Commentary

SEAFOOD FROM NORWAY – FOOD SAFETY

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Abstract. . Norway is a major supplier of seafood worldwide and this commentary gives a brief overview of the food safety of these products. Having this position, controlling food safety is a priority. To obtain this, several preventative measures during harvest/catch, processing and distribution are established and implemented. Furthermore, comprehensive monitoring programs to detect and quantify undesirable substances, such as heavy metals and PCBs are carried out. Substances with health benefits are also analysed, such as omega 3-fatty acids. In general, the level of undesirable substances in seafood from Norway is low. In fact, the majority of samples analysed were below the maximum limit of undesirable substances as set by the EU. This leads to the conclusion that consumption of seafood originating from Norway involves a low risk of negative health effects and that consumers can have confidence in the products they purchase.

Keywords: Seafood, food safety, Norway, Norwegian practice

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1 Introduction

The fisheries and aquaculture industry is one of Norway's most important industries with respect to value and volume. In fact, Norway is the world's second largest exporter of seafood, and EU is the most important market (www.Government.no). About 90% of the seafood is exported to more than 140 countries worldwide representing a consumption of approximately 31 million meals daily. In 2015, Norway exported Atlantic salmon and trout for 5.21 billion Euros and the aquaculture industry is one of the foremost export industries of Norway (www.seafood.no). This industry represents a vital settlement and activities along our long coast line. Among the farmed species, salmon and trout are the key species, but other species such as Atlantic cod, Atlantic halibut and Arctic charr are also farmed (Le Francois, Jobling, Carter & Blier, 2010; Sæther, Siikavuopio & Jobling, 2016). In 2014, the volume of Atlantic cod, Atlantic halibut, Turbot and Arctic charr was 1 386, 1 257 and.69 030 tonnes, respectively (www.SSB.no).

From time to time, food safety issues related to seafood are in focus. This can be a result of consumer's experience of seafood meals, or thorough analyses of seafood products. However, such focus can also be a result of conflicts between countries. In 2011, three Norwegian producers of Atlantic salmon were banned from the Russian market on accusations of the pathogen *Listeria monocytogenes* being present in their products. This was followed up by additional sampling of the salmon by authorities from both countries resulting in cancellation of the ban (NFSA, 2011).

Regardless of reason for questioning food safety, buyers of seafood must have confidence in the seafood products they purchase and consume. In Norway, organizations dedicated to seafood safety have created a meticulous surveillance program ensuring food safety of the seafood including feed ingredients used in farming. This program includes both wild caught and farmed fish. The role of the organizations with respect to food safety will be described in this paper.

Risks associated with ingesting seafood includes microbes, (i.e. pathogens), toxins, (i.e. algal toxins), and chemical contaminants (i.e. lead, mercury, cadmium or PCBs). However, consumption of seafood also represents health benefits with respect to nutritional value, where the ones most known are omega-3 fatty acids, vitamin D and minerals (i.e. iodide and selenium). The beneficial effects of omega-3 fatty acids on cardiac organs have been extensively studied and they continue to show promising effects in prevention of cardiovascular disease (Soumia, Sandeep & Jubbin, 2013). Benefits associated with Omega-3 are obtained by consumption of fatty fish species like Atlantic salmon, trout or herring. It is important to emphasize that most of the risks and benefits described here are not limited to seafood only, but they are more prominent in seafood compared to other food products.

The aim of this paper is to give a brief presentation of food safety aspects of seafood originating from Norway.

2 Controlling food safety

The Norwegian Food Safety Authority (NFSA) is the official national supervision and monitoring body for food safety, health and welfare of fish. NFSA implements means with respect to food safety on behalf of the Ministry of Trade, Industry and Fisheries (MTIF)). MTIF is the secretariat to the Minister of Fisheries and exercises its administrative authority through adoption, implementation of legislations and regulations. The National Institute of Nutrition and Seafood Research (NIFES) controls seafood with respect to undesirable substances such as veterinary medicals and environmental toxins. In addition, health beneficial substances such as omega-3 fatty acids and vitamin D are also analysed by NIFES. The results of all analysis are available in published reports and internet sites (www.NIFES.no). NIFES controls the seafood safety on behalf of NFSA.

In addition to these organizations, a Norwegian Scientific Committee for Food Safety (VKM) carries out independent risk assessments for the NFSA. Topics for their risk assessment includes environmental risk assessments of GMOs, foreign species and microorganisms. Incidences of food borne illnesses are reported to the Norwegian Institute of Public Health (NIPH) on a regular basis. The results are available at NIPH's homepages (www.MSIS.no). In EU, a rapid alert system for food and feed (RASFF) enables information about food safety to be shared between its members. The members are EU-28 national food safety authorities, Commission, EFSA, ESA including food safety authorities of Liechtenstein, Iceland, Switzerland and Norway. In case of food safety issues, information exchanged through this system can lead to recall of products from the market.

3 Wild fish

Baseline studies of relevant contaminants in wild fish are carried out on a regular basis. Wild fish includes mackerel, Norwegian spring-spawning herring, North Sea herring, Greenland halibut, Atlantic cod and saithe. Based on the results obtained, a follow-up plan is made for each species that ensures any changes in levels of undesirable substances to be discovered. The sampling plan is adjusted according to previous results, volume and position of harvesting. In case of saithe, analyses of undesirable substances are carried out for fish harvested in the North Sea, the Norwegian Sea and the Barents Sea. Table 1 shows the level of arsenic, mercury, cadmium and lead in muscle and liver, respectively, for saithe from the North Sea. Fillets of saithe have found to have low levels of undesirable substances, while the level of cadmium in the liver was above the maximum level (EU Directive 1881/2006). Saithe caught in the Norwegian Sea and the North Sea had higher levels of undesirable substances compared to saithe caught in the Barents Sea.

4 Crustaceans

Analyses indicate that foods with the highest levels of cadmium contamination are shellfish and the kidneys of animals such as pigs (Bendell, 2010; Jarup, Berglund, Elinder, Nordberg & Vather, 1998). In Norway, the level of cadmium in edible crab, *Cancer pagurus* has recently been monitored along the coast of northern Norway (Frantzen, Duinker & Maage, 2015). According to Council Directive 1881/2006, the maximum level of cadmium in samples of crustacean is 0.5 mg/kg ww. The level of cadmium in the meat from edible crab varied in the range of 0.13 to 1.50 mg/kg meat. This study revealed that the average level of cadmium exceeded the maximum limit in 11 samplings of 20.

Snow crab (*Chionoecetes opilio*) and king crab (*Paralithodes camtschaticus*) are high-priced commercial species that are mainly consumed in high-end markets in Korea, Japan and USA (Anderson, Martinez-Garmendia, & King, 2003; Lorentzen, Vorre Skuland, Sone, Johansen & Rotabakk, 2014; Lorentzen, Rotabakk, Olsen, Vorre Skuland & Siikavuopio, 2016).

Meat from snow crab and king crab has been analysed with respect to undesirable substances (Table 2). The snow crabs were collected from the Loophole in the Barents Sea in April 2015, while the king crabs were caught in the Varanger fjord in Northern Norway during November 2012. Before the sampling and killing, the snow crabs were starved for 4 weeks, while the king crabs were killed immediately after harvest. The meat of snow crab includes protein, water, ash (including carbohydrates) and oil with a distribution of 18.3, 79.6, 1.6 and <0.5%, respectively, while the corresponding values for king crab meat are 18.0, 78.3, 3.2 and <0.5%. For both species, the level of cadmium and mercury in the meat was below the maximum limit set by EU (Council Directive 1881/2006). Inorganic arsenic is more toxic than organic arsenic (Raber et al., 2012), therefore levels of both organic and inorganic arsenic was determined and found to be below the set maximum levels. At present, no maximum limits is set by the EU for total arsen, inorganic arsen or manganese. However, based of the results from this study, it is concluded that meat from snow and king crab is safe to eat.

In a study performed by the group of Julshamn (2015), claw and leg meat of king crab were analysed for dioxins, furans, non-ortho and mono ortho PCBs, non-dioxin like PCBs, polybrominated diphenyl ethers, arsenic, cadmium, mercury and lead. From April to November 2012, the king crab were collected from different areas of the Barents Sea, including the Varanger fjord. The concentrations of persistent organic pollutants and metals in the king crab meat were low and below the maximum limits laid down by the EC regulation (Council Directive 1881/2006) and the group of Julshamn (2015) concluded that red king crab is safe to eat.

5 Farmed fish

Food safety of farmed fish has received increased attention in recent years, especially with respect to environmental contaminants. The fish is farmed in net cages that are sited in sheltered bays along the coast line. In case of Atlantic salmon, it takes about 15-18 months from smolt stage until the fish has obtained a weight of approximately 4-5 kg.

Farmed fish are controlled frequently with respect to undesirable substances (Council Directive 96/23). For every 100 tonnes of farmed fish produced, at least one fish is analysed. NFSA performs sampling on a regular basis from the slaughterhouses and processing facilities. All these samples are analysed by NIFES. In the last years, about 12,000 farmed fish have been analysed annually. Table 3 shows level of some undesirable substances such as arsenic, cadmium, mercury, lead and tributyltin in fillets of farmed fish; Atlantic salmon, rainbow trout and Atlantic cod. Tributyltin includes a class of organic compounds and it was used as an ingredient in anti-fouling paint to the hulls of boats.

The general trend for most contaminants analysed show that the levels of undesired substances in farmed salmon are significantly declining, reflecting the shift from fish based to more vegetable based raw materials in the feed. For example, the levels of dioxins have decreased from 1.4 ng TEQ/kg ww to 0.5 ng from 2002 to 2013. TEQ refers to toxic equivalents of mixtures of PCDDs, PCDFs and PCBs and it is used for risk characterization. Since 2005, when the metals were included in the monitoring program, the level of mercury and arsenic declined from 0.037 to 0.014 mg/kg ww, and from 2.0 to 0.55 mg/kg ww, respectively.

Occasionally, medicals were used in fish farming. The use of antibiotics in Norwegian fish farming is low, in fact less than 1 mg/kg farmed fish. About 0.5 to 1.0% of farmed fish has been treated with antibiotics (www.fhi.no). The Norwegian legislation concerning residues of medicals in the fish is similar to the EU legislation. Fish treated with medicals are held in quarantine (withdrawal time) to make sure that the levels of residuals are below maximum limits. The fish farmer and the veterinarian are responsible for keeping the withdrawal time. The withdrawal time depends on medical applied, size of the fish and water temperature. In case medicals are used, this is reported to NFSA.

From time to time, a parasitic nematode *Anisakis* is present in wild caught fish. Anisakis are infective to humans as they can cause anisakiasis. Fish products that are intended to be consumed as raw, are kept at -24 ^{0}C in minimum 24 hours to kill the parasite. To our knowledge, anisakis has not been detected in farmed salmon. The most apparent explanation of this is that the fish feeds on dry feed, which is unlikely to contain parasites. Based on these facts, the NFSA consider it safe to consume raw farmed salmon, such as sushi and sashimi, without any freezing in advance.

The prevalence of the pathogen *Listeria monocytogenes* in raw and ready to eat seafood and fish products, especially smoked fish can be up to 25% (Farber, 1991) and salmon is one of several potential sources for the pathogen. Previously, presence of *L. monocytogenes* have been studied in three Norwegian companies processing salmon (Lunestad, Truong & Lindstedt, 2013). In this study, 15 types of *L. monocytogenes* were detected. Among these, 9 strains belonged to a genetic variant similar to those found in patients with listeriosis. To our knowledge, no cases of listeriosis has been linked to consumption of salmon. The limited numbers of listeriosis might be due to levels below the infective dose of 100 CFU/g (or ml) which is insufficient to cause illness in most healthy consumers. This assumption is supported by the fact that this pathogen have been isolated from 1-6% of faecal samples from healthy people (Ooi & Lorber, 2005; Rocourt & Cossart, 1997).

6 Fish feed

Food safety issues of farmed fish have predominantly been related to fish feed. Thus, considerable resources have been allocated to control fish feed frequently. In 2014, a total of 126 samples were analysed with respect to PCB including 78 feeds, 10 fish meals, 10 plant proteins, 12 plant oils and 7 fish oils (Table 4). The NFSA is notified in case of non-compliant results. With the exception of one non-compliant complete feed containing the pesticide hexachlorobenzene (HCB), the results for 2014 showed that all samples of feed and feed ingredients was compliant with regard to the maximum levels of heavy metals and organic contaminants. One of the feed samples exceeded the maximum limit with respect to cobalt, copper, manganese, iodine and zinc, while several of the feed samples exceeded the maximum limit with respect to vitamin B3 and selenium, .

7 Conclusion

Overall, consumption of seafood from Norway involves a low risk of negative health effects. This is suggested to be due to a thorough knowledge about food safety risks, a comprehensive monitoring program for seafood safety and a strict regime of fish farming in Norway.

The group of Utne Skåre (2015) has performed a comprehensive assessment of scientific literature on the positive health effects of seafood consumption and the contribution from fish to intake of beneficial substances as well as exposure to hazardous contaminants in Norway. They concluded that the benefits clearly outweigh the negligible risk presented by current levels of contaminants and other known undesirable substances in seafood.

Due to changes in climate, it is foreseen that more information about the effects of climate change in terms of food safety issues are required. Such information includes effects of an elevated sea temperature and increased acidification. In addition, climate change might also generate extreme weather, which is expected to have consequences for the biodiversity, aquaculture industry, maritime transport and infrastructure. In case climate changes or any other conditions will affect seafood safety, NFSA and NIFES will take this into account and adjust the monitoring program accordingly.

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9 Conflicts of interest

The authors report no conflicts of interest.

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Table 1. Concentrations of arsenic, mercury, cadmium and lead in muscle and liver of saithe from the North Sea. Mean, standard deviation (SD), median, min and max values and number of fish with concentration below the limit of quantification (LOQ) are given.

Element (mg/kg ww)	Mean[1)]	SD[1)]	Median	Min	Max	#<LOQ	EU limit[2)]
Arsenic in muscle (N=664)	2,9 [3)]	2,1	2,5	0,37	15	0	[4)]
Arsenic in liver (N=636)	6,5	4,6	5,6	0,86	41	0	
Mercury in muscle (N=664)	0,066	0,037	0,057	0,015	0,35	0	0,5
Mercury in liver (N=636)	0,020	0,019	0,015	<0,003	0,19	22	
Cadmium in muscle (N=664)	0,0016	0,0011	0,0010	<0,001	0,010	271	0,05
Cadmium in liver (N=636)	0,32	0,24	0,28	<0,004	1,8	1	
Lead in muscle (N=664)			<0,006	<0,006	0,075	637	0,3
Lead in liver (N=636)			<0,02	<0,02	0,40	590	

1) Mean and standard deviation (SD) were not determined in cases where more than 50% of fish were below the limit of quantification (LOQ).

2) Council Directive 1881/2006 of 19 December 2006. Setting maximum levels of certain contaminants in foodstuffs. Official Journal of the European Union, L 364/5, 5-24.

3) Data obtained from Nilsen et al., 2013.

4) There are no limits for arsenic in seafood in Council Directive 1881/2006 of 19 December 2006. Commission regulation 2015/1006 covers max levels of inorganic arsenic in rice products.

Table 2. Concentrations of undesirable substances in meat from snow crab and red king crab. The samples were obtained from legs from 10 crabs.

Element	Meat snow crab	Meat king crab	EU limit[1)]
Arsenic (mg/kg ww)	112.00	8.29	[2)]
Cadmium (mg/kg ww)	0.0140	0.0035	0.50
Mercury (mg/kg ww)	0.1190	0.0539	0.50
Manganese (mg/kg ww)	0.195	0.221	
Sink (mg/kg ww)	31.0	22.0	
Sum PCB (TEQ/WHO)[3)]	< 0.24	NA[4)]	
Sum PCDD/PCDF (TEQ/WHO)[2)]	< 0.36	NA	

1) Council Directive 1881/2006 of 19 December 2006. Setting maximum levels of certain contaminants in foodstuffs. Official Journal of the European Union, L 364/5, 5-24.

2) There are no limits for arsenic in seafood in Council Directive 1881/2006 of 19 December 2006. Commission regulation 2015/1006 covers max levels of inorganic arsenic in rice products.

3) Includes PCB 77, PCB 81, PCB 105, PCB 114, PCB 118, PCB 123, PCB 126, PCB 156, PCB 157, PCB 157, PCB 167, PCB 169 and PCB 189

4) NA=Not analyzed

Table 3. Concentrations (mg/kg wet weight) of arsenic, mercury, cadmium, lead and tributyltin in fillets of farmed fish.. No mean or median is given if more than 50% of the results are below the limit of quantification (LOQ).

Element		Atlantic Salmon	Rainbow trout	Atlantic Cod	Atlantic halibut	LOQ	EU limit[1)]
Arsenic (mg/kg ww)	N	105[2)]	8	2	1		[3)]
	Median	0,58	0,62	0,62			
	Max	2,1	1,0	0,63	1,6	0,003	
Cadmium (mg/kg ww)	N	105	8	2	1		
	Max	0,002	LOQ	LOQ	LOQ	0,001 0,002	0,050
Mercury (mg/kg ww)	N	105	8	2	1		
	Median	0,019	0,018	0,042			
	Max	0,059	0,035	0,043	0,069	0,002	0,50
Lead (mg/kg ww)	N	105	8	2	1		
	Max	0,026	LOQ	LOQ	LOQ	0,005-0,01	0,30
Tributyltin (ug/kg ww)	N	59	4	2	0		
	Max	0,60	LOQ			0,3-0,5	

[1)] Council Directive 1881/2006 of 19 December 2006. Setting maximum levels of certain contaminants in foodstuffs. Official Journal of the European Union, L 364/5, 5-24.

[2)] Data obtained from Hannisdal et al., 2015.

[3)] There are no limits for arsenic in seafood in Council Directive 1881/2006 of 19 December 2006. Commission regulation 2015/1006 covers max levels of inorganic arsenic in rice products.

Tabell 4. Concentration of PCB-28, PCB-52, PCB-101, PCB-138, PCB-153 and PCB-180 and sum PCB_6 in fish feed, fishmeal and fish oil for 2014. Values are given as mean value including minimum and maximum.

	PCB-28 (ug/kg)	PCB-52 (ug/kg)	PCB-101 (ug/kg)	PCB-138 (ug/kg)	PCB-153 (ug/kg)	PCB-180 (ug/kg)	Sum PCB_6 (ug/kg)
Feed (n=73)	0,3[1)]	0,5	1,0	1,5	2,5	0,7	6,5
Min-Max	0,1-0,7	0,1-0,4	0,1-3,0	0,2-5,0	0,3-8,0	0,1-2,3	0,8-20,4
Fish meal (n=10)	0,3	0,5	1,1	2,0	2,8	0,7	7,4
Min-Max	<0,04-0,6	<0,04-1,0	01-1,8-	0,1-5,0	0,1-6,0	<0,04-1,4	0,3-15,2
Fish oil (n=7)	2,5	4,6	9,5	12,7	21,6	6,5	56,0
Min-Max	<0,2-5,0	<0,2-10,0	0,6-21,0	1,0-28,0	1,5-48,0	0,8-14,0	3,8-120,0

[1)] Data are obtained from Sanden et al., 2015.