Fish and seafood consumption in Norway – Benefits and risks

Norwegian scientific committee for food safety, March 2006

English summary

The assignment

Fish and other seafood contain substances that have a positive effect on the public health, but they may also contain contaminants and other undesirable substances. At the request of the Norwegian Food Safety Authority, the Norwegian Scientific Committee for Food Safety (VKM) conducted an assessment of the nutritional benefits of consuming fish and other seafood compared to the health risks associated with the intake of contaminants and other undesirable substances that fish and other seafood may contain.

Under the auspices of VKM, an ad-hoc group comprised of VKM members and two outside experts has prepared this report. Several of VKM's scientific panels have reviewed the report during its preparation, and members of the head committee have given their final assessment and approval. The report has been submitted to and discussed in the National Council of Nutrition.

In this report, VKM has used Norwegian dietary data to estimate the intake of relevant nutrients and contaminants in children and adults who have consumed fish and other seafood. The various nutrients (proteins, vitamins, minerals and marine n-3 fatty acids) in fish and other seafood have been assessed with regard to their occurrence and their capacity to trigger health-promoting effects.

The potentially health damaging compounds sometimes found in fish and other seafood have been assessed with regard to their occurrence, their capacity to cause damage to health, and the levels at which they may be regarded as safe. A large number of contaminants and other undesirable substances have been assessed, including organic pollutants such as chlorinated pesticides, PCB, dioxins, brominated flame retardants and perflourinated compounds (PFOS), potentially health damaging metals and trace elements (e.g. mercury, cadmium, lead, arsenic, selenium), marine algae toxins, pharmaceutical residuals, radioactivity, infectious substances and disinfectants. VKM has also assessed farmed fish, especially the significance of feed for the amount and composition of nutrients and contaminants in fish.

VKM conducted a critical review of selected literature in preparation for its assessment of the health effects associated with fish consumption and the way in which these effects have been documented in epidemiological studies. The issue of the assumed reduced risk of cardio-vascular disease has been thoroughly addressed in a comparable risk assessment published in the UK (SACN/COT Report, 2004)), and VKM has based its assessment on the work presented in that report and has evaluated scientific studies published at a later time. VKM has also addressed the possible connection between fish consumption and cancer by conducting a separate assessment of the existing literature on epidemiology.

Background

Fish and other seafood provide us with a number of nutrients. They contain high-quality protein and are rich in vitamin D, vitamin $B_{12,}$ and the minerals iodine and selenium. Fish and other seafood are also a natural source of the marine n-3 fatty acids eicosapentaenoic acid, docosapentaenoic acid and docosahexaenoic acid. Fatty fish, and certain fatty seafood products, are the most important natural sources of the marine n-3 fatty acids and vitamin D in our diet.

A large body of documentation shows that, in general, consuming fish is beneficial to one's health, and there is solid evidence that consuming fatty fish in particular slows the development of, as well as prevents, cardio-vascular disease. Consumption of fish and other seafood is also important for foetal development, including for the foetus' growth and neurological development. It is believed that the marine n-3 fatty acids play an especially important role in the health-promoting effects of fish.

Balanced against the beneficial effects of high fish consumption, documentation also shows that high consumption of certain fish species may be associated with a relatively high intake of contaminants and other potentially health damaging substances. The potentially highest risk for contaminants and other undesirable substances in fish and other seafood is posed by dioxins and dioxin-like PCB and by methyl mercury. These contaminants may trigger various harmful health effects, and the most sensitive life stage is foetal development. Fatty fish appears to be the most important source of dioxins and dioxin-like PCB in adults. The highest mercury levels are found in large freshwater fish, such as large pike, and in predatory fish, such large halibut.

A health-based risk-benefit assessment, in which the health benefits of some substances in a food group are weighted quantitatively against the health hazards of other substances in the same food group, is a highly complex task to perform. To date there is no widely accepted method that can be used to conduct a quantitative risk-benefit assessment. It is the composition of the overall diet, genetic makeup, and other lifestyle factors that are most important for a person's health. Moreover, it is important to note that a food group is not homogeneous in terms of nutrients or contaminants. The type of fish or seafood, season, feed, life stage (developmental or reproductive stage) and age affect the amount of nutrients and contaminants within a single species and between species. It is the respective amounts of nutrients and foreign substances consumed by a person over time that determines the extent to which a food group will bring about positive or negative effects.

A safety margin is included in the recommended intake levels for nutrients which makes provisions for individual variations in the nutritional requirements of healthy individuals in the population and includes a margin to cover a possible non-specific increase in requirements. The safety margin is dependent on individual differences, variations in the body's storage capacity, utilisation of food, negative effects of high intake, and how precisely the minimum requirements can be determined. In recent years "tolerable upper intake levels" (ULs) have been established for most nutrients. The upper intake levels are levels a person can ingest without risking undesirable health effects of importance. There can thus be a risk related to a high as well as a low intake of nutrients. A risk-benefit assessment of nutrients in fish and other seafood consists of comparing recommended intake and established upper safe intake levels with national intake estimates for the population in general and for sensitive

groups in particular.

The safe intake levels of contaminants and undesirable substances in food are often determined internationally and stated in terms of tolerable daily or weekly intake (TDI/TWI). The tolerable intake values are intended to give a high level of protection and are often derived from the toxicological effects that are triggered at the lowest exposure dosage (e.g. TWI for dioxins and methyl mercury established to protect the foetus since it is most sensitive to these substances). The tolerable limit for weekly intake of dioxins is set so that a woman will not accumulate so much dioxin in her body that the foetus will not be put at risk should she become pregnant in the future. It is the total amount of dioxin accumulated over time that is significant. Tolerable intake values are thus established so that the most sensitive individuals/population groups are protected. This implies that other individuals/population groups are less sensitive and likely can tolerate exceeding the TWI with only a minimal risk to their health. The tolerable intake values are not a threshold for toxicity, and it is difficult to quantify the risk of exceeding tolerable intake. Due to the integrated safety margins and the conservative way in which the tolerable intake values are derived, exceeding the tolerable intake values will initially only represent a reduced safety margin. A toxicological risk assessment of substances such as dioxins and dioxin-like PCB in fish and other seafood consists of comparing the tolerable intake values with national intake estimates for the population in general and/or for sensitive groups in particular.

Results and discussion

Consumption of fish and other seafood in the Norwegian diet

The consumption of fish and other seafood in Norway is different from many other countries in that consumption is high, the proportion of lean fish consumed is large, and the population eats more fish in the form of cold cuts and spreads since several meals per day consist of open-faced sandwiches. Median fish consumption is approximately 65 grams per day for an adult (equivalent to approximately two meals of fish per week), and the median consumption for children varies from 6 to 19 grams per day. Two-thirds of this consumption consists of lean fish and fish farce. Although most adults eat some fish or other seafood, a large number of children and teenagers do not eat fish or other seafood. In some age groups approximately half do not do so. Young women eat less fish than the population in general. Fertile women eat fatty fish equivalent to less than 1/2 meal per week.

Nutrients in fish and other seafood

It is unlikely that fish consumption in Norway could lead to a harmfully high intake of vitamins and minerals or marine n-3 fatty acids for any age group. Therefore, interest is focused on the consequences of low intake, especially the consequences of not eating fish at all and of low consumption of fatty fish. Estimates show that even an average fish consumption equivalent to two meals per week (2/3 lean and 1/3 fatty fish) only provides approximately 25% of the recommended D vitamin intake. To meet the vitamin D requirements, dietary supplements and/or exposure to sunlight is necessary. A low intake of fish also leads to a low intake of marine n-3 fatty acids, which in turn results in the person missing out on the recognised health-promoting effects of these nutrients. In practice, low intake must be compensated for by taking a dietary supplement to achieve the same beneficial effects. It is possible to have a diet that meets most of the established nutritional requirements without eating fish, or eating only a limited amount of fish. However, it is difficult to meet the

recommended intake of vitamin D and n-3 fatty acids without resorting to dietary supplements.

Based on ***an assessment of nutrient intake***, especially the marine n-3 fatty acids and vitamin D, VKM believes that an increase in the consumption of fatty fish is advisable, especially for those who eat a limited amount of fatty fish and for that half of the population which eats the least amount of fish. n-3 fatty acids have a positive effect on cardio-vascular disease as well as on the length of pregnancy and foetal development. Adequate levels of vitamin D are also important for the health of the population. The general recommendation to consume a varied diet also applies to fish; different types of fish should be eaten. Based on an assessment of nutrient intake, there is no danger associated with eating fish and other seafood equivalent to four meals or more per week.

Contaminants and other undesirable substances, including infectious substances, in fish and other seafood

The amount of manmade radionuclides in Norwegian fish and other seafood is quite low, and VKM considers their significance for public health to be extremely limited. Pharmaceuticals used in aquaculture are thoroughly assessed with food safety in mind, and national monitoring programmes have not found illegal residuals of pharmaceuticals in Norwegian fish farmed for consumption. It is important to keep the use of antibiotics in aquaculture to an absolute minimum to prevent the development and spread of resistance to antibiotics. This also holds true for more recent types of production, such as cod farming. Algae toxins are largely a problem in shellfish. Due to the continual monitoring of algae content in the shellfish that is sold, VKM does not regard algae toxins in shellfish to be a problem.

Listeria monocytogenes pose the greatest ***risk from infectious substances*** since these bacteria can contaminate fish products, such as smoked salmon, during their production and pose a special danger to pregnant women. Also, homemade *rakefisk*, partially fermented trout, presents a risk of botulism.

In a study of a large number of contaminants, VKM has found that mercury, dioxins and dioxin-like PCB are the main substances that constitute a potential risk when consuming fish and other seafood in Norway.

On the other hand, estimates show that even for those who eat a large amount of fish, the mercury levels fall well below the tolerable intake value. In Norway, however, some lakes contain large predatory fish with very high mercury levels. Some individuals who consume large amounts of these types of fish may exceed TWI. Certain instances of localised marine mercury pollution have also resulted in high mercury levels in fish, and persons who consume large amounts of contaminated fish such as these may also exceed TWI for mercury.

It is important to note that TWI for mercury has been set to protect the most sensitive life stage, which is the child in the womb. Women who are pregnant or who will become pregnant are therefore the most vulnerable group. Special dietary recommendations related to mercury have been established for pregnant women. People in other life stages are assumed to be less sensitive, although increased exposure to mercury appears to increase the risk of cardio-vascular disease in vulnerable population groups. This effect is not yet quantifiable.

As regards dioxins and dioxin-like PCB, estimates (scenarios) show that adults who consume large amounts of fatty fish (equivalent to more than four meals of fatty fish per week) could

exceed TWI for this substance group due to the consumption of fish and other seafood alone. An additional amount of these substances will also come from other foods and any cod liver oil consumed. However, according to dietary studies, this would be an unusually high consumption of fatty fish. Dietary studies show that for at least 85% of the adult population, the intake of dioxins and dioxin-like PCB from the entire diet, including fish and other seafood, will fall below TWI. Estimates for children show that TWI is exceeded in two to four-year olds who consume large amounts of fish and other seafood, in addition to taking cod liver oil. For most children, however, other foods such as meat, dairy products and eggs are more important sources of dioxins and PCB than fish and other seafood.

Cod liver, cod roe pate and brown crab meat have the highest concentrations of dioxins and dioxin-like PCB, and persons who consume large amounts of these foods may also significantly exceed TWI. This means that there may be individuals, groups of individuals and certain age groups with an especially high consumption of fish and other seafood that have a reduced safety margin for tolerable weekly intake. Nonetheless, it is consumption over time that is important.

TWI has been established to protect the most sensitive life stage, which is the foetal stage in terms of risk from dioxins. However, dioxins and dioxin-like PCB have such a long half-life in the body that the body burden during pregnancy is not a result of the diet during pregnancy but of the diet during the many years prior to pregnancy. Women who are pregnant or who will become pregnant, and the foetus, are therefore the most vulnerable group. It is the total accumulated amount of dioxins and dioxin-like PCB ingested throughout life and throughout the fertile period that is of significance. Women who are no longer fertile and men are believed to be less sensitive to exposure to dioxins.

At the intake amounts which are possible through diet, VKM does not consider that dioxins and dioxin-like PCB pose a risk of cancer. Nor does VKM consider that PCB presents a risk of neurotoxic effects since the PCB levels in the blood of fertile women fall well below the level where instances of long-term neurotoxic effects have been seen.

In general, from ***a toxicological perspective***, there is no danger associated with eating fish and other seafood equivalent to 4 meals or more per week when consumption is varied and the fatty fish, at the current level of dioxins and dioxin-like PCB, does not exceed two meals per week. This is especially important in regard to fertile women. However, the equivalent of over two meals of fatty fish per week must be consumed starting in childhood and continue throughout the entire fertile period in order for a woman to accumulate and exceed the level of dioxins and dioxin-like PCB in the body that TWI is intended to protect against. Dietary studies show, however, that pregnant women on average consume fatty fish only equivalent to less than 1/2 meal per week. Even those with high fish consumption (95th percentile) do not eat more than 1-1/2 meals of fatty fish per week.

Comprehensive view of fish and other seafood in the Norwegian diet

Based on our review of the literature, VKM finds that from a public health standpoint, the consumption of fish, lean or fatty, has a positive effect on health. Even though today there is no widely accepted method of conducting a quantitative risk-benefit comparison, ***an integration of the nutritional and toxicological assessments*** will clearly show that Norwegians in general should eat more fish and that fish consumption should include both lean and fatty fish. This is particularly true for those who eat very little fish. These estimates are based on the current median fish consumption in Norway, which equals approximately

two meals of fish per week with a proportion of lean to fatty fish of 2:1. It is also evident that the adult population, especially the group at greatest risk of developing cardio-vascular disease, will gain the greatest health-related benefits from increasing their consumption of fatty fish in particular. The next group to benefit is pregnant women due to the potentially beneficial effects on foetal development, including the development of brain functions. The consumption of fish and other seafood has not been shown to increase or reduce the risk of any common form of cancer.

We do not know with certainty how high fish consumption must be to take full advantage of the health-related benefits. There is reason to believe that further gains from increasing fish consumption will diminish and become less for the segment of the population that already has a high consumption. It is uncertain whether those who already consume large amounts of fish will reap further health benefits by eating even more fish.

If any factor should place a limit on fish consumption, it would be the amount of dioxins and dioxin-like PCB in fatty fish. At current levels of dioxins and dioxin-like PCB, a consumption of fatty fish equivalent to more than two meals per week will lead over time to the tolerable intake level being exceeded. As mentioned above, the tolerable intake level is intended to prevent an accumulation of a high level of these substances in women's bodies before and during pregnancy. It is worth noting that consumption must have been in this range throughout the entire fertile period in order to exceed the accumulated amount of dioxins and dioxin-like PCB in the body that the tolerable intake level intends to protect against. At today's consumption rate of fatty fish, it is unlikely that a general recommendation calling for increased consumption of fish will result in young women exceeding a consumption rate equivalent to two meals of fatty fish or more per week over time. Once again we wish to point out that the tolerable intake level represents a safety level, not a limit for when health damaging effects will necessarily occur, although the desirable safety level will be reduced. Even if the safety level is moderately exceeded, the risk will likely be small. There are no population studies that can quantitatively show this with certainty since the anticipated effects are small.

Restrictions on and prohibitions against the use and discharge of PCB and dioxins have resulted in a significant decline in the levels of these organic pollutants. Due to the slow decomposition rate, these undesirable contaminants, especially in wild fatty fish and other seafood with high fat content, will nonetheless constitute a potential health risk for many years to come. A continued reduction in the levels of these substances is therefore advisable.

Farmed fish is one source of exposure to dioxins and dioxin-like PCB that currently can be influenced within a reasonable time frame without reducing fish consumption. This may be achieved by selecting feed ingredients with naturally low levels of organic pollutants or by using purifying processes. Fish and other seafood should contain the lowest possible levels of contaminants and other undesirable substances so that the safety margin for the entire consumption level of fatty fish can be held high enough to reap the health benefits. If marine fat is replaced by vegetable fat, the levels of dioxins and dioxin-like PCB can be reduced, but the nutritional benefits will change as well.

Two to four-year olds who eat fish and take cod liver oil may exceed TWI when the entire diet is taken into account. For the average child, however, other foods such as meat, dairy products and eggs are a greater source of dioxins and dioxin-like PCB than fish and other seafood. This is because many children and young people do not eat fish or eat very little fish.

Cod liver oil is a very important source of vitamin D and marine n-3 fatty acids for children, but in the amounts given to small children, the levels of dioxins and dioxin-like PCB are also relatively high. In infants, purified cod liver oil alone can constitute up to 50% of TWI for these compounds. It is therefore important that the levels of dioxins and PCB in cod liver oil/dietary supplements remain as low as possible.

The nutrient composition, including the composition of fatty acids, in farmed salmon, trout, cod and halibut will vary according to the raw materials and components found in fish feed. It is important that both the nutrient composition and the contaminant level in feed and fish be monitored closely.

Conclusion

Consumption of fatty fish in particular provides important nutrients such as vitamin D and marine n-3 fatty acids. The consumption of fish in general and marine n-3 fatty acids is important for preventing and impeding the development of cardio-vascular disease. Marine n-3 fatty acids are important for pregnancy and foetal development as well.

The general Norwegian recommendation is to eat more fish both for dinner and on bread. Based on a comprehensive assessment of scientific documentation of the positive health benefits and presence of potentially health damaging substances, as well as on knowledge about fish and other seafood in the Norwegian diet, VKM supports this recommendation. This recommendation applies especially to those who currently do not eat fish or those who eat very little fish. Except for persons with allergies to fish and those with certain metabolic diseases, there are no other health-related circumstances indicating that fish should not be eaten. Persons who eat more than two meals of fatty fish per week over a long period of time may moderately exceed the tolerable intake (TWI) for dioxins and dioxin-like PCB, but this would initially only represent a reduced safety margin. Fertile women are particularly vulnerable, but based on knowledge about young women's consumption of fatty fish, there is little reason to believe that a general recommendation to increase fish consumption would result in fertile women consuming so much fatty fish that the intake of dioxins and dioxin-like PCB over a long period would exceed the tolerable intake (TWI) and consequently constitute a health risk for the foetus. Children may exceed TWI due to intake through their diet, but for most children (2-13 years) foods other than fish are the dominant source of these substances.

A continued reduction in the level of potentially health damaging substances in fish and other seafood is advisable. Only after an extended period of time will restrictions on the discharge of contaminants have an effect on fish caught in the wild and other seafood. Levels of organic pollutants such as dioxins and dioxin-like PCB in farmed fish and cod liver oil, however, may be influenced within a reasonable time frame.