NUTRITIONAL COMPOSITION OF SELECTED WILD AND FARMED RAW FISH

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Foreword

The Norwegian Food Safety Authority and the Norwegian Directorate of Health have since 1992 had a joint food and diet surveillance system. This cooperation includes the work with the Norwegian Food Composition Database and the Norwegian Food Composition Table.

The food composition database working group was led by Rønnaug Aarflot Fagerli from the Norwegian Food Safety Authority during the project period. Other members of the group with main responsibility for this project have been Åse Borgejordet and Astrid Nordbotten from the Food Safety Authority, and Elin Bjørge Løken and Jannicke Borch Myhre from the Department of Nutrition at the University of Oslo.

This report is based on the analytical report received from the National Institute of Nutrition and Seafood Research (NIFES) in Bergen, Norway. The majority of the analytical work was conducted by NIFES' laboratory under the leadership of Kåre Julshamn with Kathrin Gjerdevik as chief technician. The samples were collected and financed by the Norwegian Food Safety Authority, Section for Fish and Seafood in Bergen, Norway.

We wish to thank all who have contributed to the work with this analytical project.

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Summary

The purpose of the present project was to supply new, representative data for the nutritional composition of seven commonly used types of unprocessed fish in the continuous work to update the Norwegian Food Composition Database.

The types of fish included in this project were wild caught mackerel *(Scomber scombrus),* Atlantic halibut *(Hippoglossus hippoglossus)* and Greenland halibut *(Reinhardtius hippoglossoides)* and farmed cod *(Gadus morhua),* halibut *(Hippoglossus hippoglossus),* trout *(Oncorhynchus mykiss)* and salmon *(Salmo salar)*. The samples were originally collected as part of a project at the Norwegian Food Control Authority's department of fish and seafood in Bergen, aiming to obtain representative data for levels of contaminants in some wild and farmed types of fish caught in the North Sea and along the Norwegian coast. As updated information about the nutritional composition of several of the same types of fish was needed for the Norwegian Food Composition Table, collaboration was established and the samples were analysed for relevant nutrients in addition to contaminants.

The sampling was organised between August 2006 and January 2008 by the Norwegian Food Safety Authority's Section for Fish and Seafood in Bergen, Norway. The majority of the analyses were conducted by the National Institute of Nutrition and Seafood Research in Bergen (NIFES), Norway. Analysis of phosphorous and folate was done by the subcontractor ALS Analytica in Oslo, Norway, whereas 25-OH D_3 was performed by the Danish Technical University (DTU). Analysis of folate was repeated by NIFES in 2009.

No large differences in nutrient content were found compared to the present values in the Norwegian Food Composition Table 2006 for the relevant fish types. The most notable finding was lower concentration of vitamin D in mackerel. Furthermore, cholesterol values were somewhat higher than earlier values for all types of fish, also compared to NIFES' own published results, www.nifes.no.

The main results from this project will be included in the Norwegian Food Composition Table on the Internet.

Norwegian summary / Norsk sammendrag

Formålet med prosjektet var å skaffe oppdatert informasjon om næringsinnholdet i noen typer ubearbeidet fisk som ledd i det kontinuerlige arbeidet med å oppdatere den norske matvaredatabasen.

Fiskeslagene som ble analysert i dette prosjektet var villfanget makrell *(Scomber scombrus)*, atlantisk kveite *(Hippoglossus hippoglossus)*og blåkveite *(Reinhardtius hippoglossoides)*, samt oppdrettsfisk av torsk (*Gadus morhua*), kveite *(Hippoglossus hippoglossus)*, ørret *(Oncorhynchus mykiss) og* laks *(Salmo salar)*. Prøvematerialet ble opprinnelig samlet inn for å overvåke innholdet av fremmedstoffer i villfanget fisk og oppdrettsfisk. Siden det var behov for oppdaterte verdier for fisk i den norske matvaredatabasen og tabellen, ble et samarbeid inngått mellom matvaredatagruppen og Mattilsynets Seksjon for fisk og sjømat i Bergen, slik at prøvematerialet også ble analysert for relevante næringsstoffer.

Prøveuttaket som ble organisert av Seksjon for fisk og sjømat i Bergen, foregikk mellom august 2006 og januar 2008 langs kysten på Vestlandet og i Nord-Norge og i havområdene utenfor. Analysearbeidet er utført av Nasjonalt institutt for ernærings- og sjømatforskning (NIFES) i Bergen, med unntak av analysene av fosfor og folat utført av ALS Analytica i Oslo og ekstra analyser av vitamin D_3 inkludert tilleggsanalyser av 25-OH D_3 som ble utført av Danmarks tekniske universitet (DTU). Analyse av folat ble senere gjentatt av NIFES i 2009.

For de fleste fiskeslagene var det ingen store avvik mellom resultatene for næringsstoffinnhold i dette analyseprosjektet og i eksisterende verdier i MVT-06. Det viktigste funnet var lavere innhold av vitamin D i makrell enn tidligere. Kolesterolverdiene var høyere for alle fisketypene, også sammenlignet med de verdiene NIFES har i sin egen sjømatdatabase, www.nifes.no.

Hovedresultatene fra analyseprosjektet vil inkluderes i den Norske matvaretabellen på Internett.

Background and purpose

The Norwegian Food Safety Authority's Section for Fish and Seafood conducts analytical projects on a regular basis to monitor contaminants in seafood. In 2006 and 2007 several types of wild and farmed fish were sampled from different areas to obtain representative data for this purpose. The samples were not processed or prepared before analysis.

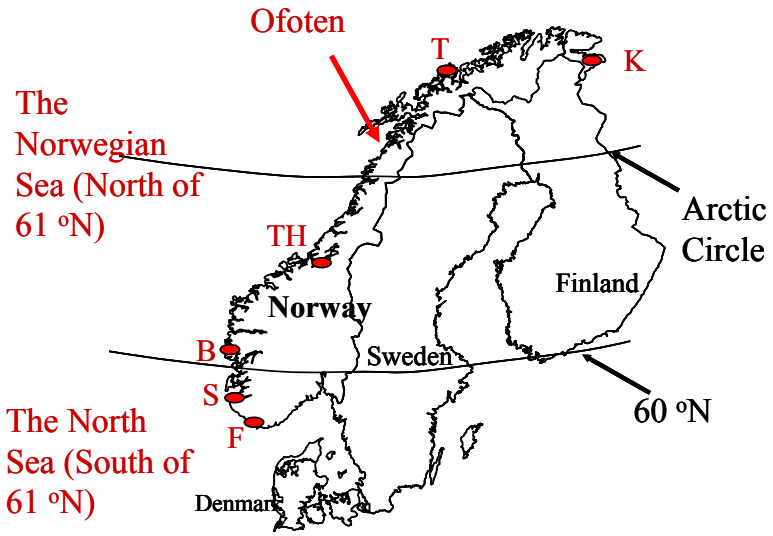
A revision of the MVT-06 edition of the Norwegian Food Composition Table (NFCT) had started and a need for updates in the fish section was evident. The current values in MVT-06 (1) were mainly from a pamphlet "Facts about Fish" (Fakta om fisk) published by the Norwegian Directorate for Fish in 1993. Unfortunately, no further reference to the origin concerning the analytical data in this pamphlet was available. Farmed salmon had been analysed for the NFCT in 1997 and 1999, whereas values for farmed halibut and cod were lacking.

A collaboration between the NFCT compiler group, and the monitoring program was established and a project with acronym P2007 was planned. The purpose of this project was to obtain new analytical data on the nutrient content of raw fish for the next NFCT edition based on fish originally sampled in a project planned for contaminant monitoring.

Materials and methods

Selection
Seven types of fish from the monitoring program were considered relevant for the P2007 project (Table 1). Four were farmed (cod, Atlantic halibut, salmon, and trout), while the remaining three were caught wild (Greenland halibut, mackerel, and Atlantic halibut larger than 30 kg). The sampling areas are shown in Figure 1 and Table 1.

Figure 1: Map of Norway.



F, Flekkefjord; S, Stavanger, B, Bergen; TH, Trondheim; T, Tromsø; K, Kirkenes

Table 1: Sample description.

Food item, raw	Norwegian name/Latin name	Position of cut for sampling	Primary samples; number	Total weight of composite sample, g	Sampling period	Sampling area
Mackerel, wild	Makrell / Scomber scombrus	Whole fillet	25	250	October 2007	The North Sea
Greenland halibut, wild	Blåkveite/ Reinhardtius hippoglossoides	Muscle B cut	50	250	August 2006	Outside the coast of Tromsø
Atlantic halibut, wild, >30 kg	Kveite / Hippoglossus hippoglossus	Muscle B cut	15	268	September and October 2007 (n=14) January 2008 (n=1)	The Norwegian Sea (Norskehavet)
Atlantic halibut, farmed	Kveite / Hippoglossus hippoglossus	Muscle B cut	7	350	February and December 2007	Seven locations; Stavanger to Trondheim
Cod, farmed	Torsk / Gadus morhua	NQC/ Muscle B cut	10	500	From May to November 2007	Ten locations; Bergen to Ofoten
Salmon, farmed	Laks / Salmo salar	NQC/ Muscle A and B cut	20	1000	December 2007 (n=6) January 2008 (n=14)	More than 16 locations; Flekkefjord to Tromsø
Trout, farmed	Regnbuørret / Oncorhynchus mykiss	NQC/ Muscle B cut	12	600	From February to November 2007	More than 8 locations; Bergen to Kirkenes

NQC, Norwegian quality cut

Sampling procedures

The sampling was organized by the Norwegian Food Safety Authority's Section for Fish and Seafood in Bergen. Samples of freshly caught fish were sent unprepared on dry ice directly from the various locations to the laboratory in Bergen where sampling region and location were recorded. The samples were collected between August 2006 and January 2008. The number of samples for each type of fish varied from seven to 50. Further details are shown in Table 1.

Position of cuts for sampling

For mackerel the whole fillet was used. Figure 2 illustrates position of cuts for sampling for halibut and Figure 3 shows position of cuts for sampling for cod, salmon and trout. B cuts were normally taken, but for trout, only one of the collected samples was a B cut while the remaining 11 samples were A cuts.

Figure 2: Position of cuts for sampling for Atlanitic halibut and Greenland halibut (2).

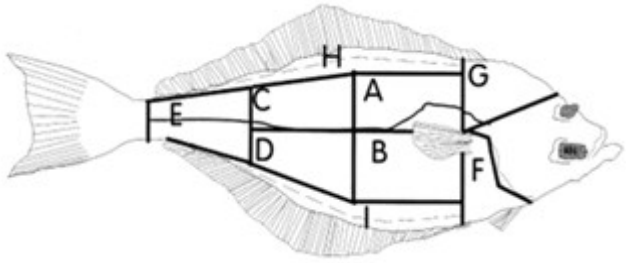
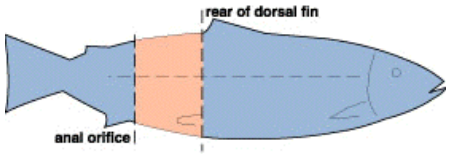
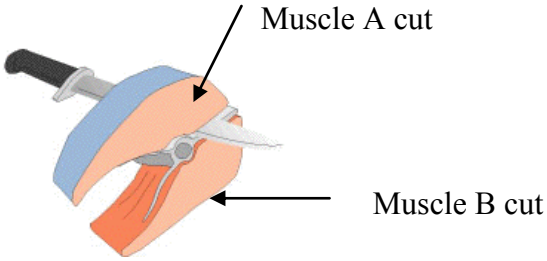


Figure 3: Position of cuts for sampling for cod, salmon and trout, Norwegian Quality Cut (3).





Sample handling
The samples were prepared, homogenized and frozen at NIFES soon after collection. When all primary samples were finally collected, one composite sample was prepared for each type of fish from equal amounts of all the primary samples. Total weights of each of the composite samples are shown in Table 1.

Each composite sample was given a unique ID-number and homogenized with a Braun food processor. Once homogenized, the samples were transferred to nunc cups containing 10 g each and stored at -80 °C. Laboratory samples were sent frozen to the relevant laboratories at NIFES. The samples intended for analysis of folate and phosphorous were packed on dry ice and sent to the subcontractor ALS Analytica in Oslo, Norway.

Most of the composite samples were prepared in week 2, 2008. A first composite sample of Greenland halibut (n=14) was prepared in week 32 and the sample of mackerel (n= 25) was prepared in week 42 in 2007. The final composite sample of Greenland halibut (n=15) was prepared in week 1, 2008.
As a follow up of the first analysis, the homogenized and frozen samples of six of the seven fish types were in week 45, 2008 sent to the Danish Technical University (DTU) for analysis of vitamin D metabolites. Mackerel was not included as not enough sample material remained from the main analytical project.

Analysed nutrients and methods
All composite samples were analysed for water, protein (i.e. as nitrogen), fat, fatty acids, cholesterol, ash, retinol, vitamin D_3, vitamin E, vitamin K, thiamine, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, calcium, iron, sodium, potassium, magnesium, zinc, selenium, copper, phosphorous, and iodine. Carbohydrates, alcohol, trans fatty acids, vitamin C, and β-carotene were assumed not to be present and therefore not analysed.

Analysis of 25-OH D_3 and vitamin D_3 was added to the project in a follow-up study at the Danish Technical University (DTU) as the method used by NIFES could not determine 25-OH D_3.

Because the folate values delivered from the subcontractor were unrealistically high compared to values from other tables and databases, six of the seven types of fish were reanalysed by NIFES.

All the concentrations given in this report are presented as µg, mg or g per 100 gram of raw fish (edible portion).

Principles of the analytical methods are given in Table 2, while a short description of the methods is presented in Appendix 1.

Table 2: Analysed nutrients, principles of analysis, and LOQ for the analytical methods.

Nutrient	**Principle of analysis**	**Accredited**	**LOQ (unit/100 g)**
Water	Gravimetric	Yes	0.1 g
Protein (i.e. as nitrogen)	Combustion method, Leco	Yes	1.9 g
Ash	Gravimetric	Yes	0.1 g
Total fat	Acid hydrolysis	Yes	0.3 g
Fatty acids: SFA, MUFA, PUFA	Capillary gas chromatography	Yes	0.001 g
Cholesterol	Gas chromatography	Yes	1.0 mg
Retinol	HPLC	Yes	2.8 µg
Tocopherols/ Tocotrienols	HPLC	Yes	5 µg
Vitamin D_3	HPLC	Yes	1.0 µg
25-OH D_3 [a]	HPLC	Yes	0.05 µg
Vitamin K	HPLC	Yes	0.1 µg
Thiamine [b]	HPLC	Yes	10 µg
Riboflavin	HPLC	Yes	13 µg
Niacin	Microbiological	Yes	90 µg
Vitamin B_6	HPLC	Yes	20 µg
Folate	Microbiological	Yes	0.4 µg
Vitamin B_{12}	Microbiological	Yes	0.1 µg
Calcium	Flame AAS	Yes	1.5 mg [d]
Iron	Flame AAS	Yes	0.3 mg [d]
Sodium	Flame AES	Yes	0.3 mg [d]
Potassium	Flame AES	Yes	8.3 mg [d]
Magnesium	Flame AAS	Yes	0.27 mg [d]
Zinc	Flame AAS	Yes	0.18 mg [d]
Selenium [c]	ICP-MS	No	10 µg [d]
Copper	Flame AAS	Yes	0.03 mg [d]
Phosphorous [a]	ICP-AES	No	0.6 mg [d]
Iodine	ICP-MS	Yes	4 µg

LOQ, limit of quantification; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; HPLC, high performance lipid chromatography; AAS, atomic absorption spectroscopy; ICP-MS, inductively coupled plasma mass spectrometry; ICP-AES , inductively coupled plasma atomic emission spectrometry

[a] Analysis performed by subcontractor.

[b] The values for thiamine are presented as hydrochlorides. The conversion factor from thiamine chloride to thiamine is 0.892.

[c] Graphite furnace AAS is the accredited method, but ICP-MS was used in the present project as this method has a LOQ 5-10 times lower than the AAS method.

[d] Limit of quantification is given on a dry weight basis.

Reliability of the analytical methods
Duplicates were analysed from each composite sample for each nutrient, except for the analyses done by DTU. For fat and protein the results were accepted when the difference between the parallels was less than 5%. For the remaining nutrients, a difference of less than 10% was accepted as long as the concentration of the nutrient was larger than 10 times the quantification limit. When the concentration was less than 10 times the quantification limit, a difference up to 20% between the parallels was accepted. If unacceptably large variation between the parallels was seen, additional parallels were analysed.

The reliability of the analytical method was further controlled by keeping a logbook, a control chart with a control sample, and analysis of a certified reference material if available (Table A2.1 in Appendix 2). NIFES participates in laboratory performance tests on a regular basis (Table A2.2 in Appendix 2). The subcontracting laboratory that analysed phosphorus has not provided information concerning use of control or reference material.

Quality control of received analytical data
After receiving the analytical data from NIFES and DTU, protein content and sums of macronutrients were calculated for all analytical results (Table 3). All macronutrient sums were within 95-103 g per 100 g of edible fish, and only one, Atlantic halibut, was outside 97-103 g as shown in Appendix 3, Table A3.3. According to Greenfield and Southgate summations should ideally range between 97-103 g, but sums within 95 to 105 g are considered acceptable taking measurement uncertainty into consideration (4).

Table 3: Algorithms for nutrient calculations.

Nutrient	**Algorithm**
Protein, g	Nitrogen (g) x 6.25 (nitrogen to protein conversion factor for fish)
Sum macronutrients, g	Protein (g) + fat (g) + water (g) + ash (g)

The laboratory report received from NIFES presented fatty acid values in grams per 100 g raw edible fish/fish fillet as well as in percentage of total fatty acids. Summation of all identified fatty acids by weight as % of fat content, ranged from 86% of total fat for mackerel to 110% for cod. Since this was not in accordance with the commonly used fatty acid factors (4) of 0.7 for lean fish (cod) and 0.9 for fatty fish (all other types of fish in this project), it was decided to recalculate the weights for individual fatty acids based on adjusted values as weight percentages of total fatty acids. The recalculations were done in two steps:

1. Total fatty acids (g) = total fat (g) * fatty acid factor for type of fish
2. Individual fatty acid (g) = individual fatty acid (%) * (total fatty acids recalculated (g) / 100)

Folate was analysed twice as the first values was considered to be unrealistically high. However, the reanalysed folate values were lower than comparable values, possibly caused by long storage. Thus, neither value could be used.

The analyses of vitamin D_3 at DTU served as an extra quality assurance of the D_3 values supplied by NIFES. No large deviation was found between the analytical results for D_3 from NIFES and DTU. Only the results from NIFES are presented in this report. For 25-OH D_3 values from DTU are presented.

Since composite samples were analysed in the present project, only one value was obtained for each nutrient. In order to evaluate if the analytical results were within expected levels, the analytical results were compared to existing values for the same kinds of fish in MVT-06, as well as values from

Swedish (5), Danish (6), Finish (7), Icelandic (8), English (9), and American (10) Food Composition Tables. The results were also compared to previous analyses by NIFES (11) of relevant fish types and to nutrient values on a French website for fish and seafood (12). This exercise resulted in rejection of the analytical value for iodine in farmed trout. As the analysed value was below the quantification limit (<1.2 µg), and the other databases presented values between 5 and 25 µg, the iodine content should have been possible to detect.

Results and discussion

Sampling issues

Most of the composite samples in this project comprised ten or more primary samples, except farmed Atlantic halibut since such samples were difficult to obtain. The composite samples may in general be considered representative for the selected types of fish as they were caught from different locations in the North Sea and farms along the Norwegian coast. However, since the samples originally were collected to obtain representative data for levels of contaminants, coverage of seasonal variation had not been the main focus. It is well known that fat content of fatty fish varies a lot during a year, which is further discussed below.

Standard A and B cuts, and fillet for mackerel, were used to make samples that were representative for what is normally used for human consumption. The fatty parts in the belly and neck of halibut were not included as these parts are normally removed before the fish is marketed.

Analytical results

Table 4 shows the analytical results compared to values in the MVT-06 edition of the Norwegian Food Composition Table 2006 (1). Comparisons with data from 2005-6 in NIFES Seafood database on the Internet (11) are presented for selected nutrients in Tables 5-7, since this database shows ranges and number of analysed samples in addition to mean values.

Table 4: Nutrient content per 100 g edible fish. Analytical results compared to values in the MVT-06

Nutrient	**Unit/ 100g**	**Mackerel, wild, raw (autumn)**		**Greenland halibut, wild, raw**		**Atlantic halibut, raw**			**Cod, farmed, raw**		**Salmon, farmed, raw**		**Trout, farmed, raw**	
		P2007	MVT[a]	P2007	MVT[a]	P2007,wild	P2007,farmed	MVT[a]	P2007	MVT[a]	P2007	MVT	P2007	MVT
Water	g	55	60	77	72	71	74	72	79	80	61	67	70	70
Ash	g	1.0		1.0		1.0	1.2		1.2		1.1		1.2	
Protein	g	17	18.5	14	17.6	17	20	16.2	20	18.1	20	19.9	19	17.2
Total fat	g	25	20.2	11	13.2	6.1	2.4	10.4	0.5	0.3	16	13.4	10	10.2
SFA	g	5.30	4.4	1.67	2	1.01	0.53	1.2	0.09	0	3.00	2.7/2.2	2.03	2.2
MUFA, cis	g	9.09	8.3	6.94	7.7	3.08	0.64	5.3	0.05	0	5.91	5.1/4.9	3.52	4.4
PUFA, cis	g	7.23	5	1.02	1.2	1.20	0.90	0.7	0.20	0.1	5.00	3.8/2.5	3.16	2.5
EPA, cis	g	1.76		0.33		0.34	0.26		0.06		1.02		15.2	
DPA, cis	g	0.34		0.09		0.07	0.04		tr		0.53		0.23	
DHA, cis	g	2.80		0.36		0.50	0.32		0.12		1.39		1.24	
Sum n-3, cis	g	6.66		0.84		1.03	0.74		0.18		3.76		2.56	
Sum long n-3, cis	g	5.20		0.80		0.94	0.64		0.18		3.17		2.22	
Cholesterol	mg	80	68	74	40	50	81	49	82	58	80	66	73	59
Retinol	µg	15	14	10	5	17	3.3	0	<2.8	2	26	11	32	10
Vitamin D_3	µg	5.4	12.5	9.1	11.4	9.7	2.7	18	<1	1.4	10	8	6.9	10
25-OH D_3	µg	n.a		<0,05		<0,05	<0,05		<0,05		0,49		0,22	
Alpha-tocopherol	mg	0.42	0.6	3.3	2.2	1.8	0.89	1	0.47	1.1	1.4	1.4	1.1	2.7
Vitamin K_1	µg	<0.1		<0.1		<0.1	<0.1		<0.1		<0.1		<0.1	
Vitamin K_2	µg	<0.3		<0.3		<0.3	<0.3		<0.3		<0.3		<0.3	
Thiamine	mg	0.1	0.11	<0.01	0.06	0.06	0.07	0.04	0.02	0.05	0.12	0.21	0.21	0.1
Riboflavin	mg	0.28	0.36	0.06	0.08	0.05	0.14	0.06	0.09	0.11	0.11	0.14	0.13	0.21
Niacin	mg	8.3	9.4	1.1	1.5	4.7	8.2	4.4	3.9	2	7.3	8.2	6.9	5.2
Vitamin B_6	mg	0.61	0.8	0.07	0.5	0.48	0.39	0.5	0.26	0.2	0.51	0.5	0.49	0.6
Folate	µg	-	1	4	12	3	7	9	5	12	4	13	5	9
Vitamin B_{12}	µg	7.4	12	0.72	1	0.72	1.8	1	0.95	1	3.5	6.9	4.8	5
Calcium	mg	15	12	5.5	8	4.3	6.3	6	22	8	6.7	12	10	20
Iron	mg	0.8	0.9	0.1	0.1	0.18	0.12	0.2	0.15	0.1	0.33	0.4	0.29	0.2
Sodium	mg	43	75	86	82	63	45	90	75	82	46	57	48	75
Potassium	mg	367	380	352	360	431	484	363	424	455	451	441	420	417
Magnesium	mg	24	27	20	19	21	27	16	26	29	26	28	27	28
Zink	mg	0.62	0.6	0.3	0.4	0.42	0.44	0.3	0.54	0.5	0.48	0.4	0.49	0.4
Selenium	mg	60	30	60	20	60	30	40	30	30	30	30	30	30
Copper	mg	0.08	0	0.02	0.2	0.03	0.03	0	0.03	0	0.04	0.04	0.05	0
Phosphorus	mg	194	240	158	180	204	229	200	207	180	227	245	216	244
Iodine	µg	63	50	7		10	6		300		12	33		

Abbreviations: MVT, The Norwegian Food Composition Table 2006; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; tr, trace (value between 0,01g and the limit of quantification (0,001 g)).

[a] Values for wild fish as no farmed variant is present in MVT-06.

Protein

The protein values obtained in the present project varied between 14 and 20 g per 100 g fish, with wild Greenland halibut having the lowest value (Table 5). The new protein values were somewhat different from the values in MVT-06, but all values were within or close to the ranges presented by NIFES.

Table 5: Protein contents according to the present project (P2007), the MVT-06 edition of the Norwegian Food Composition Table and the Seafood database by NIFES, g per 100 g edible fish.

Type of fish in P2007	**P2007**	**MVT-06**	**NIFES**	
	mean	mean	mean	range (number)
Mackerel, wild (autumn)	17	18.5	16.9	15.7 – 17.6 (10)
Greenland halibut, wild	14	17.6	13.4	12.8 – 13.9 (8)
Atlantic halibut, wild, >30 kg	17	16.2	19.4	16.5 – 23.6 (51)
Atlantic halibut, farmed	20	-	20.0	18.2 – 21.5 (15)
Cod, farmed	20	(18.1)[a]	19.2	18.9 – 19.4 (4)
Salmon, farmed	20	19.9	19.2	14.0 – 26.1 (10)
Trout, farmed	19	17.2	19.6	17.5 – 20.8 (16)

[a] Value for wild cod.

Total fat and fatty acids

As shown in Table 6 the new values for total fat varied between 0.5% (farmed cod) and 25% (mackerel). When compared to values in NIFES' Seafood database, the new fat values for farmed Atlantic halibut, farmed trout and wild mackerel were lower than the lowest values given by NIFES.

Table 6: Total fat and cholesterol contents according to the present project (P2007), the MVT-06 edition of the Norwegian Food Composition Table and the Seafood database by NIFES, per 100 g edible fish.

Type of fish in P2007	**P2007**	**MVT-06**	**NIFES**	
	mean	mean	mean	range (number)
Total fat, g				
Mackerel, wild (autumn)	25	20.2	32	30-34 (10)
Greenland halibut, wild	11	13.2	11.7	9.9-13.2 (8)
Atlantic halibut, wild, >30 kg	6.1	10.4	2.3	0.3-11.6 (53)
Atlantic halibut, farmed	2.4		7.6	5.2-12.8 (15)
Cod, farmed	0.5	(0.3)[a]	1.0	0.9-1.1 (4)
Salmon, farmed	16	13.4	13.2	8.9-17.4 (10)
Trout, farmed	10	10.2	16.5	12.9-22.5 (16)
Cholesterol, mg				
Mackerel, wild (autumn)	80	68	60	47-67 (10)
Greenland halibut, wild	74	40	54	43-82 (8)
Atlantic halibut, wild, >30 kg	50	49	29	13-43 (53)
Atlantic halibut, farmed	81		43	34-62 (15)
Cod, farmed	82	58	52	40-68 (4)
Salmon, farmed	80	68	57	22-87 (10)
Trout, farmed	73	59	44	27-71 (16)

[a]Value for wild cod.

According to the Norwegian Seafood Export Council (13) the fat content of mackerel may vary from 3% in early spring up to 30% in the autumn. The samples of mackerel used in P2007 were caught in October, thus the analysed value for fat also fits reasonably well with the seasonal ranges indicated by an export company (14); i.e. 18-20% in March, 30-32% in August, 26-30% in December and 25-27%

in January. MVT-06 has two entries for mackerel; a spring variety containing 5.4% fat and a summer/autumn variety with 20% fat content.

In addition to season, the fat content of fatty fish may vary considerably according to size and part of the fish being used. A salmon weighing 3-4 kg may contain 14% fat while a salmon weighing 6-7 kg may contain 17% fat (13). The fat content of Atlantic halibut is generally higher in samples from the abdominal and neck region than from the back (2). Only B-cuts from the back of the halibuts were analysed, which may explain why the fat content of the composite sample of farmed Atlantic halibut in P2007 was outside the range of values found by NIFES in 2005 (Table 6).

Both farmed and wild halibut were analysed in P2007 and by NIFES in 2005, providing a possibility to compare differences in nutrient content between the two types. The results from P2007 suggest that farmed halibut may contain somewhat less fat and more protein than the wild type. This may be related to the much larger size of the wild variety. All wild samples weighed >30 kg, while the slaughter weight of the farmed variety is normally only 3-10 kg. Unfortunately, no information about the weight of the sampled farmed halibuts in the present project was available. However, as shown in Tables 4 and 5 the range of values for protein as well as total fat presented by NIFES overlapped, thus no clear conclusion can be drawn.

According to Table 6 the new cholesterol values were with one exception (wild Atlantic halibut) higher than in MVT-06, and several values were also outside the ranges given in the Seafood database.

Values for individual fatty acids calculated as grams are reported in Appendix Table A3.1 and as weight percentages of all fatty acids in Appendix Table A3.2. As shown in Table 7, the fatty acid pattern of the analysed samples of fish was in most cases quite similar to the current values in MVT-06, except for farmed salmon and trout. How**e**ver, these new values were within the range of values found by NIFES over the past few years. The fluctuations are believed to be caused by sampling variations and laboratory uncertainties, in addition to possible variation in feed composition.

Table 7: Total fat, sums of fatty acids, EPA and DHA values for farmed salmon and trout, and wild Atlantic halibut and mackerel from the present project (P2007), the MVT-06 and 1995 editions of the Norwegian Food Composition Table and various sampling years in the Seafood database by NIFES, g per 100 g edible fish.

	N	Total fat		SFA		MUFA		PUFA		EPA		DHA	
		mean	range	mean	range	mean	range	mean	range	mean	range	mean	range
Salmon, farmed													
P2007	[a]	16		3.0		5.9		5.0		1.02		1.39	
MVT-06		13.4		2.2		4.9		2.5					
MVT-95		9.9		1.6		3.6		1.8		0.4		0.6	
NIFES 2005	47	16.4	3.3 – 23.4	3.1	0.9 – 4.8	6.4	2.3 – 9.6	5.6	1.7 – 8.9	1.1	0.3 – 2.1	1.6	0.7 – 2.8
NIFES 2006	10	13.2	8.9 – 17.4	2.5	1.6 – 3.2	5.2	4.0 – 7.3	4.4	3.3 – 5.9	0.8	0.5 – 0.9	1.3	0.8 – 1.5
NIFES 2008	28			2.5	1.3 – 4.0	6.8	3.6 – 10.7	4.7	2.6 – 6.4	0.7	0.4 – 1.4	1.1	0.6 – 1.6
NIFES 2009	28	15.7	12.6 – 18	2.4	1.3 – 4.4	6.9	3.9 – 9.1	4.8	2.9 – 6.4	0.7	0.3 – 1.3	1.0	0.6 – 2.1
NIFES 2010	33	15.6	9 – 23.2	3.0	1.6 – 5.1	7.7	4.4 – 12.2	5.6	3.4 – 9.0		<0.1 – 0.2	1.3	0.8 – 2.1
Trout, farmed													
P2007	[a]	10		2.0		3.5		3.2		0.6		1.2	
MVT-06		10.2		2.2		4.4		2.5					
MVT-95		10.2		2.2		4.4		2.5		0.4		1.2	
NIFES 2005	16	19.6	17.5 – 20.8	3.2	2.2 – 4.1	5.4	3.6 – 6.9	5.3	3.1 – 7.3	1.2	0.4 – 1.7	1.7	1.3 – 2.1
Halibut, wild													
P2007	[a]	6.1		1.0		3.1		1.2		0.3		0.1	
MVT-06		10.4		1.2		5.3		0.7					
MVT-95		10.4		1.2		5.3		0.7		0.2		0.2	
NIFES 2005	53	2.3	0.3 – 11.6	0.5	0.1 – 2.8	1.3	0.1 – 7.2	0.8	0.3 – 3.5	0.2	0.1 – 0.8	0.4	0.2 – 1.7
Mackerel, wild													
P2007	[a]	25		5.3		9.1		7.2		1.8		2.8	
MVT-06		20.2		4.4		8.3		5.0					
MVT-95		20.2		4.4		8.3		5.0		1.0		2.5	
NIFES 2006	10	32	30 - 34	6.8	6.3 – 7.9	12.8	11.4 – 15.3	10.4	9.1 – 12.3	2.3	1.9 – 2.8	3.7	3.3 – 4.3

NIFES, National Institute of Nutrition and Seafood Research; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid

[a] Composite sample, see table 1 for number of primary samples

Fat soluble vitamins
In general, the fatty fish in this project contained very little retinol when considering the recommended daily intake of retinol ranging from 300 to 1100 µg/day in different population groups (15).

Cod and farmed Atlantic halibut, which had the lowest content of total fat, also had very little vitamin D. No association between total fat and vitamin D was seen for the other types of fish.

As shown in Table 8 the P2007 values for vitamin D were within or close to the rather large ranges found by NIFES for the various types of fish. The new values were *20-50*% lower than the current MVT-06 values for all the fatty fish except farmed salmon.

Table 8: Values per 100 g edible fish for vitamin D3 from the present project (P2007), current Norwegian Table values (MVT) (1) and the seafood database (NIFES) (11).

	Vitamin D, µg/100 g		
Type of fish in P2007	**P2007**	**MVT**	**NIFES**
Mackerel, wild (autumn)	5.4	12.5	4 (2-7)
Greenland halibut, wild	9.1	11.4	12 (10-15)
Atlantic halibut, wild, >30 kg	9.7	18[c]	12 (2-50)
Atlantic halibut, farmed	2.7		8 (3-14)
Cod, farmed	<1	*(1.4)*[a]	3 (3-3)
Salmon, farmed	10	8	9 (6-18)
Trout, farmed	6.9	10	7 (4-10)

a Wild cod.

B vitamins
Most of the analytical values for thiamine, riboflavin, vitamin B_6 and vitamin B_{12} were quite similar (data not shown) to the current MVT-06 values, and within the ranges reported by NIFES on their website (11). Mackerel had the highest concentration of riboflavin, vitamin B_6 and vitamin B_{12} among the analysed types of fish.

Minerals and trace elements
Most of values for minerals and trace elements were rather low and not very different from the current MVT-06 values. However, selenium was higher for mackerel and the three halibuts. A rather high content of iodine was found for the farmed cod compared to the other types of fish in this project, but data from the seafood database by NIFES (11) indicate large ranges for this trace element (data not shown).

Adaptation of the analytical data for use in the Norwegian FCT

For adaptation of the analytical data for use in the Norwegian Food Composition Table, the contents of energy and niacin equivalents were calculated according to the algorithms in Table 9. Trans fatty acids, carbohydrates, fibre, added sugar, retinol, β-carotene, and vitamin C were regarded as natural zeros.

Table 9: Algorithms for calculation of energy and niacin equivalents.

Nutrient	**Algorithm**
Energy, kJ	[protein (g) x 17 kJ] + [fat (g) x 37 kJ]
Energy, kcal	[protein (g) x 4 kcal] + [fat (g) x 9 kcal]
Niacin equivalents, NE	Niacin (mg) + [protein (mg) x 0.011/60] [a]

[a] The protein in fish was estimated to contain 1.1% tryptophane. 60 mg of tryptophane equals 1 mg of niacin.

The P2007 folate values from NIFES were lower than expected which may be due to too long storage of the folate samples before analyses. As NIFES had more reliable results from a project carried out in 2005/06 based on composite samples of large numbers of primary samples, it was decided to use folate values from the NIFES database (11) for the next edition of the Norwegian food composition table. As folate values were available from two separate projects for farmed salmon and farmed cod, weighted means according to the number of analysed samples were used.

The table values for vitamin E includes only α-tocopherol, due to the fact that only this vitamer has vitamin E activity in foods (15).

As the analysed value for iodine was below the quantification limit and thus not accepted, the table value for iodine in trout is borrowed from the Danish Food Composition Database (6).

The data that will be included in the Norwegian Food Composition Table on the Internet, are shown in Table 10.

Table 10: Nutrient values for selected types of fish to be included in the Norwegian Food Composition Table on the Internet.

Component	Unit	Mackerel, autumn raw	Greenland halibut raw/smoked	Atlantic halibut wild, raw	Halibut farmed, raw	Cod, farmed, raw	Salmon, farmed, raw	Trout farmed, raw
Water	g	55	77	71	74	79	61	70
Energy1	kJ	1214	645	515	429	359	932	693
Energy2	kcal	293	155	123	102	85	224	166
Protein (NCF 6,25)	g	17	14	17	20	20	20	19
Fat	g	25	11	6.1	2.4	0.5	16	10
SFA	g	5.30	1.67	1.01	0.53	0.09	3.0	2.03
Trans [a]	g	0	0	0	0	0	0	0
MUFA, cis	g	9.09	6.94	3.08	0.64	0.05	5.91	3.52
PUFA, cis	g	7.23	1.02	1.20	0.90	0.20	5.00	3.16
EPA	g	1.76	0.33	0.34	0.26	0.06	1.02	0.64
DPA	g	0.34	0.09	0.07	0.04	<0.001	0.53	0.23
DHA	g	2.80	0.36	0.50	0.32	0.12	1.39	1.24
Sum n-3, cis	g	6.66	0.84	1.03	0.74	0.18	3.76	2.56
Sum long n-3, cis	g	5.20	0.80	0.94	0.64	0.18	3.17	2.22
Cholesterol	mg	80	74	50	81	82	80	73
Carbohydrate, sum. [a]	g	0	0	0	0	0	0	0
Starch [a]	g	0	0	0	0	0	0	0
Mono+Di sacchar. [a]	g	0	0	0	0	0	0	0
Dietary fiber [a]	g	0	0	0	0	0	0	0
Vitamin A	RAE	15	10	17	3.3	<2.8	26	32
Retinol	µg	15	10	17	3.3	<2.8	26	32
Beta-carotene [a]	µg	0	0	0	0	0	0	0
Vitamin D (D_3)	µg	5.4	9.1	9.7	2.7	<1	10	6.9
Vitamin E	α-TE	0.42	3.3	1.8	0.89	0.47	1.4	1.1
Thiamine [b]	mg	0.10	<0.01	0.06	0.07	0.02	0.12	0.21
Riboflavin	mg	0.28	0.06	0.05	0.14	0.09	0.11	0.13
Niacin equivalents	NE	11.4	3.7	7.8	11.9	7.6	11.0	10.4
Niacin	mg	8.3	1.1	4.7	8.2	3.9	7.3	6.9
Vitamin B_6	mg	0.61	0.07	0.48	0.39	0.26	0.51	0.49
Folate	µg	15 [c]	5 [c]	7 [c]	16 [c]	11 [c]	7 [c,d]	5 [c]
Vitamin B_{12}	µg	7.4	0.72	0.72	1.8	0.95	3.5	4.8
Vitamin C [a]	mg	0	0	0	0	0	0	0
Calcium	mg	15	6	4	6	22	7	10
Iron	mg	0.80	0.10	0.18	0.12	0.15	0.33	0.29
Sodium	mg	43	86	63	45	75	46	48
Potassium	mg	367	352	431	484	424	451	420
Magnesium	mg	24	20	21	27	26	26	27
Zink	mg	0.62	0.30	0.42	0.44	0.54	0.48	0.49
Selenium	µg	60	60	60	30	30	30	30
Copper	mg	0.08	0.02	0.03	0.03	0.03	0.04	0.05
Phosphorus	mg	194	158	204	229	207	227	216
Iodine	µg	63	7	10	6	300	12	5 [e]
Ash	g	1.0	1.0	1.0	1.2	1.2	1.1	1.2

NFCT, The Norwegian Food Composition Table; NCF, Nitrogen conversion factor; SFA, saturated fatty acids; Trans, trans unsaturated fatty acids; MUFA, onounsaturated fatty acids; PUFA, polyunsaturated fatty acids; n.q., not quantifiable (<1.2 µg), n.a, not analysed;
RAE, retinol activity equivalents; NE, niacin equivalents; α-TE, α-tocopherol equivalents

[a] Compiled as natural zero, not analysed.

[b] Given as hydrochloride.

[c] Value from www.nifes.no, updated per 12 July 2010

[d] Weighted value

[e] Value from the Danish Food Composition Databank, revision 7.0; 2008, reference 6.

Conclusion

The analytical values from project P2007 were generally in good agreement with the current values for cod, halibut, salmon, trout and mackerel in the MVT-06 edition of the Norwegian Food Composition Table, especially when considering the rather wide ranges for many nutrients found by NIFES in other analytical projects of the same types of fish. The most notable exception was a lower concentration of vitamin D, especially in mackerel. Furthermore, the cholesterol values were higher than earlier values for all types of fish, also compared to NIFES own published results.

No clear conclusion could be drawn concerning the apparent difference in fat content between the wild and farmed varieties of Atlantic halibut.

The main part of the new analytical values will be included in the Norwegian Food Composition Table on the Internet.

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Appendix 1: Description of analytical methods

Water (recalculated from dry matter)
Method: Gravimetric
Method description: The dry matter content was determined gravimetrically by drying a finely grinded, homogenous sample at 104 ^{o}C until constant weight. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid according to NMKL method number 23, 3rd edition 1991.
Limit of quantification: 0.1 g/100 g.

Ash
Method: Gravimetric
Method description: The ash content was determined gravimetrically. The samples were ashed in a muffle furnace until constant weight. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid.
Limit of quantification: 0.1 g/100 g.

Crude protein
Method: Combustion method, Leco
Method description: Protein (crude protein) was determined by burning the samples in pure oxygen gas in a combustion tube at minimum 850°C. Nitrogen was determined by measuring the thermal conductivity of the nitrogen gas. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid when the Leco FP-528 is used (the method of Dumas and Liebig). A thoroughly homogenized sample is necessary when using the method. Furthermore it is important to be aware of the method's critical points. This is particularly true when it comes to using the right nitrogen to protein conversion factor. In this project the protein conversion factor 6.25 was used.
Limit of quantification: 1.9 g/100 g.

Total fat (acid extraction)
Method: Gravimetric
Method description: The samples were preextracted with petroleum ether in a Soxtec extraction system. The fat containing extracts were evaporated until dryness and weighed. Possible bound fat was hydrolyzed from the samples in boiling HCl. The solution was cooled down and the acid was filtered off. The samples were then dried in a drying cabinet. Fat was extracted with petroleum ether in a Soxtec extraction system. The remaining amount was weighed. Total fat content was calculated based on the sum of the two remaining amounts and the weight of the initial samples. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid. The principle behind the method is based on the EU directive 84/4 EC, The Official Journal of the European Union (OJ) no L 15/28, 18.1.84, method B. In addition the following was used: Tecator application note AN 301,REV 3.0 " Solvent Extraction using the Socxtec System".Tecator application note ASN 3427, "The extraction of total fat in feed."
Limit of quantification: 0.3 g/100 g.

Individual fatty acids (saturated, monounsaturated cis, and polyunsaturated cis fatty acids)
Method: GC
Method description: The individual fatty acids were separated by gas chromatography and determined using a flame ionization detector. Fat was extracted from the samples using chloroform/methanol. The fatty phase was filtered, evaporated until dryness, saponified, and finally methylated before the fatty acid esters were separated and detected as methyl esters. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid. The analytical results for fatty acids were reported from NIFES as g/100 g fish.
Limit of quantification: 0.001 g/100 g.

Cholesterol
Method: GC
Method description: The samples were saponified in a solution containing 0,5M NaOH in methanol at 80^{o}C. The solution is cooled, and then water and hexane is added - followed by shaking. The solution is centrifugated and the hexane phase (containing the cholesterol) is isolated. Cholesterol was determined by gas chromatography fitted with a FID detector. The method is an internal method based on several publications[5, 6 and 7.] The method has been validated and accredited for food, animal feed, tissue and tissue fluid.
Limit of quantification: 1.0 mg/100 g

Retinol (all trans retinol and 13-cis retinol), (Vitamin A)
Method: HPLC
Method description: The samples were saponified, and the unsaponified material was extracted. Vitamin A was determined by HPLC (normal phase) fitted with a UV detector. The content of all trans retinol and 13-cis retinol was calculated using an external standard method. The method has been validated and accredited for food items, animal feed, tissue, and tissue fluid and it is based on CEN prEN 12823-1 (1999), Foodstuffs – Determination of vitamin A by high performance liquid chromatography – Part 1: Measurement of all trans retinol and 13-cis retinol.
Limit of quantification: 2.8 µg/100g

Vitamin D_3
Method: HPLC
Method description: The samples were saponified, and the unsaponified material was extracted. The sample was purified on a preparative high performance liquid chromatography (HPLC) column, The fraction containing D_2 og D_3 was collected. This fraction was injected on a analytical HPLC column. Vitamin D_3/D_2 determined by an UV detector. The content of the vitamin was calculated using an internal standard. The method has been validated and accredited for food items, animal feed, tissue, and tissue fluid and is based on CEN prEN 12821 (1999). Foodstuffs – Determination of vitamin D by high performance liquid chromatography - Measurement of cholecalciferol (D_3) and ergocalciferol (D_2).
1 µg/100g
Limit of detection: 1 µg/100g

25-OH Vitamin D_3 (subcontractor Danish Technical University)
Method: HPLC
*Method description***:** The internal standards of vitamin D2 and 25-hydroxyvitamin D2 were added to the samples and saponified with ethanolic potassium hydroxide. The unsaponifiable matter was extracted. The solution was the purified on a SPE and two different preparative

HPLC. The fraction of the vitamin D metabolites were collected (25-OH D and vitamin D, separately), and separated on two different HPLC-systems equipped with a reversed phase column. For detection and quantification PDA and UV at 265 nm were used. The method has been validated and accredited according to ISO17025. The principle is equivalent to the CEN EN12821 (2000): Foodstuffs - Determination of vitamin D by high performance liquid chromatography - Measurement of cholecalciferol (D3) and ergocalciferol (D2).
Limit of quantification: 0.03µg vitamin D3/100g and 0.05 µg 25-OH vitamin D3/100 g.

Vitamin K_1 and K_2 (MK4). From 2003 analysed by NIFES (accredited in 2005).
Method: HPLC
Method description: The concentrations of K_1 and K_2 in the test samples are separated on a C18 high performance liquid chromatography(HPLC) column and detected by fluorescens. Prior to the end determination fat is removed by lipase and the vitamin is extracted. After the HPLC separation Vitamin K is reduced to vitamin K hydroquinone by a post-column reaction with zinc. Vitamin K_1 and K_2 is quantified by external calibration. The method is based on CEN/TC 275 prEN 14148 (2002). The method is validated and accredited.
Limit of quantification: 0.1 µg/100g

Tocopherols/tocotrienols (Vitamin E)
Method: HPLC
Method description: The samples were saponified, and the unsaponified material was extracted. α-, β-, γ-, δ-tocopherol and α-, β-, γ-, δ-tocotrienol were determined by HPLC using a fluorescence detector. The content of the vitamin was calculated using an external standard method. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and is based on CEN prEN 12822 (1999). Foodstuffs – Determination of vitamin E by high performance liquid chromatography - Measurement of α-, β-, γ- and δ-tocopherols.
Limit of quantification: Tocopherols/tocotrienols 5 µg/100 g.

Thiamine HCL (vitamin B1)
Method: HPLC
Method description: Diluted HCL was added to the sample and hydrolyses performed in an autoclave. After hydrolysing, the pH in the test samples was adjusted followed by an enzyme treatment. The test samples were injected on a HPLC and the vitamin was derivatized post-column from thiamine to thiochrome and finally detected by fluorescence.
The content was calculated using an external standard method. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and is in accordance with CEN TC 275, N 125 Food stuff determination of vitamin B1 by HPLC (2002). The HPLC method for determining thiamine has been compared to the microbiological method with comparable results. However, the HPLC method has a significantly higher precision. The result is given as thiamine hydrochloride.
Limit of quantification: 10 µg/100 g.

Riboflavin (vitamin B2)
Method: HPLC
Method description: Diluted HCL was added to the sample and hydrolyses performed in an autoclave. After hydrolysis the test samples were pH adjusted and enzyme treated. The riboflavin content was determined by HPLC using a fluorescence detector and calculated by an external standard method. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and is based on CEN – N1452 Foodstuff determination of vitamin

B_2 by HPLC (2003). Riboflavin is light sensitive, and the analyses were performed with dimmed yellow lights. The HPLC method for analysis of riboflavin has been compared to the microbiological method with comparable results. However, the HPLC method has a significantly higher precision.
Limit of quantification: 13 µg/100 g.

Niacin
Method: Microbiological
Method description: The vitamin was extracted from the sample by autoclaving the sample with an acidic solution. Niacin is present in the water soluble part of the sample. The water-extract was then diluted to give an appropriate concentration of niacin and mixed with a growth medium and the microorganism (*Lactobacillus plantarum*-ATCC 8014), followed by incubation overnight. The niacin content was calculated by comparing the growth of the organism in the test samples to the growth of the same organism in samples with a known standard concentration of the vitamin. The quantification was done by a spectrophotometric measuring of optical density (575 nm). The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and is based on Pharmacopea Scandinavica 1958. The method has been modified by use of ready made medium from Merck.
Limit of quantification: 90 µg/100 g.

Pyridoxine (total vitamin B6),
Method: HPLC
Method description: Diluted HCL was added to the sample and hydrolyses performed in an autoclave. After hydrolyzing the test sample was treated with an enzyme, followed by a pH adjustment. The compounds pyridoxine, pyridoxal, and pyridoxamine in the samples were separated by HPLC and determined using fluorescence detection and external calibration (standard curve) of the three chemical forms. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and is based on CEN TC 275, N 126 Foodstuff determination of vitamin B_6 by HPLC (2002). Vitamin B6 is light sensitive, and the analyses were performed with dimmed yellow lights. The HPLC method yields correct and precise results compared to the microbiological method.
Limit of quantification: 20 µg/100 g.

Cobalamin (vitamin B12)
Method: Microbiological
Method description: Vitamin B12 was extracted from the sample by autoclaving the sample with an acetate buffer. The vitamin is present in the water soluble part of the sample. The pH in the water extract was adjusted, followed by a dilution to an appropriate concentration. The extract was then mixed with a growth medium, the microorganism (*Lactobacillus delbruecki* –ATCC 4797) was added, and the sample was incubated. Vitamin B12 content was calculated by comparing the growth of the organism in the test samples with the growth of the same organism in samples with a known standard concentration of the vitamin. The determination was done by a spectrophotometer, measuring optical density at 575 nm. Cyanocobalamin is used as an internal standard. The method has been validated and accredited for food items, animal feed, tissue, and tissue fluid and is based on the AOAC method from 1980 (Tangvay A. E. (1958) Applied Microbiol. 7, 84-88). The method uses a ready made medium from Merck.
Vitamin B12 is light sensitive, and the analyses were performed with dimmed yellow lights.
Limit of quantification: 0.1 µg/100g.

Folate, total
Method: Microbiological
Method description: Folate (Folic acid) was extracted from the sample by autoclaving of the sample with a phosphate buffer, followed by an addition of Chicken pancreas enzyme and then incubation for 18 hours. The vitamin is present in the water soluble part of the sample. The pH in the water extract was adjusted, followed by a dilution to give an appropriate concentration of the vitamin to accommodate the standard curve. The extract was then mixed with a growth medium, the microorganism (Lactobacillus casei/rhamnosus ATCC 7469)) was added, and the sample was incubated. The content of folate was calculated by comparing the growth of the organism in the test samples with the growth of the same organism in samples with a known standard concentration of the vitamin. The measuring was done by a spectrophotometer measuring optical density (turbidimetric measurement at 575 nm). The method has been validated and accredited for food items, animal feed, tissue, and tissue fluid and is based on "Svenska Nestlè ABs mikrobiologiske bestämning av folsyra i livsmedel". Method number.71 C-2. Folate is light sensitive, and the analyses were performed with dimmed yellow lights. Ascorbic acid was added to the sample before homogenization. The samples were stored at -80 ^{o}C.
Limit of quantification: 0.4µg/100g.

Calcium
Method: Flame AAS
Method description: Calcium was determined using flame atomic absorption spectroscopy (AAS) after digestion of the samples using concentrated and extra purified nitric acid and concentrated hydrogen peroxide in a microwave oven. The decomposing process breaks calcium's various chemical bonds to the biological material. Free calcium ions are suiTable for determination by AAS. The calcium content was determined using external calibration (standard curve). The method has been validated in a collaborative study by NMKL and accredited for foods, animal feed, tissue, and tissue fluid. The method is published in: Julshamn et al. (1998) J. AOAC Int., 81, 1202-1208 and NMKL- method 153
Limit of quantification: 1.5 mg/100 g dry weight.

Iron
Method: Flame AAS
Method description: Iron was determined using flame atomic absorption spectroscopy (AAS) - as described for calcium. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid according to: Steiner, Julshamn & Lie, (1991). Food Chemistry 40, 309-321.
Limit of quantification: 0.3 mg/100 g dry weight.

Sodium
Method: Flame AES
Method description: Sodium was determined using flame atomic emission spectroscopy (AES). For the rest the method follows the same procedure as described for calcium. The method has been validated in a collaborative study and accredited according to: Steiner, Julshamn & Lie, (1991). Food Chemistry 40, 309-321.
Limit of quantification: 0.3 mg/100g dry weight.

Potassium
Method: Flame AES
Method description: Potassium was determined using flame atomic emission spectrometry (AES). For the rest the method is performed according to the same procedure as described for calcium. The method has been validated and accredited for food items, animal feed, tissue, and tissue fluid according to the method described by Steiner, Julshamn & Lie, (1991). Food Chemistry 40, 309-321.
Limit of quantification: 8.3 mg/100g dry weight

Magnesium
Method: Flame AAS
Method description: Magnesium was determined using flame atomic absorption spectroscopy (AAS) as described for calcium. The method has been validated in a collaborative study by NMKL and accredited for foods, animal feed, tissue, and tissue fluid according to the method: Julshamn et al. (1998) J. AOAC Int., 81, 1202-1208. (NMKL method 153)
Limit of quantification: 0.27 mg/100 g dry weight.

Zinc
Method: Flame AAS
Method description: Zinc was determined using flame atomic absorption spectroscopy (AAS) as described for calcium. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid according to the following CEN method: CEN /TC 275, prEN 14084 (2001). Foodstuffs- Determination of trace elements – Determination of lead, cadmium, zinc, copper and iron by atomic absorption spectrometry (AAS) after microwave digestion. The CEN method is based on an NMKL method no 161.
Limit of quantification: 0.18 mg/100 g dry weight.

Selenium
Method: ICP-MS
Method description: Selenium was determined using ICP-MS after preparation/digestion of the samples in a microwave oven as described for calcium. For determination of the selenium content of the samples, an internal standard was used in addition to the standard addition procedure to correct for matrise interference which would otherwise cause systematic errors. The method has been validated but so far is not accredited. The method has been suggested as a CEN method and a collaborative study will be organized by a French laboratory in 2003/2004. The quantification limit of the present method is 10 times lower than when using the graphite oven AAS which is the accredited method.
Limit of quantification: 0.01 mg/100 g dry weight

Copper
Method: Flame AAS
Method description: Copper was determined using flame atomic absorption spectroscopy (AAS) as described for calcium. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid according to the following CEN method: CEN /TC 275, prEN 14084 (2001). Foodstuffs- Determination of trace elements – Determination of lead, cadmium, zinc, copper and iron by atomic absorption spectrometry (AAS) after microwave digestion. The CEN method is based on an NMKL method 161.
Limit of quantification: 0.03 mg/100 g dry weight.

Phosphorous (subcontractor ALS Scandinavia, former Analytica)
Method: ICP-AES
Method description: Phosphorous was determined by inductive coupled plasma analytical emission spectrometry (ICP-AES), after digestion of the samples using nitric acid and hydrogen peroxide in a microwave oven. The method is a modification of the EPA methods 200.7 and 200.8. The method used is a multi-element method and it is accredited for several heavy metals - assuring a good quality assurance. But the method is not accredited for Phosphorous.
Limit of quantification: 0,6 mg/100 g dry matter

Iodine (I)
Method: ICP-MS,
Method description: The method of digestion of the sample used will depend on the carbohydrate content (CC). If CC is high (>10%) the samples are digested according to the procedure described for Calcium – but just before performing the measurement the Iodine is stabilized by adding NH_4^+ to the sample solution. If the sample contains CC< 10% the sample is digested by adding tetra methyl ammonium hydroxide (TMHA) and heat in an incubator at 90 ^oC. The determination of Iodine is done by inductive coupled plasma mass spectroscopy (ICP-MS) using tellur as an internal standard, and as an standard addition to eliminate bias due to matrix effect. The method is based on: Kåre Julshamn, Lisbeth Dahl og Karen Eckhoff (2001). Determination of iodine in seafood by ICP-MS. J. AOAC International 84, 1976-1983. The method is validated for food and biological material, and is accredited in 2006.
Limit of quantification: 4 µg/100 g dry matter.

Appendix 2: Quality assurance data

Table A2.1: Performance data of the analytical methods, from information supplied by NIFES.

Nutrient	**Quantification interval**	**Measurement uncertainty**	**Control material/ Reference material**	**Accuracy %**
Water	0.1 g/100 g	3%	Haddock 19.1 g/100 g 2% (2* RSD%)	97-104 [c]
Ash	0.1 g/100 g	17%	Fish meal 11.6 g/100 g 5% (2*RSD%)	95-105 [c]
Protein	1.9 g/100 g	8% (1.9-7 g /100 g) 3% (7-100 g /100 g)	Meat product SMRD2000 31.7 g/100 g 2.8%(2* RSD%)	98-100 [a]
Fat	0.3- 100 g/100 g	30% (0.3-1 g/100 g) 10% (1-5 g/100 g) 5% (5-100 g/100 g)	Fish feed 36.9 g/100 g 2.2% (2* RSD%) Meat product 18.0 g/100 g 4.5% (2*RSD%)	95-105 [a, c]
Fatty acids	Relative values 0.1-100%, absolute values >0.001 g/100 g (wet weight)	mg/g: 7-18% Depends on the concentration of the individual fatty acid	Salmon liver concentration in% 16:0, 16.6%, 2RSD=1.8% 18:1n-9, 13.6% 2RSD=3.1% 20:5n-3, 8.7% 2RSD= 2.3%	90-110 [a]
Cholesterol	0.025-20 000 mg/kg	40% (0,025-50 mg/kg) 20% (50-1000 mg/kg) 15% (1000-20 000 mg/kg)	SRM1544 143 mg/kg 14% (2*RSD)	94-98 [a]
Retinol	LOQ-1000 mg/kg	20% (>LOQ-1 mg/kg) 15% (1-100 mg/kg) 15% (>100-1000 mg/kg)	Trout liver 211.5 mg/kg 6% (2* RSD%)	95-107 [a, c]
Vitamin D_3	0.01 mg/kg-40 mg/kg	20% (>0,01-0,5mg/kg) 15% (0,5-40 mg/kg)	Atlantic haddock, fillet, 0.34 mg/kg 17.9% (2*RSD)	96-106 [a]
Vitamin D, 25-OH D_3	0.150	1.8%	Fat	90
Tocopherol, Tocotrienol-isomers (α, β, γ, δ)	LOQ-1000 mg/kg	With tocotrienols 2RSD 25%	Salmon filet 22 mg/kg 9.6% (2* RSD%)	92- 107 [a, c]
Vitamin K	K1 0.001-3	K1: 54% (LOQ-0.2	SRM1846 0.97 mg/kg 13% (2*RSD)	91- 100 [a, c]

Nutrient	Quantification interval	Measurement uncertainty	Control material/ Reference material	Accuracy %
	mg/kg MK4 0.003-3 mg/kg	mg/kg:) 22% (0.2 -3 mg/kg:,) MK4: 57% (LOQ-0.2 mg/kg) 24% (0.2 -3 mg/kg)		
Thiamine HCL	0.1-75 mg/kg wet weight	30% (0,1- 1 mg/kg) 15%, (1-50 mg/kg) 10% (50-75 mg/kg)	Salmon filet 2.4 mg/kg 9.6% (2* RSD%)	92- 107 [a]
Riboflavin	0.1-75 mg/kg wet weight	24% (0.13-1 mg/kg) 8% (1-50 mg/kg) , 5% (50-75 mg/kg)	Salmon filet 1.1 mg/kg 19% (2* RSD%)	90-110 [a, c]
Niacin	0.9 - 300 mg/kg	10% (0.9-300 mg/kg)	Fish powder 95.3 mg/kg 8% (2* RSD%)	85-110 [a]
Vitamin B6	0.2 - 75 mg/kg	15% (0.1-75 mg/kg)	Salmon filet 6.0mg/kg 16% (2* RSD%)	95-105 [a, c]
Folate	0.004 - 15 mg/kg	20% (0.004-15mg/kg)	Fish powder 0.49 mg/kg 27% (2* RSD%)	80-110 [a, c]
Cobalamin (Vitamin B12)	0.001-0.3mg/kg	30% (0.001-0.3 mg/kg)	Fish powder 0.23 mg/kg 29% (2*RSD%)	86 [a, c]
Calcium	15-13000 mg/kg	10%	Beef liver 11.6 mg/100 g 10% (2* RSD%)	90-105 [b]
Iron	3-1100 mg/kg	9%	Beef liver 19.0 mg/100 g 7.6% (2* RSD%)	85-105 [b]
Sodium	2.9-34900 mg/kg	7%	Beef liver 242 mg/100 g 6.8% (2* RSD%)	95-105 [b]
Potassium	83-16900 mg/kg	10%	Beef liver 1000 mg/100 g 9.2% (2* RSD%)	85-105 [b]
Magnesium	2.7 -1200 mg/kg	9%	Beef liver 60 mg/100 g 9% (2* RSD%)	85-105 [b]
Zink	1.8-1425 mg/kg	8%	Beef liver 12.7 mg/100 g 8.6% (2* RSD%)	85-105 [b]
Selenium	0.29-5.6 mg/kg	15%	Lobster 56.0µg/100 g 13.8% (2* RSD%)	85-105 [b]
Copper	0,3-160 mg/kg	6%	Beef liver 16 mg/100 g 6% (2* RSD%)	85-105 [b]
Phosphorous	41-15600 mg/kg	20%	Beef liver 1100 mg/100 g 10% (2* RSD%)	90-108 [b]
Iodine	0.04-5 mg/kg	15%	Milk powder (2* RSD%)	95-105

NIFES, National Institute of Nutrition and Seafood Research; RSD, relative standard deviation; HCL, hydrochloride

[a] Based on reference material.

[b] Based on proficiency tests.

[c] The measurement uncertainty includes the bias and the standard deviation

Table A2.2: Results from proficiency tests 2005-2007.

Nutrient	Initiated by	Year	Test material	Concentration	Z-score
Water	NSFA	2005	Powder mix	3.32 g/100 g	-0.2
	Bipea	2006	Rapeseed cake	9.7 g/100 g	0,0
	Fapas	2007	Fish paste	65.5 g/100 g	0,01
Ash	NSFA	2005	Powder mix	3.84 g/100 g	0.9
	Bipe	2006	Rapeseed cake	6.9 g/100 g	0.0
Protein	Fapas	2005	Bread crumbs	12.7 g/100 g	0.5
	Bipea	2005	Animal feed	19.9 g/100 g	1.5
	Bipea	2006	Beans	25.7 g/100	-1.1
	Fapas	2007	Meat		0.3
Fat	Nutreco	2006	Fish meal	21.0 g/100 g	-0.7
	Nutreco	2006	Fish meal	34.4 g/100 g	-0.5
	Fapas	2007	Canned meat	13.0 g/100 g	
Fatty acids: Saturated fatty Monounsaturated Polyunsaturated	Bipea	2005-2007	Various matrix	0.1 – 64 g/100 g	<±2.0
Cholesterol	Fapas	2007	Mixed fat spread	157 mg/100 g	-0.23
Retinol	Bipea	2005	Baby food	407 mg/100 g	0.4
	Fapas	2006	Baby food	454 mg/100 g	1.5
	Fapas	2007	Pre-mix	27.9 mg/100 g	0.3
Vitamin E	Fapas	2006	Baby food	4.3 mg/100 g	-0.3
	Fapas	2007	Pre-mix	479 mg/100 g	-0.9
Vitamin D_3	Fapas	2007	Milk powder	9,3 µg/100g	1,0
	Fapas	2007	Pre-mix	0,18 mg/100g	-0,1
Vitamin K [a]					
Thiamine HCl (HPLC)	Bipea	2006	Pre-mix	3.3 mg/100 g	0.6
	Bipea	2007	Supplemented soup	0.06 mg/100 g	-0.5
Riboflavin (HPLC)	Fapas	2006	Breakfast cereal	2.1 mg/100 g	-0.2
	Fapas	2007	Breakfast cereal	2.0 mg/100 g	0.1
Niacin	Fapas	2006	Breakfast cereal	21.3 mg/100 g	0.3
	Fapas	2007	Supplement	20.8 mg/100 g	-0.6
Vitamin B_6	Fapas	2006	Breakfast cereal	2.1 mg/100 g	-1.3
	Fapas	2007	Breakfast cereal	2.1 mg/100 g	0.2
Folate	Bipea	2004	Powdered milk	0.14 mg/100 g	-0.3
	Fapas	2007	Supplement	438 ug/100g	-1,81
Vitamin B12	Fapas	2004	Baby food	36.3 mg/100 g	-0.4
	Fapas	2007	Baby food	1.7 mg/100g	-0,1
Calcium	NSFA	2006	Baby food, meat	8.6 mg/100 g	2.0
	NSFA	2007	Baby food, meat	11.0mg/100 g	-0.4
Iron	Bipea	2007	Pre-mix	806 mg/100 g	0.5
	NSFA	2007	Baby food, meat	0.43 mg/100 g	-0.9
Sodium	NSFA	2005	Powder mix	283 mg/100 g	-0.40
	Bipea	2006	Fre-mix	3 mg/100 g	1.5
	Fapas	2007	Fish paste	0.14 mg/100 g	0.1
Potassium	NSFA	2005	Powder mix	661 mg/100 g	0.2
	Bipea	2006	Pre-mix	0.22 mg/100 g	1.0
	NSFA	2007	Baby food, meat	253 mg/100 g	0.6
Magnesium	Bipea	2006	Pre-mix	0.3 mg/100 g	1.5
	Bipea	2007	Pre-mix	0.03 mg/100 g	0.6

Nutrient	Initiated by	Year	Test material	Concentration	Z-score
Zink	Bipea Bipea	2006 2007	Rapeseed cake Pre-mix	5.28 mg/kg 1427 mg/100 g	-0.5 0.6
Selenium	Quasimeme	2006	Tuna fish	176 µg/100 g	0.83
Copper	Bipea Bipea	2006 2007	Rapeseed cake Pre-mix	0.5 mg/100 g 262 mg/100 g	-0.8 1.5
Phosphorous [b]					
Iodine	Bipea	2007	Pre-mix	24 mg/100 g	-0.6

NSFA, The National Swedish Food Administration; Bipea, Bureau InterProfessionnel d'Etude Analytique

[a] Proficiency tests are not available

[b] Nutrients analysed by subcontractor

Appendix 3: Sum of individual fatty acids, macro nutrients and tocopherols/tocotrienols

Table A3.1: Fatty acids (g) per 100 g edible sample (calculated)[a].

Food name	Mackerel, wild	Greenland halibut	Atlantic halibut	Halibut, farmed	Cod, farmed	Salmon, farmed	Trout, farmed
Fatty acid factor [b]	0.9	0.9	0.9	0.9	0.7	0.9	0.9
Fat, g	**25**	**11**	**6.1**	**2.4**	**0.5**	**16**	**10**
Sum total fatty acids, g [c]	22.5	9.9	5.5	2.2	0.35	14.4	9.0
SFA, sum, g	**5.30**	**1.67**	**1.01**	**0.53**	**0.09**	**3.00**	**2.03**
C14:0	1.60	0.32	0.18	0.11	tr	0.59	0.43
C15:0	0.12	0.02	0.02	tr	nd	0.05	0.04
C16:0	2.95	1.08	0.64	0.33	0.06	1.86	1.27
C17:0	0.08	0.01	tr	tr	nd	0.04	0.02
C18:0	0.50	0.22	0.16	0.07	0.02	0.41	0.25
C20:0	0.04	nd	tr	nd	nd	0.03	0.02
C22:0	nd	nd	nd	nd	nd	0.02	nd
C24:0	nd	0.01	nd	nd	nd	nd	nd
MUFA cis, sum, g	**9.09**	**6.94**	**3.08**	**0.64**	**0.05**	**5.91**	**3.52**
C14:1, n-9	nd	nd	tr	nd	nd	nd	nd
C16:1, n-9	0.10	0.03	0.03	tr	nd	0.05	0.03
C16:1, n-7	0.77	1.33	0.50	0.14	tr	0.71	0.46
C18:1, n-11	0.08	0.23	0.10	tr	nd	0.08	0.08
C18:1, n-9	2.41	2.02	1.05	0.24	0.03	3.09	1.53
C18:1, n-7	0.43	0.57	0.30	0.06	tr	0.44	0.24
C20:1, n-11	0.17	0.20	0.07	tr	nd	0.08	0.08
C20:1, n-9	1.84	1.33	0.50	0.07	tr	0.66	0.47
C20:1, n-7,	0.03	0.17	0.06	tr	nd	0.03	0.02
C22:1, n-11	2.85	0.73	0.32	0.07	nd	0.61	0.51
C22:1, n-9	0.19	0.21	0.09	tr	nd	0.08	0.06
C24:1, n-9	0.22	0.10	0.04	tr	nd	0.08	0.05
PUFA cis, sum, g	**7.23**	**1.02**	**1.20**	**0.90**	**0.20**	**5.00**	**3.16**
C16:2, n-4	0.06	0.022	0.02	0.02	nd	0.08	0.04
C16:3, n-3	nd	nd	nd	0.02	nd	0.05	0.03
C16:4, n-3	0.09	nd	tr	0.03	nd	0.06	0.04
C18:2, n-6	0.36	0.07	0.06	0.11	0.01	0.97	0.45
C18:3, n-3	0.34	0.01	0.02	0.02	nd	0.31	0.14
C18:4, n-3	1.03	0.03	0.06	0.03	nd	0.17	0.13
C20:2, n-6	0.05	0.02	0.02	tr	nd	0.08	0.03
C20:3, n-6	nd	nd	nd	nd	nd	0.03	0.02
C20:3, n-3	0.03	nd	nd	nd	nd	0.03	nd
C20:4, n-6	0.09	0.07	0.07	0.03	tr	0.08	0.07
C20:4, n-3	0.27	0.02	0.03	0.02	nd	0.21	0.11
C20:5, n-3 (EPA)	1.76	0.33	0.34	0.26	0.06	1.02	0.64
C22:5, n-3 (DPA)	0.34	0.09	0.07	0.04	tr	0.53	0.23
C22:6, n-3 (DHA)	2.80	0.36	0.50	0.32	0.12	1.39	1.24
Sum n-3, cis	6.66	0.84	1.03	0.74	0.18	3.76	2.56
Sum long n-3, cis	5.20	0.80	0.94	0.64	0.18	3.17	2.22
Sum n-6, cis	0.50	0.16	0.15	0.14	0.02	1.17	0.57
Sum n-9, cis	4.76	3.70	1.72	0.34	0.04	3.96	2.13
Sum unidentified	0.88	0.27	0.20	0.09	tr	0.48	0.28

SFA, saturated fatty acids; MUFA, cis-monounsaturated fatty acids; PUFA, cis-polyunsaturated fatty acids; nd, not detected (below the limit of quantification, 0.001 g); tr, trace (value between 0.01 and the limit of quantification (0.001 g)); EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; sum long n-3, cis includes EPA, DPA and DHA.

[a] The following fatty acids were not analysed: F4:0-F12:0, F10:1C, 18:2n-9C, F18:3C n-6, F20:3C n-9, F21:5C n-3, F22:4C n-6, F22:5C n-6, F24:5C n-3, F24:6C n-3.
[b] Factor for estimating total amount of fatty acids from fat content, Greenfield and Southgate (reference 4)
[c] Calculation of fat*fatty acid factor.

Table A3.2: Fatty acids as weight%, per 100 g fatty acids.

	Mackerel, wild	**Greenland halibut**	**Atlantic halibut**	**Halibut, farmed**	**Cod, farmed**	**Salmon, farmed**	**Trout, farmed**
Fat, g	**25**	**11**	**6.1**	**2.4**	**0.5**	**16**	**10**
Sum total fatty acids, g	22.5	9.9	5.5	2.2	0.35	14.4	9.0
SFA, sum, %	**23.5**	**16.8**	**18.4**	**24.4**	**25.4**	**20.9**	**22.6**
C14:0	7.13	3.26	3.26	5.04	1.82	4.12	4.83
C15:0	0.51	0.22	0.30	0.42	tr	0.33	0.42
C16:0	13.1	10.9	11.7	15.1	18.2	13.0	14.2
C17:0	0.37	0.11	0.15	0.42	nd	0.26	0.21
C18:0	2.24	2.25	2.82	3.36	5.45	2.88	2.73
C20:0	0.19	nd	0.15	nd	nd	0.20	0.21
C22:0	nd	nd	nd	nd	nd	0.13	nd
C24:0	nd	0.11	nd	nd	nd	nd	nd
MUFA cis, sum, %	**40.4**	**70.1**	**56.1**	**29.8**	**14.6**	**41.1**	**39.1**
C14:1, n-9	nd	nd	0.15	nd	nd	nd	nd
C16:1, n-9	0.47	0.34	0.59	0.42	nd	0.33	0.32
C16:1, n-7	3.40	13.5	9.20	6.72	1.82	4.91	5.14
C18:1, n-11	0.37	2.36	1.78	0.42	nd	0.59	0.94
C18:1, n-9	10.7	20.4	19.1	10.9	9.09	21.4	17.0
C18:1, n-7	1.91	5.73	5.49	2.94	1.82	3.07	2.62
C20:1, n-11	0.75	2.02	1.34	0.42	nd	0.59	0.84
C20:1, n-9	8.16	13.5	9.05	3.36	1.82	4.58	5.25
C20:1, n-7,	0.14	1.69	1.19	0.42	nd	0.20	0.21
C22:1, n-11	12.7	7.42	5.79	3.36	nd	4.25	5.67
C22:1, n-9	0.84	2.13	1.63	0.42	nd	0.59	0.63
C24:1, n-9	0.98	1.01	0.74	0.42	nd	0.52	0.52
PUFA cis, sum, %	**32.1**	**10.3**	**21.8**	**41.6**	**58.2**	**34.7**	**35.2**
C16:2, n-4	0.28	0.22	0.30	0.84	nd	0.52	0.42
C16:3, n-3	nd	nd	nd	0.84	nd	0.33	0.32
C16:4, n-3	0.42	nd	0.15	1.26	nd	0.39	0.42
C18:2, n-6	1.59	0.67	1.04	5.04	3.64	6.74	5.04
C18:3, n-3	1.49	0.11	0.44	0.84	nd	2.16	1.57
C18:4, n-3	4.57	0.34	1.04	1.26	nd	1.18	1.47
C20:2, n-6	0.23	0.22	0.30	0.42	nd	0.59	0.32
C20:3, n-6	nd	nd	nd	nd	nd	0.19	0.21
C20:3, n-3	0.14	nd	nd	nd	nd	0.19	nd
C20:4, n-6	0.42	0.67	1.34	1.26	1.82	0.59	0.74
C20:4, n-3	1.21	0.22	0.59	0.84	nd	1.44	1.26
C20:5, n-3 (EPA)	7.83	3.37	6.23	12.2	18.2	7.06	7.14
C22:5, n-3 (DPA)	1.49	0.90	1.34	2.10	1.82	3.66	2.52
C22:6, n-3 (DHA)	12.4	3.60	9.05	14.7	32.7	9.68	13.8
Sum n-3, cis	29.6	8.54	18.8	34.0	52.7	26.1	28.4
Sum long n-3, cis	23.1	8.09	17.21	29.8	52.7	22.0	24.7
Sum n-6, cis	2.24	1.57	2.67	6.72	5.45	8.11	6.30
Sum n-9, cis	21.2	37.4	31.3	15.6	10.9	27.5	23.7
Sum unidentified	3.92	3.71	2.70	4.20	1.82	3.34	3.15

SFA, saturated fatty acids; MUFA, cis-monounsaturated fatty acids; PUFA, cis-polyunsaturated fatty acids; nd, not detected (below the limit of quantification, 0.001 g); tr, trace (value between 0.01 and the limit of quantification (0.001 g);)); EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; sum long n-3, includes EPA, DPA and DHA.

Table A3.3: Sum of macro nutrients (g) per 100 g edible sample.

	Sum of macro nutrients		
Type of fish in P2007	**P2007**	**MVT-06**	**NIFES** [b]
Mackerel, wild (autumn)	98,0	98,7 (July-Sept)	100,8 [c]
Mackerel, wild (autumn)	98,0	98,0 (May-June)	
Greenland halibut, wild	103	102,8	99,0
Atlantic halibut, wild, >30 kg	95.1	98,6	99,9
Atlantic halibut, farmed	97.6	98,6 [a]	99,9
Cod, farmed	100,7	(98,4) [a]	100,4
Salmon, farmed	98,1	100,3	98,8/99,6
Trout, farmed	100,2	97,4	103,1

[a] Wild
[b] ww.nifes.no, updated values per 12 July 2010
[c] Unknown season

Table A3.4: Tocopherols and tocotrienols, mg/100 g sample.

Fish	**Tocopherols. mg**				**Tocotrienols. mg**			
	alpha	**beta**	**gamma**	**delta**	**alpha**	**beta**	**gamma**	**delta**
Atlantic halibut. wild. raw	1.8	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Greenland halibut. wild. raw	3.3	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Atlantic halibut. farmed. raw	0.89	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cod. farmed. raw	0.47	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Salmon. farmed. raw	1.4	<0.005	0.11	<0.005	<0.005	<0.005	<0.005	<0.005
Trout. farmed. raw	1.1	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Mackerel. wild. raw	0.42	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005