing colon cancer. Conversely, those women who ate red meat most often (ie. every day) had about twice the risk of colon cancer as those who ate red meat least (less than once per month).

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Phillips RL et al. Association of meat and coffee use in cancers of the large bowel, breast and prostate among Seventh Day Adventists: Preliminary results. Cancer Res 1983;43:suppl 2403-2408.

Willett WC, Stampfer JM, Colditz GA, et al. Relation of meat, fat, and fiber intake to the risk of colon cancer in a prospective study among women. N Engl J Med 1990;323:1664-1672.

23. Fish oils and bowel cancer risk

Cancers of the intestinal tract are an extremely important public health problem in the industrialised world, being the second most common cause of cancer deaths in the USA. Although colorectal cancer rates have been in decline since 1980 in the USA, they are still an important public health problem. In Australia they are equally important, with 1550 males and 1535 females dying of this disease in Australia in 1988. This represents 11.2 and 12.1%, respectively of all cancer deaths during that year. Genetic factors undoubtedly play a major role in colorectal cancer risk. However, environmental factors such as diet also are recognised as very important determinants of disease risk.

A range of dietary factors has been well-studied in terms of their affect on risk of colorectal cancer. These include fat, red meat, fibre, fruits and vegetables and alcohol. Nutrients which are emerging as potentially important protective factors include folate, omega-3 fatty acids and selenium. Dietary fat is a risk factor for colon cancer. However, fish consumption is protective against this disease. Numerous epidemiological studies show that nutrients such as the fish oils EPA and DHA are associated with a decreased risk of colorectal cancer.

Gastro-intestinal hyperproliferation has become a useful *in vitro* model for colon cancer development. Hyperproliferation is associated with increased risk of colon cancer and fish oil inhibits hyperproliferation. Research in test tubes and experimental animals has shown that omega-3 oils have an anti-proliferative effect on cancer cells. This means that such cells multiply less vigorously in the presence of omega-3 oils. This observation presents great potential, although the specific implications for cancer prevention and treatment have yet to be worked out. Unfortunately, no randomised controlled trials on the effects of omega-3 oils on cancer prevention in humans have been conducted to date.

It is thought that the long chain polyunsaturated fatty acids in fish oil suppress the formation of inflammatory metabolites in the gut. Inflammation also may inhibit the immune surveillance systems which remove cancerous growths under optimal circumstances. Although the effects of omega-3 oils are in some ways similar to the effects of non-steroidal anti-inflammatory drugs such as aspirin, the omega-3 oils have a broader, less specific action because aspirin blocks specific pathways of oil metabolism, where as omega-3 ingestion influences substrate availability. Nevertheless, omega-3 oils have a nett effect of inhibiting the conversion of arachadonic acid to prostaglandins and leukotrienes, compounds which contribute to inflammatory reactions.

A recent study on 24 volunteers has shed some light on this topic. The subjects all had evidence of sporadic adenomatous polyps (possible precursors to colon cancer) and were fed capsules containing either 455mg EPA and 395 mg DHA (total of 850 mg omega-3 oils) or a placebo (3 capsules, 3 times/day) for 12 weeks.

Colon biopsy of patients showed that fish oil supplementation reduced cell proliferation in the gut wall. EPA contents of the rectal mucosa increased and linoleic and arachadonic acid content decreased in the fish oil supplemented group. This study looked at some of the mechanisms which may affect cancer development and these promising results are consistent with a protective role for fish oils. However, no specific conclusion about the effects of omega-3 oil supplementation can be drawn from this study.

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24. A brief chronology of fish and coronary heart disease

A curious conundrum emerged in the early 1970s for scientists working on coronary heart disease in the Nordic countries. They observed that the Greenland Inuits (Eskimos) had only one-third to one-tenth the rates of heart attacks than that of the Danes. In subsequent studies the Inuit people were found to have substantially lower blood cholesterol, triglyceride and LDL levels, but higher HDL levels than their Danish equivalents.

Fatty acid profiles of the two groups showed the Inuits to have much lower levels of omega-6 fats and much higher omega-3 oil levels (especially EPA, DHA and DPA). The origin of these fatty acids was traced back to the diet which contained a heavy consumption of seal and whale meat - both rich in omega-3 oils.

In retrospective studies of the nutritional effects of world war II, Bang and Dyerberg have calculated that Norwegians were consuming 4 to 5 g EPA per day because dairy foods and meat were very scarce and they had to make up the deficit with fish. As the table below shows, this intake represents quite high amounts of fish consumed in terms of Australian fish equivalents. Incidence of thrombotic and embolic diseases decreased significantly during that time.

Amounts of various Australian fish containing 5g EPA

Fish	Amount containing 5g EPA
Mullet, sea	4500g
Gemfish	4670g
Patagonian toothfish	6750g
Spikey oreo	6570g

A 1982 Japanese report subsequently revealed that people from Kohama island, having the lowest incidence of cardiovascular disease in Japan, had much higher serum levels of EPA than people on the Japanese mainland. This was due to their higher intake of fresh fish.

Since that time, various large prospective studies have suggested that fish intake has important health implications:

A large study on Swedish twins conducted by Norell et al found that risk of death by heart attack fell as fish intake increased. The reported effect of fish was the same for both men and women.

Results from the Chicago Western Electric Study involving 1931 male subjects over a 25-year period found a similar inverse relationship between coronary heart disease mortality and fish consumption, with the highest heart disease rates seen in those men who ate no fish at all.

The Zutphen Study which tracked 852 middle-aged Dutch men for 20 years showed that men who consumed as little as 30g of fish per day had less than half the death rate from coronary heart disease than did those who ate no fish at all. Dutch studies led by Kromhout indicate that as few as one or two fish meals per week can substantially lower coronary heart disease risk.

The Honolulu Heart Program found in their group of 120 Japanese men that two or more fish meals per week decreased risk of heart muscle injury by up to 65%.

Up until this point in time the scientific basis for fish protecting against heart disease relied on observational prospective studies. Burr et al in 1989 studied 2033 men who had previously suffered heart attacks. They fed these men diets containing about 300g of fish per week and found that this led to a 29% decrease in deaths from heart attacks after 2 years, compared to those who ate no fish. Interestingly, the number of coronary events was not reduced, indicating that fish intake may have acted via mechanisms such as prevention of thrombosis or cardiac arythmia, rather than atherosclerosis. This has been confirmed somewhat by more recent results from the Lyon Diet Heart Trial which showed that a "Mediterranean" diet was more effective than a low fat diet in protecting against sudden cardiac death in people who had previously suffered a heart attack. This advantage was despite no change in blood cholesterol levels between the two diets. The authors of the Lyon Trial have speculated that these remarkable results were due to intake of the shorter chain omega-3 oil, alpha-linolenic acid.

The early nineties also saw the emergence of evidence suggesting that fish oils could lower blood pressure. This work was based on clinical findings by Kestin and others which showed that 3.4g of omega-3 oils (EPA and DHA) per day for 3 weeks led to a fall in systolic blood pressure of 5.1 mm. The recently concluded DASH trial involving 459 patients showed that their "combination" diet (incorporating 0.5 serves of fish per day) decreased systolic and diastolic blood pressures by 5.0 and 3.0mm Hg, respectively.

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25. Diet-related diseases in Australia

Diet-related diseases pose a significant burden to the Australian health system. The Australian Institute of Health and Welfare has estimated the cost of diet-related diseases in Australia using three separate methods as in the following table. Diseases are ranked for each criterion.

Leading diet-related causes of death in Australia 1989-90 (AIHW)

	Productive years of life lost to age 65
Ischaemic heart disease	17 190
Some cancers	8433
Stroke	6168
late-onset diabetes	3476
Gallbladder disease	667
Hypertension	569

	Total cost to the community ($M)
Dental caries	478
Ischaemic heart disease	474
Hypertension	364
Stroke	270
late-onset diabetes	248
Certain cancers	198

	Health care costs ($M)
Dental caries	475
Hypertension	276
Ischaemic heart disease	194
Stroke	178
late-onset diabetes	166
Certain cancers	60

Intercountry comparisons identify countries with the lowest incidence of a particular disease. By comparing Australian death rates with those from the country of lowest incidence, Wahlqvist and Kouris-Blazos established the proportion of disease incidence due primarily to environmental factors (including diet) in Australia.

The most preventable diet-related diseases in Australia as identified by Wahlqvist and Kouris-Blazos

Disease	Percentage preventable
Ischaemic heart disease	67.1
All cancers	18.3
Stomach	40.6
Breast	10.4
Stroke	39.8
Chronic liver disease and cirrhosis	59.8
Digestive system diseases	27.2

Aetiological fractions describe the proportion of disease prevalence which can be attributed to a particular cause. In the case of diet, aetiological fractions for the following diseases have been calculated by Crowley et al. These are 0.5 for diabetes, stomach cancer, non-cancer bowel conditions, dental caries, gallstones and coronary heart disease; 0.4 for stroke; 0.35 for colon and rectal cancer; 0.3 for breast cancer; 0.25 for endometrial cancer; and 0.2 for osteoporosis. This information means, for example, that half the above coronary heart diseases could have been prevented through appropriate diet.

Dietary strategies which help to prevent these diseases are very cost-effective and can generate enormous savings for the community over a period of years. The costs to the community need not just be measured in monetary terms. Indirect consequences of poor diet such as loss of quality of life and the impact of illness on family members are difficult to measure, but none-the-less important to the community. Factors such as foregone earnings, sick leave, pharmaceutical and medical costs also place a significant burden on the community.

Fish consumed as part of a well-balanced diet has been shown to have a positive impact on diseases such as coronary heart disease, rheumatoid arthritis, diabetes mellitus, glucose intolerance, obesity, hypertension, and hypertriglyceridaemia, with promising early results in conditions such as asthma, infant neural development, Crohn's disease, colon cancer, inflammation, psoriasis, inflammatory bowel disease and atopic dermatitis. Clearly, the responsible promotion of appropriate fish consumption will generate substantial cost savings for the Australian community through disease prevention.

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26. Absorption of cholesterol from seafood

Quite a substantial body of literature indicates that dietary cholesterol can increase plasma cholesterol, therefore increasing coronary heart disease risk. This is particularly so when combined with dietary saturated fat intake. The relationship between plasma cholesterol and dietary cholesterol remains uncertain in terms of the effect on HDL cholesterol levels, which are an important protector against coronary heart disease.

It is indeed well established that dietary cholesterol increases plasma cholesterol levels, but only 15% of the population undergo increases greater than 10%. Recently, Clifton and Nestel found that diets containing 700mg cholesterol (equivalent to about 3 eggs) caused potentially atherogenic changes in post-prandial serum lipid profiles, but only in subjects with abnormally high triglyceride levels.

Gender, age and distribution of body fat have an important influence on how the body processes dietary cholesterol. Transfer of cholesteryl ester from HDL to apolipoprotein B is an important determinant of how cholesterol is distributed in plasma (ie. whether bound to HDL or LDL). Elevation of this transfer is seen in patients with established atherosclerosis. A study by Sutherland et al investigated the effect of dietary cholesterol from eggs on this transfer in a group of 26 healthy subjects. These subjects were fed one egg per day on top of their usual diets. This intake resulted in a significant decrease in newly synthesised cholesteryl ester transfer activity in women. As a result, apo-B and total cholesterol levels rose significantly in men, but not women. Age also influenced this activity. In summary, the extra egg resulted in decreased newly synthesised cholesteryl ester transfer activity in women, elderly men, and in individuals with the highest usual cholesterol intakes. The decrease in this activity may help to suppress increases in apo-B levels in women when their cholesterol intakes increase.

How does this relate to seafood? Patients at risk of developing coronary heart disease are often advised to eat crustaceans (prawns, crabs, lobsters) only rarely because of the high cholesterol levels found in these foods.

In the late 1980s Childs et al conducted an important study on the effects of various American shellfish on cholesterol levels in humans. Amounts of between 225 and 625 g of oyster, clam, crab, squid, mussel and shrimp were fed to 18 volunteers per day for 3-week periods. The shellfish replaced other protein sources (ie. meat, cheese, egg) in the diets of the volunteers. Cholesterol absorption was the same for the crab, squid and shrimp diets, but decreased significantly on the oyster, clam and mussel diets. These latter three diets also caused a significant decrease (34-52%) in VLDL cholesterol levels and the crab diet led to a decrease of 26%. No significant changes in VLDL cholesterol were seen for the squid and shrimp diets. LDL levels fell by 11-14% on the oyster, clam and crab diets, but no significant change was seen with the other three diets. The usual diet (about 111g fat, 511mg cholesterol per day) of these subjects was used as the baseline. The conclusions from this study were that oysters, clams, mussels and crab are suitable for cholesterol-lowering diets, in combination with a reduced saturated fat intake. The omega-3 content of the six shellfish tested (see table below) varied considerably and may have had some impact on the changes in cholesterol levels seen in this study.

Daily omega-3 content of shellfish diets

Shrimp	0.9
Crab	1.4
Squid	1.9
Clam	3.7
Mussel	4.3
Oyster	4.6

In a subsequent study 6 years later, a New York research team (De Oliveira e Silva et al) investigated the effect of shrimp consumption on cholesterol levels. They looked at adding 300g of shrimp per day (supplying 590 mg dietary cholesterol) to a low fat diet. This led to an increase in LDL and HDL cholesterol of 7.1 and 12.1%, respectively compared to a low fat diet containing only 107 mg cholesterol. Thus, the LDL:HDL ratio, and therefore coronary heart disease risk was lower. Triglyceride levels were reduced by 13%. A separate diet, supplying 581 mg cholesterol per day from eggs, led to a higher increase in LDL than HDL, thus increasing the LDL:HDL ratio and CHD risk. The results indicate that shrimp eaten in conjunction with a low fat diet is more suitable for reducing CHD risk than a low fat diet on its own.

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27. Essential fatty acids - how much do we need?

Since the 1820s we've known that protein, fat and carbohydrate are essential to good health. It wasn't until a century later that nutritionists realised that fat plays such a crucial role in growth and reproduction. Out of this work emerged the essential fatty acid concept. In a sense, they are like vitamins. The body can't synthesise them, they must be ingested. The consequences of an inadequate essential fatty acid intake are dire. The main symptoms of essential fatty acid deficiency are scaling of the skin and reproductive problems.

Which fatty acids are essential? The two families of fatty acids which are essential are the omega-3 oils and the omega-6 oils. These two types of oils lead to the production of two separate groups of mediators of important biochemical processes in the body. Imbalances of these mediators are thought to be the basis for the symptoms of essential fatty acid deficiencies.

How much of these oils do we need for optimal health? To prevent essential fatty acid deficiency, humans need to consume 2.4% of their oil intake as omega-6 oils. The recommended intake for linoleic acid is a little higher, about 3 to 5% of total dietary fat. To ensure maximum levels of the omega-3 fish oil DHA in tissues, an intake of omega-3 oils as 0.5 to 1.0% of total fat is required. Newborn infants seem to require longer chained arachadonic acid (omega-6) and DHA (omega-3) for optimal neural development. Premature infants seem to be in particular need of these longer-chained oils.

Essential fatty acid requirements

	Omega-3 oils	Omega-6 oils
% total fat	0.5 - 1.0%	3 - 5%
requirements for 2000 calorie diet containing 30% energy as fat	370 - 740 mg	2.2 - 3.7 g

Where do we find these oils? There are two major sources of omega-3 oils: plant oils such as soybean, canola and flaxseed, which supply alpha-linolenic acid, and fish which supply the longer chained fish oils such as EPA and DHA. The body still needs to convert alpha-linolenic acid into the longer-chained oils EPA and DHA, a conversion that depends on the effectiveness of the appropriate enzymes. Infants are not particularly efficient at manufacturing EPA and DHA. Oils from corn, sunflower, and safflower all have very low levels of omega-3 oils and if these oils are used as the sole source of fat in the diet, an omega-3 fat deficiency will develop.

Omega-6 oils, mainly in the form of linoleic acid, are found in oils from foods such as sunflower, safflower, corn and soybean. The longer-chained omega-6 oil arachadonic acid is found in animal foods such as egg yolk, meat and offal.

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28. Fatty acid structure and nomenclature

The terms omega-3, omega-6, polyunsaturated, monounsaturated, saturated, and essential fatty acid are used quite extensively on food labels and in the promotion and marketing of food and nutrition supplements. But what do these terms mean?

What are fats and oils?

There are four macronutrients: protein, carbohydrate, alcohol and fat. Each of these four macronutrients generate energy when they are metabolised by the body. Carbohydrates supply glucose, the major fuel of the body. Apart from supplying energy to the body, proteins and fats provide structural building blocks for the body and supply a range of other important functions which the body needs to remain healthy.

We eat fat mainly in the form of triglycerides (or more correctly, triacylglycerides), which as the name suggests are a conglomerate of three fatty acids joined together by a glyceride backbone. From a chemical viewpoint fatty acids are chains of carbon atoms joined together by either single or double bonds. Fatty acids have an acidic end and a methyl (omega) end. It is the length of the carbon chain and the distribution of single and double bonds along this carbon chain that differentiate fatty acids. Fatty acids with no double bonds are called saturated fatty acids, those with one double bond are called monounsaturated fatty acids, and those with more than one are called polyunsaturated fatty acids.

For example, the omega-3 fatty acid DHA (docosahexaenoic acid) is a chain of 22 carbon atoms and has six double bonds. It is therefore a polyunsaturated fatty acid. The fact that the first double bond occurs after the third carbon atom from the methyl end means that it is an omega-3 (or n-3) fatty acid. EPA (eicosapentaenoic acid) is also an omega-3 fatty acid, but in this case the chain has only 20 carbon atoms, and five double bonds, so it is also a polyunsaturated fatty acid. The location of the first double bond from the methyl end is important because this determines how the body metabolises this fatty acid.

What is the difference between omega-3 and omega-6 oils?

The location of the first double bond on the fatty acid carbon chain is important because this determines which compounds will be manufactured from them by the body. Omega-6 fatty acids are synthesised into series 1 and 2 eicosanoids and series 4 leukotrienes, whereas omega-3 fatty acids are synthesised into series 3 eicosanoids and series 5 leukotrienes.

How does the structural difference between omega-3 and omega-6 oils affect their action in the body?

Eicosanoids are important for many biochemical reactions in the body. The series 1 and 2 eicosanoids (derived from omega-6 oils) are converted into prostaglandins which are very potent mediators of inflammation and smooth muscle contraction. The series 3 prostaglandins (derived from omega-3 oils) are less potent, which may lead to less severe inflammatory reactions in people who have higher intakes of omega-3 fatty acids, as reported by some studies. The inflammatory process is involved in many diseases including coronary heart disease, rheumatoid arthritis and asthma, and the ratio of omega-3 to omega-6 fatty acids in the diet may have an important role to play in the prevention of such diseases.

What is a saturated fat?

Saturated fats have no double bonds in their carbon chains. These fatty acids have acquired a bad name in terms of coronary heart disease prevention since intake is associated with increased risk. However, it is only three saturated fatty acids, lauric acid (C12:0), myristic (C14:0) and palmitic (C16:0) which lead to increases in LDL cholesterol, the strongest serum predictor of coronary heart disease risk. Other saturated fatty acids such as stearic acid (C18:0) have a neutral effect on blood cholesterol levels.

Some examples of fatty acid structure

Fatty acid	Number of carbon atoms	Number of double bonds	Distance of first double bond from methyl end	Abbreviation
DHA	22	6	3	C22:6n-3
EPA	20	5	3	C20:5n-3
Oleic acid	18	1	9	C18:1n-9
Palmitic acid	16	0	na	C16:0
Linoleic acid	18	2	6	C18:2n-6

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29. The role of fish in the treatment and prevention of rheumatoid arthritis

Rheumatoid arthritis (RA) is a painful and debilitating illness which, in its most severe forms, can shorten the life expectancy of those who are affected. Diseases which develop from a combination of mechanisms, such as coronary heart disease and diabetes mellitus are often treated using multiple therapy types, for example drugs and diet. There seems to be a good deal of potential to take the same approach for treatment of rheumatoid arthritis.

As at 1997, there have been eleven double-blind, placebo-controlled trials looking at the effects of supplementation with omega-3 fish oils. In the mid-1980s Kremer et al conducted two short clinical trials feeding 1.8-2.7 EPA and 1.2-1.8 DHA per day to RA patients, leading to improvements in patient symptoms, assessed both by the patient and the attending physician. In 1988, Cleland et al used higher dosages (3.2g EPA, 2.0g DHA) and similarly found improvement in patient symptoms. All of the patients in these studies continued on with their usual medications.

In 1993, Lau et al reported in a longer term study (52 weeks) that supplementation with 1.7g EPA and 1.1g DHA led to decreased usage of non-steroidal anti-inflammatory drugs by RA patients.

One of the many possible environmental factors which may have contributed to increased prevalence of diseases such as rheumatoid arthritis is the increase in linoleic acid, from 1g per day at the beginning of the 20^{th} century to 7g per day in the 1990s. This increase in omega-6 oil intake was initially caused by revolutions in agricultural practices and food technology, but more recently has been fuelled by the concentrated effort of public health authorities and food industry alike to focus on plasma cholesterol reduction. Whilst current epidemiological evidence does not support a direct link between linoleic acid intake and inflammatory disorders, the basic understanding that omega-6 is an omega-3 antagonist at a biochemical level warrants closer scrutiny. In particular, when assessing the effects of omega-3 supplementation on RA symptoms it is important to consider both the omega-6 content in the diet and concurrent drug therapy. Diets rich in omega-3 oils but low in omega-6 oils have the potential to improve drug efficacy and in doing so will decrease the dosages required of such drugs.

In comparisons between inhabitants in the Faroe Islands (Northern Atlantic) and mainland Nordic countries, there seems to be much lower prevalence of RA. This lower prevalence is associated with much higher consumption of fish and far lower consumption of meat, dairy products and vegetables. Of note is that the inhabitants of the Faroe Islands also consume significant amounts of whale meat and fat, increasing their intake of omega-3 fish oils further.

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30. How omega-3 fish oils affect the immune system

In theory at least, the consumption of omega-3 fish oils has the potential to moderate the inflammatory process, a phenomenon which is involved in many disease processes including coronary heart disease, asthma, and rheumatoid arthritis. The following table compares the metabolic destinies of the omega-3 and omega-6 essential fatty acids.

Metabolic fate of essential omega-3 and omega-6 fatty acids

	Omega-3	Omega-6
18 carbon fatty acid	alpha-linolenic acid	linoleic acid
Sources	flaxseed, rapeseed, perslane	sunflower, safflower, corn, cottonseed
20 carbon fatty acid	eicosapentaenoic acid	arachidonic acid
Dietary intake	0.3 to 0.4% energy	7 to 8% energy
Amount in leukocytes	0.1 to 0.3%	10 to 16%
Metabolic destiny of 20-carbon fatty acids relevant to inflammation	Inhibit omega-6 prostaglandin and leukotriene production	converted to omega-6 prostaglandins (pro-inflammatory)
Actions of 20-carbon fatty acids relevant to inflammation	↓Inflammatory cytokine (TNF-α and IL-1β) production	Uncertain because tissue arachidonic acid levels don't vary extensively

Adapted from Cleland et al 1995

An increase in omega-6 fatty acid consumption and a consequent increase in the dietary omega-6:omega-3 ratio may cause physiological imbalances which could facilitate inflammatory disorders such as asthma. The omega-6 derived eicosanoid compounds such as series 1 and 2 prostaglandins and leukotrienes are pro-inflammatory, and are displaced or their production inhibited by their omega-3 derived equivalents. An imbalance favouring accumulation of omega-6. derived eicosanoids might lead to conditions more conducive to asthma development. Leukotrienes and eicosanoids are potent mediators of immune cell activity, and are often self-perpetuating, leading to a cascade effect resulting ultimately in an inflammatory reaction.

But what do we know of the effects of omega-3 fish oil or fish consumption on immunity and the immune system? Fatty acids have two major functions in the body, as a fuel and as a structural component of cell membranes. Changing fatty acid profiles might not impact significantly on energy supply of fats, but such changes can affect cell membrane fluidity, which in turn can influence ion and substrate transport across the cell membrane, membrane-bound enzyme activity and membrane receptor function. These effects can have major physiological consequences. Immune cells such as macrophages and lymphocytes are similar to other cells in that membrane lipid changes can have a substantial impact on cell function.

Although removed from the human situation, studies involving the feeding of rats 200g fish oil/kg body weight have shown that such dosages result in a suppression of graft versus host reaction, a feature which may at some stage be useful in situations such as transplant patients.

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31. Fish and asthma: what do we know?

The last two decades have seen an increase in asthma rates in children and young adults in a range of countries including Australia, Canada, New Zealand, United Kingdom, Finland, Sweden, and the USA. Along with environmental factors such as pollution, cigarette smoking and allergen exposure, dietary factors have also been proposed as possible causes of this apparent increase in prevalence.

A recent Sydney-based study by Hodge et al caused much media attention when they found an association between regular fresh oily fish consumption and lower risk of having asthma. Their study involved a survey of 574 children who had presented recently with wheeze (ie. over the past 12 months). Results showed that those children who ate fresh oily fish (fat content >2%) had a reduced risk of having asthma. No protection was detected for consumption of total fish nor for tinned fish, which are generally rich in omega-3 oils. These results are consistent with, but do not prove, the hypothesis that fresh fish consumption may protect against asthma development in children, and the effect may not be related to omega-3 oil intake.

In fact, the hypothesis is a little more complicated. The increase in omega-6 fatty acid consumption and the consequent increase in the dietary omega-6:omega-3 ratio over several decades may have led to physiological imbalances which could facilitate inflammatory disorders such as asthma. The omega-6 derived eicosanoid compounds such as series 1 and 2 prostaglandins and leukotrienes are pro-inflammatory, and are displaced or their production inhibited by their omega-3 derived equivalents. An imbalance favouring accumulation of omega-6 derived eicosanoids might lead to conditions more suitable for asthma to develop.

Intervention trials looking at the effects of feeding fish oil or pure EPA have been inconclusive in reducing asthma symptoms to date. These studies represent a therapeutic approach to asthma. For example, Arm et al in 1988 gave a group of 12 mild asthmatics 16g of fish oil per day (containing 3.2g EPA) over a 10 week period. Although EPA levels in leukocytes increased substantially, no improvement in symptoms were seen in comparison to a group of asthmatics taking a placebo.

The influence of fish consumption on asthma development and therefore asthma prevention still needs to be investigated before claims of any substance about the effects of seafood consumption on asthma can be made.

Some Australian fish with fat contents in excess of 2%

Orange roughy	4.9%	Western blue groper	3.6%
Atlantic salmon	2.7%	Butterfish	2.0%
Gemfish	2.6%	Threadfin emperor	2.6%
Silver perch	6.1%	Black oreo	2.9%
Blue mackeral	3.8%	Spanish mackeral	3.0%
Patagonian toothfish	3.7%	Smooth oreo	3.0%

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32. Fish and diabetes

People with diabetes have an increased risk of developing coronary heart disease, so it makes sense to incorporate heart protective strategies into the dietary treatment of diabetes. Omega-3 fish oils have demonstrated positive effects on factors such as platelet aggregation, blood pressure and plasma lipoprotein metabolism, all important in the development of coronary heart disease.

However, some studies have shown that relatively high doses of omega-3 fish oils can increase blood glucose in diabetic patients. Such studies were commonly using dosages of omega-3 fish oils of between four and ten grams per day. In a 1994 study, Axelrod et al studied the effects of a smaller dose (2.5g/day for 6 weeks) of omega-3 oils on a variety of factors related to coronary heart disease and on glucose response in a group of nine subjects with non-insulin dependent diabetes mellitus (NIDDM). At the omega-3 oil intake tested, no effect on blood glucose levels was noted. However, favourable effects on platelet aggregation, thromboxane (mediator of inflammation) production, blood pressure and triglyceride levels were seen as a result of omega-3 oil intake at this level.

Another important issue in diabetes, especially non-insulin-dependent type diabetes (NIDDM) is insulin resistance. Skeletal muscle is a major consumer of glucose in the body. The way in which this muscle metabolises glucose has a significant impact on blood glucose levels. The composition of muscle cell membranes is important in this process. Incorporation of unsaturated fats into these membranes improves insulin action, thereby improving diabetes symptoms. Previous studies have shown that insulin resistance in skeletal muscle can be prevented by substituting omega-3 oils into a high fat diet (Storlien et al 1987, Borkman et al 1993). This observation is consistent with the general finding that regular intake of omega-3 oils (from fish) seems to be protective against insulin resistance (Feskens et al 1991, Dyerberg and Ban 1979, Adler et al 1994). Further, high dietary omega-6/omega-3 ratios seem to increase insulin resistance, indicating that increases in dietary omega-3 fish oil should be combined with a decrease in dietary omega-6 oils.

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33. The role of omega-3 oils in obesity prevention

Obesity has become the health concern of the nineties. More Australians than ever before have become obese. Why? There are some populations in the world which are genetically susceptible to obesity. However, in the main, the obesity problem in Australia relates to our changing lifestyles, with diet and physical activity being the most important factors.

The body mass index (BMI) is a common measure of the suitability of persons weight in proportion to their height. The BMI is calculated by dividing a person's body weight in kilograms by the square of their height in metres. For example, if a person weighed 78 kg and was 1.82 metres tall, their BMI would be 78/(1.82x1.82), or 23.5. Generally in Australia it is recommended to have a BMI of between 20 and 25. People are classified as obese when their BMI extends beyond 30.

Nutritionists talk about the macronutrients as being the components in foods which deliver energy to the body. There are four macronutrients: fat, protein, carbohydrates and alcohol which deliver 37, 16, 17 and 29 kilojoules per gram of energy. So it is clear that one gram of fat contains a far greater amount of energy than one gram of carbohydrate or protein. The number of calories in the diet is one factor which contributes to the accumulation of body weight. In many instances, if one consumes more calories than is required by the body, the end result is an accumulation of body fat. This is the basis of the popularity of low fat diets to help with weight loss.

An interesting feature of fish is its low fat content. This makes it a useful protein source to include in calorie-controlled, weight loss diets. The following table compares the energy contents of 100g of fish compared to other animal protein sources.

	Fatty acid (grams/100g)			
Protein food	Polyunsaturated	Monounsaturated	Polyunsaturated	Total kilojoules (per 100g)
Fish, raw, unspecified	1	1	1	457
Beef fillet steak	0	2	2	521
Chicken breast, lean	0	1	1	469

Recent research has shown that the development of obesity may not be a simple case of consuming too many calories. Several studies (Dreon et al 1988, Feskens & Kromhout 1990, Parker et al 1993) now indicate a relationship between accumulation of excess body fat and saturated fat intake (independent of total energy intake). In addition to this, studies by Feskens et al show that increased fish intake may protect against obesity and glucose intolerance. So that the previous premise that all fats are equal (ie. 37 kiloJoules per gram) is not so straightforward. The tendancy of a fat to be stored seems to be related to its degree of saturation and its carbon chain length.

One of the mechanisms by which dietary fat may influence the accumulation of body weight is through their incorporation into cell membranes. Most of the shorter fatty acids need to be processed by various enzymes in the body. Competition for access to these enzymes by various fatty acids seems to be important for excess accumulation of body weight. In particular, omega-6 oils compete with omega-3 oils to a greater extent than do saturated fats. It seems that omega-3 oil supplementation needs to be combined with a low omega-6 oil intake to have beneficial effects on insulin action and excessive body weight accumulation.

Oxidation rates of individual fatty acids are inversely related to propensity for storage of these fatty acids. In other words, the more readily oxidised a fatty acid is, the less likely it will be stored (incorporated into body fat). A study by Leyton et al in 1987 found that alpha-linolenic acid (omega-3) and oleic acid (monounsaturated) were much more readily oxidised than linoleic acid (omega-6) or stearic acid (saturated). Various animal studies indicate that diets supplemented with omega-3 oils are less likely to cause weight gain than diets incorporating omega-6 or omega-9 oils.

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34. Fish oil intake and nitric oxide production

Omega-3 oils can impact positively on coronary heart disease complications associated with diabetes via a number of ways including lipoprotein changes, effects on insulin levels, blood pressure and blood rheology changes. It is thought that increased blood glucose levels in combination with changes in blood rheology combine to promote atherosclerosis through blood vessel injury.

One way in which omega-3 fish oils might act is through localised relaxation of blood vessels. The main mediator of this relaxation is nitric oxide, which relaxes artery wall smooth muscle cells, allowing the artery to dilate. Cells in injured parts of the artery wall have an impairment in their ability to produce nitric oxide. Fish oils are thought to increase nitric oxide levels released by blood vessel tissue, especially by injured blood vessel tissue. Previous work by Fleischhauer et al showed that omega-3 fish oil supplementation was able to enhance coronary artery dilation in a group of heart transplant patients.

In a study on 23 patients with non-insulin dependent diabetes mellitus (NIDDM), McVeigh et al studied the effects of a fish oil supplement (containing 1.8g EPA and 1.2g DHA) given for 6 weeks on release of nitric oxide by blood vessels. The fish oil supplementation improved forearm blood flow in these subjects, indicating that such supplementation may protect such patients against vasospasm and thrombosis in NIDDM patients.

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McVeigh GE et al. Dietary fish oil augments nitric oxide production or release in patients with Type 2 (non-insulin-dependent) diabetes mellitus. Diabetologia 1993;36:33-38.

35. Multiple dietary strategies to reduce coronary heart disease risk

There are no "good" or "bad" foods, but some diets are healthier than others.

This is a common concept for nutrition worldwide in the 1990's, and has a certain element of truth. For example, no single food will cause or prevent coronary heart disease. Prevention of this disease through dietary intervention relies on a combination of strategies such as:

- Reduction of serum total cholesterol
- Reduction of serum LDL cholesterol with concomitant maintenance of serum HDL levels
- Minimisation of platelet stickiness and aggregation
- Optimisation of blood pressure
- Minimisation of cardiac arrythymias
- Prevention of obesity
- Minimisation of LDL oxidation

Contemporary recommendations for a heart friendly diet have been outlined by the US National Cholesterol Education Program, which is a national US organisation which sets standards about the ways Americans should eat to avoid coronary heart disease. Their dietary recommendation for lowering coronary heart disease risk (a NCEP step 2 diet) includes having no more than 30% energy as fat, < 7% energy as saturated fat, and < 200 mg cholesterol, and is recommended for patients with moderately high blood cholesterol levels.

High cholesterol, high LDL and low HDL levels are established risk factors for coronary heart disease. Elevated triglycerides in combination with these factors compounds this risk further. Various studies have shown that fish oils rich in the omega-3 oils DHA and EPA can significantly decrease elevated triglyceride levels. However, some studies have indicated that fish oils can lead to an unfavourable increase in LDL levels. This means that other strategies for lowering cholesterol have to be taken into consideration.

Low fat diets in general have been found to lower total cholesterol levels. However, in most of these studies the protective HDL levels have also decreased significantly, negating much of the potential protective effect. Various studies now have shown that diets rich in sources of monunsaturated fats (such as olive oil, avocado, macadamia nut, walnut, almond) can reduce total and LDL cholesterol, but maintain the protective HDL levels.

The quality of the oils we eat is also important. Fish is quite often deep-fried in oil which has been in use for longer than it should have been. Given the large amount of data demonstrating the benefits of eating fish and fish oils, deepfrying fish in oils which are likely to contribute to coronary heart disease or cancer risk is counterproductive. The optimal ways to cook fish are by steaming, grilling or baking. If fish is to be fried, it should be pan-fried in a small amount of extra-virgin olive oil.

Cooking with various herbs may also be beneficial to health. For example, garlic supplementation has previously been shown to lower cholesterol levels. Recently, Adler and Holub tested whether garlic powder combined with fish oil supplementation could achieve the positive effects of fish oil on triglycerides whilst avoiding an associated increase in LDL cholesterol.

In groups of 50 men with elevated cholesterol levels, a combination of 900 mg of garlic powder with 12 g of fish oil (equivalent to 3.6 g omega-3 oils) led to a reduction of triglyceride levels of 34.3% and a reduction in LDL cholesterol of 9.5%.

At this point in time, the Mediterranean style diet is being recommended as the set of dietary strategies most conducive to coronary heart disease risk reduction. Renaud et al have compared the effects of a Mediterranean diet with a standard low fat diet in a group of 605 people recovering from a heart attack. Their recommendations for the Mediterranean diet were as follows:

- More bread
- More vegetables and legumes
- More fish
- Less meat (beef, lamb, pork), to be replaced by poultry
- No day without fruit
- No butter or cream

Fish is an important food for disease prevention, but it shouldn't be considered in isolation. It should be considered as one of many important components of a healthy diet.

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Willett WC. Diet and Health: What should we eat? Science 1994;264:532-537.

36. Fish consumption and high blood pressure

Omega-3 fish oils have been suspected at least since the early 1980s to help lower both systolic and diastolic blood pressure (Sanders et al 1981). In that particular study, a dose of 4g per day for 6 weeks was fed to a group of 20 healthy young men. Other studies using similar dosages have also shown drops in blood pressure, although some other studies showed no such effect. Recently, Morris et al analysed the results of 31 major studies of the effects of omega-3 fish oils on blood pressure, involving 1356 subjects in total. The verdict was that omega-3 fish oils seem to have a small effect in reducing moderate hypertension, and that this effect was statistically significant.

In another recent experiment, Yosefy and colleagues fed twenty hypertensive subjects Alsepa fish oil (EPA 180 mg, DHA 120 mg) to assess the effects on omega-3 for omega-6 oil exchange on serum phospholipids, blood pressure, triglycerides and primary hemostasis. After 13 days, omega-3 oils (EPA and DHA) in plasma phospholipids increased from 2.0 to 5.9% ($P < 0.01$), and omega-6 oils (arachidonic acid and linoleic acid) decreased from 29.8 to 22.6% ($P < 0.01$). Systolic and diastolic blood pressure also decreased from 158.7 +/- 23.8 mm Hg to 146.5 +/- 17.0 mm Hg, $P = 0.04$, and 80.8 +/- 8.4 mm Hg to 72.9 +/- 14.9 mm Hg, $P = 0.04$, respectively. There was also a significant decrease in platelet adhesion and aggregation, and in triglyeride levels. The authors believe that in severe and life-threatening situations, fish oil may be useful for rapid exchange of omega-3 for omega-6 oils, to help normalise blood pressure and a range of other risk factors for myocardial infarction.

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37. The traditional indigenous Australian diet

Diabetes has recently been recognised as a priority area for public health activity in Australia. The indigenous people of Australia are at particular risk of developing late-onset or non-insulin dependant diabetes, having up to six times the rates of Australians of European descent.

Over the past ten to fifteen years, O'Dea and others have studied the impact of changes in dietary patterns from traditional to modern western diets seen in indigenous populations. In a landmark study, O'Dea (1984) showed that a reversion by a group of ten diabetic indigenous Australians from a modern western diet high in fat and low in complex carbohydrate, to a more traditional diet which is low in fat, low in saturated fat and high in dietary fibre resulted in a remarkable improvement of risk factors for diabetes and coronary heart disaease. In particular, the group lost an average of 8kg over the 7-week period, and had significant improvements in glucose tolerance and insulin sensitivity over this time. The fatty acid profile of such diets is dominated by polyunsaturated fats.

In general, the traditional diet in south-eastern Australia comprised a mixture of fruits, vegetables, roots, seeds, wild animals and fish, which were available throughout the year. In one dietary study completed by O'Dea (1984) in north-eastern Australia, 19% of energy was derived from fish over a 2 week period, with total energy levels of around 1200 kcal/day.

Some of the fish species reported in traditional indigenous diets by Naughton et al include Black Bream, Bluebone and Freshwater Baramundi. The omega-3 oils levels reported for these fish species are as follows:

Omega-3 oil contents of commonly consumed fish species (mg/100g)

Fish species	DHA	EPA
Black bream	4.2	1.6
Bluebone	23.6	2.1
Freshwater baramundi	9.8	3.6

The fatty acid profile of Bluebone is particularly dominated by DHA.

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38. Fish and pregnancy

Essential fatty acids (EFA) are used to make cell membranes. Therefore, the formation of new tissues depends on an adequate availability of EFA. Humans cannot make primary EFA and, therefore, must have an adequate EFA supply from the diet. The foetus has a high EFA requirement, and relies on the mother for its EFA supply. At birth, there is a strong correlation between the various EFA (omega-3 and omega-6 oils) concentrations in maternal and umbilical plasma phospholipids (PL), indicating how important the essential fatty acid intake of mothers is. Hornstra and colleagues found that EFA status progressively decreases during pregnancy. This is especially the case for the omega-3 fish oil DHA, the major structural and functional EFA in the central nervous system. In general, Hornstra found that maternal DHA status appears significantly higher in women undergoing their first pregnancy compared with those in their second or subsequent pregnancy. Following on from this, there was a tendency for a woman's first child to have a higher DHA status than that of following children. It seems that the source from which the mother supplies DHA to the foetus is not easily replenished in time for subsequent pregnancies. This study also found that foetal DHA status of premature infants is positively related to head circumference, birth weight and birth length. The authors of this study indicate that increasing foetal DHA status could promote foetal growth, which improves the chances of survival of premature infants. Increasing EFA intake during pregnancy may benefit both mother and child.

Al and colleagues from Maastricht University in the Netherlands have also found that DHA status falls with each subsequent pregnancy, potentially resulting in less DHA being available to the foetus. It seems that the DHA required during pregnancy is obtained from the mother's stores, which take a long period of time to replenish. If the mother breastfeeds, this replenishment is likely to take longer.

It is important to ensure adequate amounts of omega-3 fatty acids during pregnancy and lactation, to facilitate replenishment of maternal DHA stores. The following fish species are good sources of DHA.

Amounts (mg) of omega-3 oils in 100g of some popular Australian fish

Fish	Amount (mg) of omega-3 oils in 100g
Blue eye	228
Gemfish	302
Silver warehou	238
Pilchard	238

Foreman-van Drongelen et al , in a study on 52 preterm infants, found a significant relation (p</= 0.05) between weight, head circumference, and length at birth and long-chain polyunsaturated levels (both omega-3 and omega-6) in the umbilical artery wall. Long-chain polyunsaturated fat content of the umbilical cord reflects the long-term fetal fatty acid status. Postnatal diet significantly influenced DHA and arachidonic acid levels in plasma phospholipids of infants, formula-fed infants having lower values than breastfed infants. Both the postnatal diet and the long-chain polyunsaturated fatty acid status at birth significantly affect long-chain fatty acid levels in infants. It seems that fatty acid-enriched maternal diets during pregnancy have an important influence on neonatal long-chain polyunsaturated fatty acid status at birth.

Odent et al recently evaluated the effects of prenatal nutritional counselling about the benefits of increased dietary intake of seafish. This study involved giving 499 pregnant women (before 20 weeks gestation) a 20-min nutritional advice session where they were encouraged to increase oily sea fish intake and reduce intake of foods rich in trans-fatty acid. Mean birth weight was slightly higher in the study group (3349 g vs. 3284 g). The rate of premature delivery (before 37 weeks) was lower in the study group (7.3% versus 9.5%). Mean neonatal head circumference was greater in the study group (34.7 cm vs. 34.4 cm). This is further evidence that fish consumption is an important part of the diet for pregnant women.

Key points
DHA status is important in optimal neural development in infants
DHA is especially important in the third trimester of pregnancy because of the rapid development of brain and eye tissue.
The foetus only has a limited ability to manufacture its own DHA
The foetus therefore needs to obtain DHA from the mother via the placenta
DHA status in the mother decreases over the course of a pregnancy, and even six months after childbirth these levels are still depressed.
Birth weight, head circumference and length are related to long-chain polyunsaturated fat status at birth
Maternal diet can influence DHA status of the foetus and newborn infants
Omega-3 oil intake becomes more important with each subsequent pregnancy

Al MDM et al. Relation between birth order and the maternal and neonatal docosahexaenoic acid status. Eur J Clin Nutr 1997;51:548-553.

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39. Subject Index

Index of topics covered by research summaries.

BENEFITS

There are a number of anecdotal observations by fish retailers indicating that **health issues sell fish**. The most notable occurrences recently have been the media coverage of an FRDC-funded study on the relationship between fish consumption and asthma, and the launch of the CSIRO publication "Seafood the good food". Both events coincided with an unseasonal increase in fish sales at the Sydney Fish Markets of about 10%.

This report provides a basis upon which a range of programs to promote the health benefits of seafood can be based, to enable the industry to utilise the marketing power of health issues in an organised manner. Extension from material produced from this project have already occurred in the form of State-based fish promotion strategies, the development of an industry training program based on the health benefits of seafood, input into the revision of the Seafood Caterers Manual, communication of health benefits at national industry conferences and the production of a pamphlet outlining health benefits for marketers of fish.

This project has identified a number of areas of nutrition research (eg. Infant development, maternal health, coronary heart disease prevention, diabetes, obesity, rheumatoid arthritis, food composition) where fish promotion can have an impact. Like all scientific research, there are questions in these areas which remain unanswered, and the resolution of such questions could assist in the further promotion of fish as a healthy food.

FURTHER DEVELOPMENT

An important step in the effective and sustained (long-term) promotion of fresh fish requires a global planning mechanism for nutrition promotion, which considers the nutrition situation in Australia in its broadest context. A key outcome of this report is the identification of a comprehensive set of nutrition issues upon which such a planning mechanism can be based. At an operational level, collaboration between marketing and nutrition specialists to act on the issues raised in this report is essential, to target specific groups of consumers.

For example, there are many opportunities for fish to contribute to the health and well-being of mothers and infants in Australia. However, further specific research on the nutritional status and dietary habits of Australians is required so that fish-related nutrition messages can be targeted to appropriate groups. Early introduction of foods to infants is the best way to encourage consumption over the entire lifespan, a clear marketing opportunity.

Nutrition communication operates at numerous levels, spanning from fundamental nutrition research, scientific consensus and conference participation, health professional awareness, fish marketing programs and public education activities. Promotion of the health benefits of seafood requires sustained investment across all levels. A coordinated approach to nutrition/health research and communication represents a cost-effective solution to gain the maximum return for the fishing industry.

Much of this report refers to health issues related to the oil composition of fish. Previous FRDC-funded research (FRDC Project 95/122) looking at oil contents in Australian fish species provides significant insight into the relationship between fish consumption and health in Australia. We know very little about other nutrients (vitamins, minerals, amino acids) in Australian fish species, and more extensive compositional information would provide further insight into the relationship between fish consumption and health

CONCLUSION

Seafood has an important and rightful place in the diet of Australians. There are many opportunities to communicate the benefits of seafood consumption throughout the human lifespan, in both health and illness. A background of ample scientific evidence is available to do this in a reputable and constructive manner, to contribute to both national economic and social objectives. However, significant research questions remain.

Scientific understanding of human nutrition is an evolving phenomenon requiring ongoing investment. The role of seafood in the diet of Australians is positive and presents significant scope. To extend this advantage into the future requires funding by the fishing industry for nutrition research. Such investment will yield valuable results for the industry. Many of these important research questions are likely not to be funded by any other sector.

Appendix 1: Intellectual property

This project analysed and collated information from the public domain. As such, there are no outstanding intellectual property issues.

Appendix 2: Staff

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