THE NUTRITIONAL COMPOSITION OF NORWEGIAN WHITE WHEAT FLOUR (78% EXTRACTION)

Norwegian Food Safety Authority

Directorate for Health and Social Affairs

Department of Nutrition, University of Oslo

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Foreword

The Norwegian Food Safety Authority and the Norwegian Directorate for Health and Social Affairs 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 is led by Rønnaug Aarflot Fagerli from the Norwegian Food Safety Authority. Other members of the group are Åse Borgejordet and Astrid Nordbotten from the Food Safety Authority, Kari Norunn Vesterhus from the Directorate for Health and Social Affairs and Jannicke Fredriksen, Elin Bjørge Løken and Kerstin Trygg from the Department of Nutrition at the University of Oslo.

The sampling plan and requirement specification for this particular project were prepared by Borgejordet and Nordbotten with the assistance of Trygg, Løken, and Vesterhus. Control of the analytical results was performed by Borgejordet, Nordbotten, and Fredriksen. The manuscript for the present report was prepared by Fredriksen in collaboration with the rest of the food composition database group.

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 in the present project was conducted by NIFES's laboratory under the leadership of Kåre Julshamn with Kathrin Gjerdevik as chief technician.

We wish to thank everybody who has been involved in 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 white wheat flour (78% extraction), henceforth called wheat flour, in the continuous task to update the Norwegian Food Composition Table and database.

Each year a varying percentage of imported wheat is added to the wheat grown in Norway to enhance the quality of the flour. In the present project, the wheat flour was sampled as ready for purchase, i.e. the flour consisted of a mix of Norwegian and imported wheat. Eleven samples of wheat flour based on the Norwegian 2003 crop and 10 samples of wheat flour based on the Norwegian 2004 crop were analyzed for relevant nutrients. Flour samples from the two largest Norwegian milling companies, Norgesmøllene and Cerealia, were included in the project. Both milling companies receive wheat from mills from different parts of the country and make flour for household use (household flour) and flour for use by bakeries and the food industry (industrial flour). For key nutrients, household flour and industrial flour were sampled separately to be able to identify possible differences in the nutritional composition between the two types of flour. Samples from each milling company were also kept separate to be able to identify possible differences in nutritional composition in flour from the two companies. Likewise, samples from each of Norgesmøllene's three regional mills were analyzed separately for selected nutrients to study possible regional differences in nutrient composition in flour from mills located in different parts of the country.

The majority of the analyses were performed at the National Institute of Nutrition and Seafood Research's laboratory in Bergen, Norway. However, analysis of starch, dietary fiber, and sugars were performed by a subcontractor.

Generally, only small differences were seen between the nutrient content of household flour and industrial flour, between flour based on the 2003 crop and flour based on the 2004 crop, and between flour from mills in different parts of the country. The flour samples based on the 2004 crop had a lower water content than the samples based on the 2003 crop, while the starch content was higher in the samples based on the 2004 crop.

For the majority of nutrients, no large differences in nutrient content were seen compared to the present values in the Norwegian Food Composition Table 2006 for wheat flour. However, the carbohydrate content was higher in the present project due to a higher analyzed content of starch.

The analytical results from the various mills, milling companies, and flour types were combined according to market shares at the beginning of the project. For the majority of nutrients, a mean value between the flour based on the 2003 and 2004 crop was calculated for future inclusion in the food composition table. As no explanation was found with respect to the somewhat deviant analytical results for water and starch in the 2004 crop, these values were not used when compiling the table values.

New analytical values from the present analytical project will be included in the Norwegian food composition database and replace the present values for wheat flour in the Norwegian Food Composition Table at the next update.

Norwegian summary/Norsk sammendrag

Formålet med prosjektet var å skaffe til veie oppdatert informasjon om næringsinnholdet i siktet hvetemel (heretter kalt hvetemel) som et ledd i det kontinuerlige arbeidet med å oppdatere den norske matvaredatabasen og Matvaretabellen.

Hvert år tilsettes den norske hveten en varierende andel importert hvete for å øke kvaliteten på melet. Det ble i dette analyseprosjektet tatt prøver av hvetemel slik det selges til forbrukere og matvareprodusenter, det vil si mel bestående av en blanding av norsk og importert hvete. Elleve prøver av hvetemel basert på den norske avlingen fra 2003 og 10 prøver av hvetemel basert på den norske avlingen fra 2004 ble analysert for relevante næringsstoffer. Mel fra de to største norske melprodusentene Norgesmøllene og Cerealia ble inkludert i prosjektet. Begge produsentene mottar mel fra flere ulike møller og produserer hvetemel til bruk i privathusholdninger (husholdningsmel) og hvetemel som brukes av bakerier og matvareindustrien (bakerimel). Utmalingsgraden ble oppgitt å være 78 % for begge meltyper og begge produsenter. For de mest sentrale næringsstoffene, ble husholdningsmel og bakerimel analysert hver for seg for å kunne avdekke eventuelle forskjeller i næringsinnhold. Tilsvarende ble mel fra de to produsentene og mel fra de tre regionale møllene tilhørende Norgesmøllene analysert som separate prøver for utvalgte næringsstoffer for å avdekke mulige forskjeller i sammensetning.

Nasjonalt institutt for ernærings- og sjømatforskning i Bergen var hovedansvarlig for analysearbeidet. For analyse av stivelse, fiber og mono- og disakkarider ble det benyttet en underleverandør.

Generelt var det små forskjeller i næringsinnhold mellom husholdningsmel og bakerimel, mellom hvetemel fra de to avlingsårene, og mellom hvetemel fra de ulike møllene. Melprøvene basert på 2004-avlingen hadde et lavere vanninnhold enn prøvene basert på 2003-avlingen, mens melprøvene basert på 2004-avlingen hadde et høyere stivelsesinnhold.

For de fleste av næringsstoffene ble det ikke funnet vesentlige forskjeller mellom resultatene fra dette analyseprosjektet og eksisterende verdier for hvetemel i Matvaretabellen 2006. Innholdet av karbohydrater var imidlertid høyere enn tidligere på grunn av et høyere stivelsesinnhold.

Analyseresultatene fra de to hvetemeltypene og de forskjellige møllene ble kombinert i henhold til markedsandeler ved prosjektets start. For de fleste analyserte næringsstoffene ble det så regnet et gjennomsnitt mellom analyseresultatene fra mel basert på 2003-avlingen og mel basert på 2004-avlingen. Da det ikke ble funnet noen logisk forklaring på hvorfor vann- og stivelsesinnholdet i melet basert på 2004-avlingen avvek fra melet basert på 2003-avlingen, melverdier i Matvaretabellen 2006 og andre lands verdier for vann og stivelse i hvetemel, ble disse verdiene ansett som ikke representative for norsk hvetemel og derfor ikke inkludert i gjennomsnittsverdiene som skal presenteres i Matvaretabellen.

Hovedresultatene fra dette analyseprosjektet vil erstatte tidligere verdier for siktet hvetemel i den norske matvaredatabasen og Matvaretabellen ved neste oppdatering.

Background

Norwegian white wheat flour (henceforth called wheat flour) contains 78% of the wheat grain, i.e. the extraction rate is 78%. Each year a varying percentage of imported wheat grain is added to the wheat grown in Norway to enhance the quality of the flour. As shown in Table 1, the percentage of Norwegian grown wheat grain in wheat flour has increased during the last 10 years[1]. In 2003 wheat was imported mainly from Kazakhstan, Denmark, Canada, and USA, and in 2004 wheat was imported mainly from Canada, Kazakhstan, and Germany[2]. Norwegian wheat flour is not enriched. However, a small amount of vitamin C is added to the flour for technological purposes. The two largest milling companies in Norway are Cerealia and Norgesmøllene. Both milling companies make flour for household use (household flour) and flour for use by the food industry (industrial flour).

Table 1: Percentage of Norwegian wheat grain in wheat flour produced in Norway[1].

Year	Percentage of Norwegian wheat grain
1996	51
1997	59
1998	65
1999	46
2000	60
2001	68
2002	42
2003	68
2004	75
2005	75
2006	73
2007	74

According to the most recent Norwegian dietary survey (Norkost 1997), 14 % of the energy intake came from wheat flour for men (117 g wheat flour/day) while wheat flour contributed 13% to the total energy intake in women (87 g wheat flour/day)[3, 4]. Table 2 shows the contribution of wheat flour to intake of selected nutrients in the Norwegian diet. As can be seen from the table, wheat flour contributes significantly to the total intake of several essential nutrients, emphasizing the importance of having reliable data on the nutritional composition of this food item.

Table 2: Wheat flour as a source of nutrients in Norkost 1997 (n = 2672)[3, 4].

Nutrient	Total intake per day	Intake per day from wheat flour	Percentage of total intake from wheat flour
Energy, MJ	9.4	1.3	14
Protein, g	86	11	13
Fat, g	79	2	3
Carbohydrates, g	284	63	22
Fiber, g	23	3	13
Alpha-tocopherol, mg	8	0.6	8
Thiamin, mg	1.4	0.26	19
Riboflavin, mg	1.7	0.04	2
Calcium, mg	949	17	2
Iron, mg	10.8	1.4	13
Magnesium, mg	347	32	9

The most recent revisions of the nutritional composition of Norwegian wheat flour were done for the edition of the Norwegian Food Composition Table that was published in 2001 (MVT-01[5]). These data were mainly analytical values from 1991, 1992, 1997, and 1998. The same data were also used in the Norwegian Food Composition Table from 2006 (MVT-06)[6].

Purpose

The purpose of the present analytical project was to obtain new, representative data on the nutritional composition of wheat flour on the Norwegian market. The main results from this project will be included in the Norwegian food composition database and replace existing nutrient values in the next updated version of the Norwegian Food Composition Table.

Materials and methods

Sampling procedures

Wheat flour from the milling companies Cerealia (Regal) and Norgesmøllene (Møllerens) was included in the project. Cerealia has two mills, one in Oslo (South Eastern Norway) and one in Kristiansand (Southern Norway), and Norgesmøllene has three mills located in Vaksdal (Western Norway), Skien (South Eastern Norway), and Buvika (Central Norway) (Figure 1). These locations represent the largest wheat producing areas in Norway. Only small amounts of wheat are grown north of Trondheim.

Figure 1: Location of the mills included in the project.

Household flour and industrial flour were sampled separately to be able to identify possible differences in the nutritional composition of key nutrients between the two flours. Samples from Norgesmøllene's three mills were kept separate for analysis of the main nutrients to be able to study possible regional differences in nutritional composition between the flours. Cerealia's industrial flour was analyzed as a composite sample of flour from the mills in Oslo and Kristiansand. Cerealia's household flour is only produced in Oslo.

As shown in Table 1, wheat flour sold in Norway is a mix between Norwegian grown wheat and imported wheat. For Norgesmøllene about 10 % of the wheat was imported in 2003 while 15 % of the wheat was imported in 2004. For Cerealia 25-30 % of the wheat was imported both years. The Norwegian grown part of wheat flour sold from January to early August is made from the crop from the previous year while the Norwegian part of flour sold from August is made from the crop from the present year. However, from August to December the flour may be a mix between flour from the previous and present year's crops. Hence, flour samples that were collected from June to August 2004 represent the 2003 crop while samples collected from January to February 2005 represent the 2004 crop.

The majority of the nutrient analyses were performed at the National Institute of Nutrition and Seafood Research's (NIFES) laboratory in Bergen, Norway. Analysis of starch, dietary fiber, and sugars were performed by a subcontractor (AnalyCen) in Sweden.

Wheat flour samples of 1-3 kg were sent by mail at normal temperature from the various mills to the laboratory in Bergen. Additional samples of household flour from the milling company Cerealia were bought in grocery stores and supermarkets in Bergen in June 2004 (wheat crop from 2003) and November 2004 (wheat crop from 2004) and stored at room temperature (20-22 ^{o}C) until preparation. A pooled sample of household flour based on the 2003 crop from both milling companies was stored for approximately half a year under dark and dry conditions at room temperature (20-22 ^{o}C) to be able to study possible changes in the nutritional composition for selected nutrients after storage. The total number of primary samples was 58, while the number of analyzed samples was 21. A description of the primary and composite samples is presented in table A1 in Appendix 1.

Sample handling

All primary samples were weighed at arrival, wrapped in plastic bags, and stored under dark and dry conditions until all samples had arrived at the laboratory. Monthly temperature controls were performed, and the temperature varied between 20-22°C.

Composite samples were prepared according to the sampling plan and mixed using a Braun food processor. The aggregation of the samples is given in Appendix 1 (Table A1). The composite samples were then divided into secondary samples using a Recht vibratory feeder and transferred to 100 ml cups for distribution to the respective laboratories. For the laboratory analyzes of fat and vitamins, the samples were split into smaller portions of 20 g each with a Retsch Rotary Sample Divider. Secondary samples for analysis of vitamin C were analyzed the same day as the samples were divided and prepared because of the instability of this vitamin. Vitamin C was added to samples for analysis of folate before freezing at -80°C until analysis. The secondary samples from the 2003 crop were prepared in September 2004, and secondary samples from the 2004 crop were prepared in March 2005.

Samples for analysis of sugars, dietary fiber, and starch were sent to a subcontractor (AnalyCen) in Sweden using an overnight express delivery, packed on dry ice (carbon dioxide snow).

Analytical methods

Principles of the analytical methods are given in Table 3, while a detailed description of the methods is presented in Appendix 2.

Table 3: Analyzed 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	Combustion method, Leco	Yes	0.1 g
Ash	Gravimetric	Yes	0.1 g
Total fat	Acid hydrolysis	Yes	0.1 g
Fatty acids: SFA, MUFA, PUFA	Capillary gas chromatography	Yes	0.001 g
Sugars [a]	HPLC	Yes	40 mg
Starch [a]	Enzymatic	Yes	40 mg
Dietary fiber [a]	Gravimetric	Yes	0.5 g
Tocopherols/ Tocotrienols	HPLC	Yes	5 µg
Thiamin [b]	HPLC	Yes	10 µg
Riboflavin	HPLC	Yes	13 µg
Niacin	Microbiological	Yes	90 µg
Vitamin B_6 [b]	HPLC	Yes	20 µg
Folate	Microbiological	Yes	0.4 µg
Vitamin C	HPLC	Yes	0.1 mg
Calcium	Flame AAS	Yes	1.5 mg [d]
Iron	Flame AAS	Yes	0.3 mg [d]
Sodium	Flame AAS	Yes	0.3 mg [d]
Potassium	Flame AAS	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	Graphite furnace AAS	Yes	4.1 mg [d]

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

[a] Analysis performed by subcontractor.

[b] The values for thiamin and vitamin B_6 are presented as hydrochlorides. The conversion factor from thiamin chloride to thiamin is 0.892. The conversion factor from pyridoxine chloride to pyridoxine is 0.823.

[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.

Analyzed nutrients

Both household flour and industrial flour from each milling company and year were analyzed for the key nutrients; water, protein, fat, sugars, starch, fiber, ash, thiamin, folate, vitamin C, vitamin E, iron, and selenium. Fatty acids, riboflavin, niacin, vitamin B6, calcium, sodium, potassium, magnesium, zinc, copper, and phosphorous were analyzed in a composite sample of household and industrial flour for each milling company and year. Cholesterol, retinol, vitamin D, and vitamin B12 were not analyzed as these nutrients are present only in foods of animal origin[7]. Likewise, alcohol, trans fatty acids, and β-carotene were assumed not to be present in the flour and therefore not analyzed. The stored sample of household flour from the 2003 crop was analyzed for water, sugars, starch, vitamin E, thiamin, folate, and vitamin C, to evaluate possible changes in nutrient composition after storage. All the concentrations given in this report are based on µg, mg or g per 100 gram of flour.

Reliability of the analytical methods
Two parallels were analysed for each secondary sample for each nutrient. The result was accepted when the difference between the parallels was less than 5 % for the energy yielding nutrients and less than 10% for the remaining nutrients where 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 larger difference between the parallels was accepted. If an unacceptably large variation between the parallels was seen, additional parallels were analyzed. 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 A3.1in Appendix 3). NIFES participates in laboratory performance tests on a regular basis (Table A3.2 in Appendix 3). The subcontracting laboratory has not provided information concerning use of control or reference material.

Calculation of nutrient values
The sum of macronutrients and the contents of protein and total carbohydrates were calculated according to the algorithms given in Table 4.

Table 4: Algorithms for nutrient calculations.

Nutrient	**Algorithm**
Sum macronutrients, g	Protein (g) + carbohydrates (g) + fat (g) +dietary fiber (g) + water (g) + ash (g)
Protein, g	Nitrogen (g) x 5.7 (nitrogen to protein conversion factor for wheat flour)
Carbohydrates, g	Starch (g) + mono and disaccharides (g)

Quality control of received analytical data
After receiving the analytical data from the laboratory, the sum of macronutrients was calculated for all analytical results as a control of the reliability of the data. Summations within the range of 97 to 103 g are considered acceptable[8]. Weighted means according to market shares in 2003 were calculated for each flour type and year and compared to existing values for wheat flour in MVT-06[6], values from Swedish[9], Danish[10], Finish[11], English[12], and American[13] tables, and information from the milling companies. The purpose of this comparison was to evaluate if the analytical results were within expected ranges and hereby reveal possible divergent values caused by errors during the analytical process or during recording of results or special circumstances concerning the food item.

The wheat flour samples based on the 2004 crop showed high starch values also after adjusting for the water content of the samples. Summation of the macronutrients in each analyzed sample showed values higher than 103 g for the same samples, suggesting that the values for starch were somewhat higher than normal. However, there is always a measurement uncertainty connected to an analytical result (x). In the case of the flour based on the 2004 crop, the starch content was determined to approximately 76 g/100 g. According to the laboratory the uncertainty of the starch analyzes (u) was 8%. Using a covering factor of 2 the expanded uncertainty (U) is given by the equation

$$U = 2 * u$$

A result based on the analytical result (x) should thus be reported as X

$$X = x \pm U \quad (95\% \text{ confidence})$$

Applied on the starch a result x of 70.7 g/100 g (2003 crop), this should be reported as

$$X = \left[70.7 \pm 2 * 70.7 \frac{8}{100} \right] g/100g = \left[70.7 \pm 11 \right] g/100g$$

In other words, the content of starch in a sample with a reported value x *=70.7* is with 95 % confidence between 60 g/100 g and 82 g/100 g. This range includes the starch content determined in the 2004 crop.

The water content of the wheat flour samples based on the 2004 crop were lower than the water levels in MVT-06, other countries' tables and information from the milling companies. No large deviations were seen for the other nutrients.

Results and discussion

Macronutrients

The concentration ranges of nutrients in the analyzed samples of wheat flour are shown in Table 5. The individual analytical values are presented in Appendix 4 (Table A4.1).
Only small differences in macronutrient content were seen between household flour and industrial flour (Figure 2). The largest differences between the flours based on the 2003 and the 2004 crop were a lower water content in the 2004 flour and a higher starch content in the 2004 flour (Figure 2). The nutritional composition of the flour did not differ notably between the two milling companies or between the three mills belonging to Norgesmøllene (Tables A4.1-A4.4). Compared to the values for wheat flour in MVT-06[6], the carbohydrate content was generally higher in the present project due to a higher analyzed content of starch, particularly in the results based on the 2004 crop. For wheat flour based on the 2004 crop, the analyzed water content of the flour was lower than the values in both MVT-06 and MVT-95[14].

Micronutrients

Vitamin C levels of 4-6 mg/100 g were measured in all the analyzed flour samples. According to the milling companies this is explained by the addition of 3-4 mg vitamin C per 100 g wheat flour to speed up the maturation process of the flour.

The analyzed selenium content of wheat flour in the present project ranged from 0-9 µg/100 g (Figure 6). The selenium content seemed to be slightly higher in the industrial flour than in the household flour, but was generally low which was expected because of the low selenium levels in Norwegian soil[15]. The selenium content of imported wheat is usually higher than in wheat grown in Norway. For example, the selenium content of unenriched all-purpose white wheat flour in the American food composition table (USDA SR20[13]) is listed as 34 µg/100 g. Therefore the amount and origin of imported wheat added to the Norwegian wheat will influence selenium levels in the flour from year to year. The differences in selenium content between household flour and industrial flour may have been caused by differences in the percentage of imported wheat added to the Norwegian wheat between the two flour types or by addition of wheat from different countries. The selenium value (6 µg) listed for wheat flour in MVT-06 lies within the range of selenium values analyzed in the present project. In MVT-95 the selenium content was higher, presumably due to a higher percentage of imported wheat added to the Norwegian wheat.

For the other analyzed micronutrients no large differences were seen between household flour and industrial flour, between flour from mills in different parts of the country or between flour based on the 2003 and 2004 crops (Figures 3-5).

Stored sample

For the composite sample of household flour from the 2003 crop that was stored dark at room temperature (20-22°C) for 6 months, the water content had dropped about 50 % during storage while the content of maltose was higher than for the flours that had not been stored (Table 5). The content of carbohydrates, vitamin E, thiamin, folate, and vitamin C was not notably changes after six months of storage.

Table 5: Range of nutrient content of the analyzed samples of wheat flour and content of selected nutrients in the stored composite sample.

Nutrient/100 g wheat flour	Unit	Wheat flour household 2003, range (n = 4)	Wheat flour household 2004, range (n = 4)	Wheat flour industrial, 2003, range (n = 4)	Wheat flour industrial, 2004, range (n = 4)	Stored sample [a] (n = 1)
Water	g	12.5-13.6	10.2-10.6	13.2-13.7	10.3-10.5	7.1
Ash	g	0.3-0.6	0.6	0.3-0.6	0.6-0.7	
Protein	g	11.5 -11.6	10.5-11.7	11.5-12.0	10.9-11.7	
Total fat	g	1.2-1.6	1.5-1.6	1.4-1.6	1.4-1.7	
SFA [b]	g	0.2-0.4	0.2	0.2-0.4	0.2	
MUFA [b]	g	0.2	0.2	0.2	0.2	
PUFA [b]	g	0.8-0.9	0.7-0.8	0.8-0.9	0.7-0.8	
Glucose	g	<0.04	<0.04	<0.04	<0.04-0.04	<0.04
Fructose and lactose	g	<0.04	<0.04	<0.04	<0.04	<0.04
Maltose	g	0.21-0.31	0.28-0.43	0.28-0.90	0.41-0.64	1.4
Sucrose	g	0.27-0.32	0.33-0.38	0.28-0.35	0.34-0.42	0.30
Starch	g	70.5-71.0	75.1-78.6	70.2-71.3	74.2-78.3	74.7
Dietary fiber	g	3.1-3.4	3.1-3.4	3.0-3.5	3.0-3.6	
Alpha-tocopherol	mg	0.6-0.8	0.7-0.9	0.7	0.8-0.9	0.7
Thiamin [c]	mg	0.19-0.29	0.22-0.28	0.24-0.29	0.25-0.30	0.24
Riboflavin [b]	mg	0.04	0.04	0.04	0.04	
Niacin [b]	mg	1.3-1.6	1.4-1.5	1.3-1.6	1.4-1.5	
Vitamin B6 [b, c]	mg	0.07	0.08	0.07	0.08	
Folate	µg	16-17	17-22	17-18	18-21	17
Vitamin C	mg	4-6	4-5	4-5	4-5	5
Calcium [b]	mg	15-16	19-22	15-16	19-22	
Iron	mg	1.1-1.3	1.1-1.3	1.2-1.3	1.2-1.9	
Sodium [b]	mg	<0.29	1	<0.29	1	
Potassium [b]	mg	163-174	160-165	163-174	160-165	
Magnesium [b]	mg	31-33	37	31-33	37	
Zink [b]	mg	0.8-0.9	0.9-1.0	0.8-0.9	0.9-1.0	
Selenium	mg	0-3	1-5	2-6	6-9	
Copper [b]	mg	0.12-0.15	0.14-0.15	0.12-0.15	0.14-0.15	
Phosphorus [b]	mg	135-138	126-136	135-138	126-136	

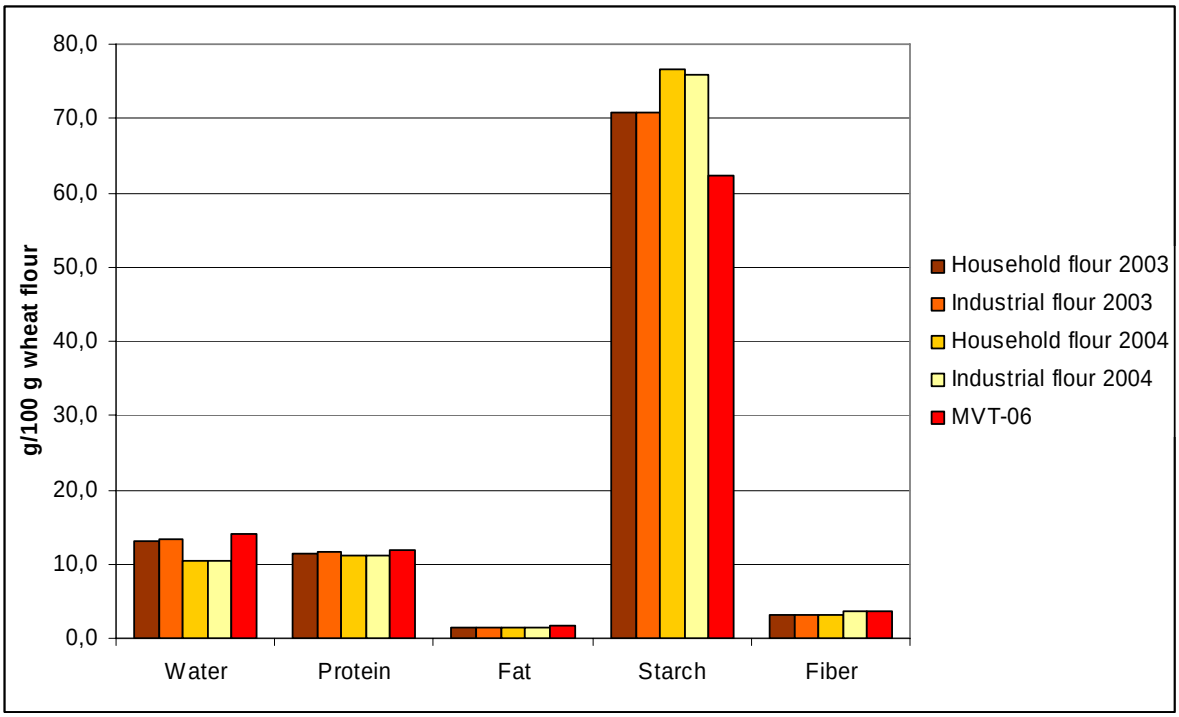
SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids

[a] This sample consisted of household flour from the 2003 crop from Cerealia and Norgesmøllene that was stored under dark conditions for six months prior to analysis.

[b] Analyzed as a composite sample of household and industrial flour from each milling company, n=2.

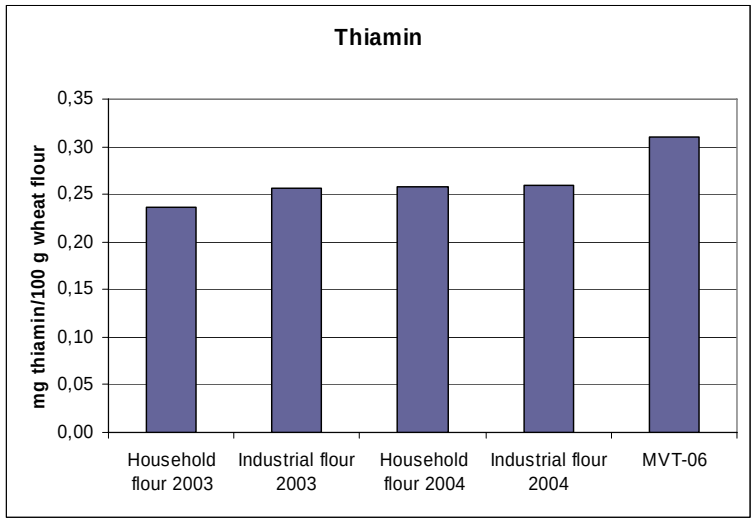
[c] Analyzed as hydrochloride

Figure 2: Concentrations of water and macronutrients in household and industrial flour from 2003 and 2004 compared to values presently in the Norwegian Food Composition Table.



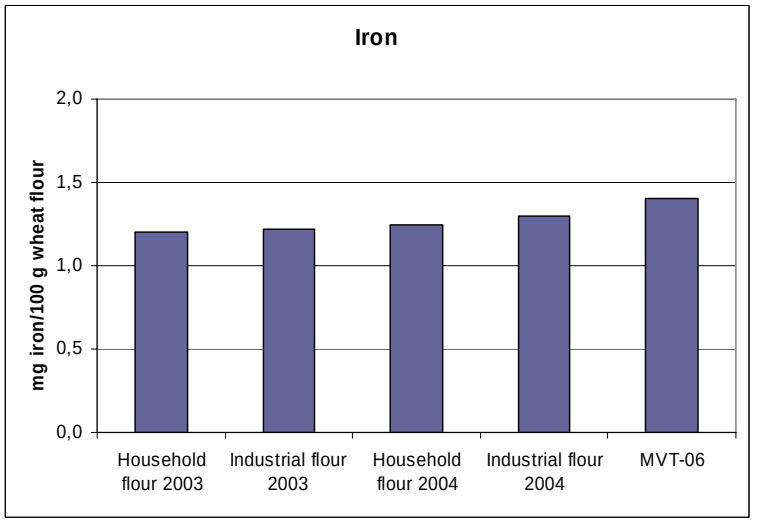
MVT-06, The Norwegian Food Composition Table 2006

Figure 3: Thiamin in wheat flour.



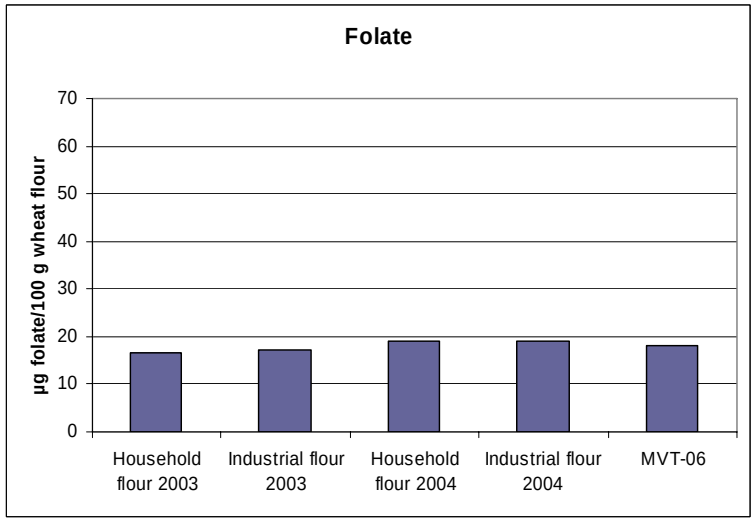
MVT-06, The Norwegian Food Composition Table 2006.

Figure 4: Iron in wheat flour.



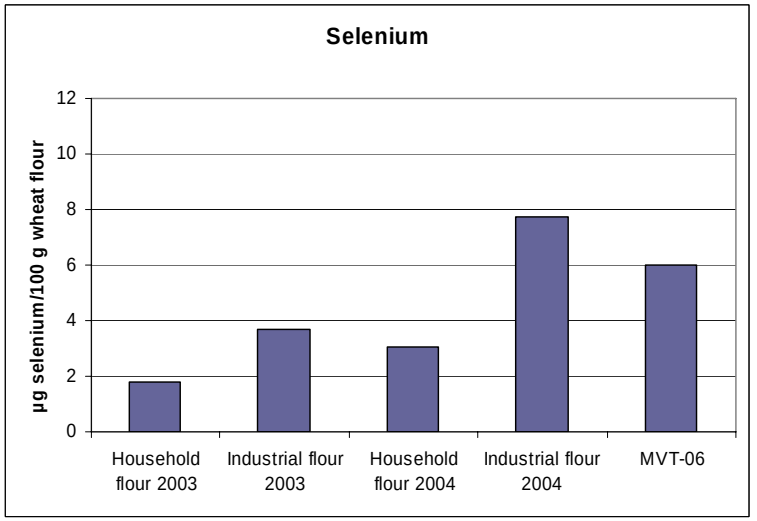
MVT-06, The Norwegian Food Composition Table 2006.

Figure 5: Folate in wheat flour.



MVT-06, The Norwegian Food Composition Table 2006.

Figure 6: Selenium in wheat flour.



MVT-06, The Norwegian Food Composition Table 2006.

Adaptation of 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 6. Trans fatty acids, added sugar, alcohol, cholesterol, retinol, β-carotene, vitamin D, and vitamin B12 were regarded as natural zeros.

Table 6: Algorithms for calculation of energy and niacin equivalents.

Nutrient	Algorithm
Energy, kJ	(protein (g) x 17 kJ) + (fat (g) x 37 kJ) + (carbohydrate (g) x 17 kJ) + (dietary fiber (g) x 8 kJ)
Energy, kcal	(protein (g) x 4 kcal) + (fat (g) x 9 kcal) + (carbohydrate (g) x 4 kcal) + (dietary fiber (g) x 2 kcal)
Niacin equivalents, NE	(Niacin (mg) x 0.30) + (protein (mg) x 0.01/60) [a]

[a] The protein in wheat flour was estimated to contain 1% tryptophan. 60 mg of tryptophan equals 1 mg of niacin. The bioavailability of niacin in wheat flour was set to 30%[16, 17].

As only α-tocopherol contributes vitamin E activity in foods[18], the listed content of vitamin E includes only the contribution from α-tocopherol.

Only small differences were seen in nutritional composition between household and industrial flour, and therefore a weighted mean between the two flour types was calculated for future inclusion in the food composition table. Based on information from the milling companies, this weighted mean was calculated as 17% household flour and 83% industrial flour. Results from the various mills were combined according to estimated market shares in 2003. For the majority of the analyzed nutrients, a mean value between the flour based on the 2003 crop and flour based on the 2004 crop was calculated for inclusion in the food composition table.

However, the analyzed starch values for wheat flour based on the 2004 crop were higher than the starch value for wheat flour in MVT-06, starch values for wheat flour from other countries' food composition tables, and results from analysis of starch in flour based on the 2003 crop. The sum of macronutrients was higher than the acceptable maximum level of 103 g[8] for the same samples where the analyzed starch content was higher than expected. Even though the starch values from 2004 were within the acceptable measurement uncertainty of analyzes for starch in flour based on the 2003 crop, this may suggest that the analyzed starch content in the 2004 flour might be higher than what is representative of Norwegian wheat flour in general. Likewise, the water content of the flour samples based on the 2004 crop was lower than expected compared to MVT-06, other countries' tables and results from analysis of flour based on the 2003 crop. As no explanation was found with respect to the somewhat deviant analytical results for water and starch in the 2004 crop, these values were not used when compiling the starch and water values to be included in the food composition table.

Vitamin C levels of 4-6 mg/100 g were measured in all the analyzed flour samples. However, according to a bread baking study from 1998 (unpublished results), the vitamin C content in bread was not quantifiable after baking although similar vitamin C levels as in the present project were measured in the flour before baking. Hence, the vitamin C content of wheat flour will be presented as zero in the food composition table because of cooking losses during the bread baking process.

The data that will be included in the Norwegian Food Composition Table at the next update, the nutrient content of wheat flour currently in MVT-06, and the nutrient content of wheat flour from the Norwegian Food Composition Table from 1995 are shown in Table 7.

Table 7: Updated nutrient values for wheat flour compared to values in MVT-95 and MVT-06

Nutrient	**Unit**	**Wheat flour, MVT-95** [a]	**Wheat flour, MVT-06** [b]	**Wheat flour, present project**
Edible	%	100	100	100
Water	g	15	14	13
Energy	kJ	1410	1379	1493
Energy	kcal	332	325	352
Protein	g	11.4	11.8	11.4
Fat	g	2.0	1.7	1.5
Saturated fatty acids	g	0.2	0.2	0.2
Trans fatty acids [c]	g	- [d]	0	0
Monounsaturated fatty acids	g	0.3	0.3	0.2
Polyunsaturated fatty acids	g	0.9	0.8	0.8
Cholesterol [c]	mg	0	0	0
Carbohydrates [e]	g	67.2	63.9	71.6
Starch	g	63.0	62.4	70.7
Mono- and disaccharides	g	0.5	1.5	0.9
Added sugar [c]	g	0	0	0
Fiber	g	2.9	3.6	3.4
Alcohol [c]	g	0	0	0
Retinol [c]	µg	0	0	0
b-carotene [c]	µg	0	3	0
Vitamin A [c]	RAE	0	0	0
Vitamin D [c]	µg	0	0	0
Vitamin E	α-TE	0.6	0.8	0.8
Thiamin [f]	mg	0.28	0.31	0.26
Riboflavin	mg	0.04	0.03	0.04
Niacin	mg	1.4	2.7	1.4
Niacin equivalents	NE	2.3	2.8	2.3
Vitamin B6 [f]	mg	0.08	0.08	0.08
Folate	µg	13	18	18
Vitamin B12	µg	0	0	0
Vitamin C [c]	mg	0	0	0 [g]
Calcium	mg	18	18	18
Iron	mg	1.5	1.4	1.2
Sodium	mg	6	2	1
Potassium	mg	167	193	166
Magnesium	mg	34	39	34
Zinc	mg	1.0	1.0	0.9
Selenium	µg	17	6	5
Copper	mg	0.18	0.14	0.14
Phosphorous	mg	- [d]	144	134

RAE, retinol activity equivalents; NE, niacin equivalents; α-TE, α-tocopherol equivalents; MVT-06, The Norwegian Food Composition Table 2006; MVT-95, The Norwegian Food Composition Table 1995.

[a] Mainly analytical data from 1991 and analytical data from manufacturers.

[b] Mainly analytical data from 1992 and 1998 updated to be included in MVT-01 and forwarded to MVT-06.

[c] If zero, compiled as natural zero, not analyzed.

[d] Missing value.

[e] Carbohydrates are calculated as the sum of mono- and disaccharides and starch.

[f] Given as hydrochloride.

[g] Compiled as zero because of cooking losses during the bread baking process.

Values for individual fatty acids are shown in Table A4.3 in Appendix 4.

As shown in Table 7, the results from the present project showed a higher starch content in the flour compared with current (MVT-06) and previous (MVT-95) values for wheat flour in the Norwegian Food Composition Table. For the remaining nutrients, no large differences were seen between the present project and previous values.

Conclusion

Compared to current values for wheat flour in the Norwegian Food Composition Table, the results from the present project showed a higher content of starch in the flour. For the remaining nutrients, no large differences were seen between the present project and the previous values. Only small differences were seen between flour based on the 2003 and the 2004 crops, between flour from different milling companies and regions, and between flour for household use compared to wheat flour made for industrial purposes.

With the exception of a lower water content and a somewhat higher maltose content, the nutritional composition of wheat flour was not notably changed after six months of storage.

New analytical values from the present project will replace the current values for wheat flour in the Norwegian Food Composition Table at the next update.

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Appendix 1: Food samples

Table A1. Sample identification number, product, milling company, mill, primary, and composite samples.

Sample no	Product [a]	Milling company	Mill(s)	No of primary samples	Description of samples
2003-1	Household flour	Norgesmøllene	Vaksdal	2	1 sample from June and 1 sample from August 2004
2003-2	Household flour	Norgesmøllene	Buvika	2	1 sample from June and 1 sample from August 2004
2003-3	Household flour	Norgesmøllene	Skien	2	1 sample from June and 1 sample from August 2004
2003-4	Household flour	Cerealia	Oslo	7	1 sample from June and 1 sample from August, 5 samples from stores in June 2004
2003-5	Industrial flour	Norgesmøllene	Vaksdal	4	1 sample for each of 2 types of industrial flours in June and August 2004
2003-6	Industrial flour	Norgesmøllene	Buvika	4	1 sample for each of 2 types of industrial flours in June and August 2004
2003-7	Industrial flour	Norgesmøllene	Skien	4	1 sample for each of 2 types of industrial flours in June and August 2004
2003-8	Industrial flour	Cerealia	Oslo and Kristiansand	4	1 sample from each of 2 mills in June and August 2004
2003-9	Household flour and industrial flour	Norgesmøllene	Vaksdal, Buvika, and Skien	18	Aggregated sample from 2003-1, 2003-2, 2003-3, 2003-5, 2003-6, and 2003-7
2003-10	Household flour and industrial flour	Cerealia	Oslo and Kristiansand	11	Aggregated sample from 2003-4 and 2003-8
2003-11	Household flour for storage	Nørgesmølle Cerealia		13	Aggregated sample from 2003-1, 2003-2, 2003-3, and 2003-4
2004-1	Household flour	Norgesmøllene	Vaksdal	2	1 sample from January and 1 sample from February 2005
2004-2	Household flour	Norgesmøllene	Buvika	2	1 sample from January and 1 sample from February 2005
2004-3	Household flour	Norgesmøllene	Skien	2	1 sample from January and 1 sample from February 2005
2004-4	Household flour	Cerealia	Oslo	7	1 sample from January and 1 sample from February 2005, 5 samples from stores in November

Sample no	Product [a]	Milling company	Mill(s)	No of primary samples	Description of samples
					2005
2004-5	Industrial flour	Norgesmøllene	Vaksdal	4	1 sample for each of 2 types of industrial flours in January and February 2005
2004-6	Industrial flour	Norgesmøllene	Buvika	4	1 sample for each of 2 types of industrial flours in January and February 2005
2004-7	Industrial flour	Norgesmøllene	Skien	4	1 sample for each of 2 types of industrial flours in January and February 2005
2004-8	Industrial flour	Cerealia	Oslo and Kristiansand	4	1 sample from each of 2 mills in January and February 2005
2004-9	Household flour and industrial flour	Norgesmøllene	Vaksdal, Buvika and Skien	18	Aggregated sample from 2004-1, 2004-2, 2004-3, 2004-5, 2004-6, and 2004-7
2004-10	Household flour and industrial flour	Cerealia	Oslo and Kristiansand	11	Aggregated sample from 2004-4 and 2004-8

[a] All flour samples were analyzed as raw material.

Appendix 2: Description of analytical methods

Water (dry matter)
Method description: The dry matter content was determined gravimetrically by drying a 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 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 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 factor 5.7 was used.
Limit of quantification: 0.1 g/100 g.

Total fat (acid extraction)
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: 0.1 g/100 g.

Individual fatty acids (saturated, monounsaturated, and polyunsaturated cis fatty acids)
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 wheat flour.
Limit of quantification: 0.001 g/100 g.

Mono and disaccharides (subcontractor - AnalyCen)
Method description: All samples were homogenized before being sent to the subcontractor AnalyCen. The sugars were solved in distilled water at 85 °C. Determination was done using high pH anion exchange chromatography fitted with an electrochemical detector. The analysis is based on the methods described in "Methods of analysis for nutrition labeling (1993) ch.33, Sugars (Mono, Di)". AnalyCen participate in LPTs organized by *AACC (American association of cereal chemists).* The method is accredited.
Limit of quantification: 40 mg/100 g.

Starch (subcontractor-AnalyCen)
Method description: All samples were homogenized before being sent to the subcontractor AnalyCen. The starch is hydrolysed to oligosaccharides using a thermostable α-Amylase; Thermamyl. The oligosaccharides were then hydrolyzed to glucose using amyloglucosidase. The detection was done using high pH anion exchange chromatography fitted with an electrochemical detector. The analysis is based on the method described in " Methods of analysis for nutrition labeling (1993) ch.33, Sugars (Mono, Di)". AnalyCen participate in LPTs organized by *AACC (American association of cereal chemists).* The method is accredited.
Limit of quantification: 40 mg/100 g.

Dietary fiber (subcontractor - AnalyCen)
Method description: All samples were homogenized before being sent to the subcontractor AnalyCen. AOAC method 991.43/NMKL method number 129 was used. The principle of the methods is an sequential enzymatic digestion to remove starch and proteins. The samples were gelatinized using a heat stable amylase followed by an enzymatic digestion by a protease and amyloglucosidase. The dietary fiber was then precipitated with 95% ethanol. The amount was measured gravimetrically.
Limit of quantification: 0.5 g/100 g.

Vitamin E (Tocopherols/tocotrienols)
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.

Thiamin HCL (vitamin B1)
Method description: Diluted HCL was added to the sample and hydrolyses performed in an autoclave. After hydrolyzing 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 thiamin 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 thiamin has been compared to the microbiological method with comparable results. However, the HPLC method has a significantly higher precision.
Limit of quantification: 10 µg/100 g.

Riboflavin (vitamin B2)
Method description: Diluted HCL was added to the sample and hydrolyses performed in an autoclave. After hydrolyzing the pH in the test samples was adjusted followed by an enzyme treatment. 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 TC 275, N 126 Foodstuff determination of vitamin B_2 by HPLC (2001). 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. Riboflavin is light sensitive, and the analyses were performed with dimmed yellow lights.
Limit of quantification: 13 µg/100 g.

Niacin
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 HCl (total vitamin B6**)**
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.

Folate
Method description: Folate (Folic acid) was extracted from the sample by autoclaving of the sample with a phosphate 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 give an appropriate concentration of the vitamin. The extract was then mixed with a growth medium, the microorganism (*Lactobacillus casei*-ATCC 8014) 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 foods, 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: 0.4 µg/100 g.

Vitamin C (Sum of Dehydro-ascorbic acid and L-ascorbic acid)
Method description: Vitamin C was extracted from the sample after addition of 5% Meta-phosphoric acid containing EDTA and dithiothreito (DTT). DTT reduces dehydroascorbic acid to ascorbic acid in addition to stabilisation ascorbic acid. The solution was centrifugated and the upper phase, which contains vitamin C, was collected. The compounds in the water solution were separated by HPLC. The concentration of ascorbic acid was determined by use of electrochemical detection at 0.6 V and standard calibration (standard curve). The concentration of ascorbic acid was determined by use of electrochemical detection at 0.6 V and standard calibration (standard curve). The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and developed according to the Hewlett Packards procedure: *Analysis of selected vitamins with HPLC and electochemical detection*. The samples were stored at -80 ^{o}C until preparation and analyzed the same day they were prepared.
Limit of quantification: 0.1 mg/100 g.

Calcium
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 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 description: Sodium was determined using flame atomic absorption spectroscopy (AAS) 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/100 g dry weight.

Potassium
Method description: Potassium was determined using analytical emission spectrometry (AES) according to the same procedure as described for calcium. The method has been validated and accredited for foods, 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/100 g dry weight.

Magnesium
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 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 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 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
Method description:. Phosphorous was determined using graphite furnace AAS and external calibration (standard curve). Digestion of the biological samples was identical to the procedure described for calcium. The method has been validated and accredited for foods, animal feed, tissue, and tissue fluid and is described in the following article: Bjørn Liaset, Kåre Julshamn og Marit Espe (2003). Chemical composition and theoretical nutritional evaluation of produced fractions from enzymatic hydrolysis of salmon frames with Protamex. Process Biochemistry (in press).
Limit of quantification: 4.1 mg/100 g dry weight.

Appendix 3: Quality assurance data

Table A3.1: Performance data of the analytical methods (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 (2x RSD %)	97-104
Ash	>0.1 g/100 g	17 %	Fish meal 11.6 g/100 g 5 (2xRSD %)	95-105
Protein	>1.9 g/100 g	8 % (<6.8 g /100 g) 3 % (6.8-89.5 g /100 g)	Meat product SMRD2000 10.2 g/100 g (2.7 (2x RSD %)	98-100 [a]
Fat	≥ 0,1- 100 g/100 g	Low <5 g/100 g fat 7.5 % Medium 5-15 g/100 g fat 4.5 % High >15 g/100 g fat 2.5%	Fish feed 36.9 g/100 g 7.5 (2x RSD %) Meat product 18.0 g/100 g 4.5 (2x RSD %)	95-105 [a]
Fatty acids	Relative values 0.1 - 100 %, absolute values >0.001 g/100 g Fat >1 mg fat /100 g	mg/g: 7-18 % Depends on the concentration of the individual fatty acid	mg/g: 7-18 % (2x RSD %) Depends on the concentration of the individual fatty acid	90-110 [a]
Sugar	>40 mg/100 g	10 %		Not supplied
Starch	>40 mg/100 g	8 %		Not supplied
Dietary fiber	>0.5 g/100 g	8 %		Not supplied
Tocopherol and Tocotrienol-isomers (α, β, γ, δ)	>50 µg/kg - 2000 mg/kg	25 %	Baby food α 25.0 mg/kg 8 (2x RSD %) γ 5.51 mg/kg 28 (2x RSD %) δ 1.51 mg/kg 12 (2x RSD %)	90-110 [a] α,β,γ-tocopherol 40-100 [a] δ-tocopherol
Thiamin HCL	0.1-75 mg/kg wet weight	Low 0.15 mg/kg: 28 % Medium 1.5 mg/kg: 7.5 %, High 79 mg/kg: 3,8 %	Beans 0.22mg/100 g 15 (2x RSD %)	90-110 [a]
Riboflavin	0.13-75 mg/kg	Low 0.85 mg/kg: 24 % Medium 17 mg/kg: 4 %, High 88 mg/kg: 3 %	Powdered milk 1.73 mg/100 g 4 (2x RSD %)	90-105 [a]
Niacin	>0,9 - 300 mg/kg	7.5 %	Powdered milk 6.33 mg/100 g 7 (2x RSD %)	85-110 [a]
Vitamin B6 HCL total	>0.2 - 75 mg/kg	15 %	Powdered milk 0.84mg/100 g 4 (2x RSD %)	95-105 [a]
Folate	>0,004 - 15 mg/kg	20 %	Powdered milk 129 µg/100 g 14 (2x RSD %)	80-110 [a]
Vitamin C	>1.1 - 3000 mg/kg	20 %	Powdered milk 115mg/100 g 20 (2x RSD %) Beans 15.1 mg/100 g 12 (2x RSD %)	90-110 [a]
Calcium	15-13000 mg/kg	10 %	Beef liver 11.6 mg/100 g 10 (2x RSD %)	90-105 [b]

Nutrient	Quantification interval	Measurement uncertainty	Control material/Reference material	Accuracy %
Iron	3-1100 mg/kg	9 %	Beef liver 19.0 mg/100 g 7.6 (2x RSD %)	85-105 [b]
Sodium	2,9-34900 mg/kg	7 %	Beef liver 242 mg/100 g 6.8 (2x RSD %)	95-105 [b]
Potassium	83-16900 mg/kg	10 %	Beef liver 1000 mg/100 g 9.2 (2x RSD %)	85-105 [b]
Magnesium	2,7 -1200 mg/kg	6 %	Beef liver 60 mg/100 g 9 (2x RSD %)	85-105 [b]
Zink	1,8-1425 mg/kg	8 %	Beef liver 12.7 mg/100 g 8.6 (2x RSD %)	85-105 [b]
Selenium	0,29-5,6 mg/kg	15 %	Lobster 56.0µg/100 g 13.8 (2x RSD %)	85-105 [b]
Copper	0,3-160 mg/kg	6 %	Beef liver 16 mg/100 g 6 (2x RSD %)	85-105 [b]
Phosphorous	41-15600 mg/kg	20 %	Beef liver 1100 mg/100 g 10 (2x RSD %)	90-108 [b]

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

[a] Based on reference material.

[b] Based on proficiency tests.

Table A3.2: Results from proficiency tests 1998-2005.

Nutrient	Initiated by	Year	Test material	Concentration	Z-score
Water	NSFA	1999	Wheat flour	5.23 g/100 g	0.6
	NSFA	2005	Powder mix	3.32 g/100 g	-0.15
Ash	NSFA	1999	Wheat flour	1.97 g/100 g	-1.1
	NSFA	2005	Powder mix	3.84 g/100 g	0.9
Protein	Bipea	2004	Ground Bran	17.2 g/100	1.5
	FAPAS	2005	Bread crumbs	12.4 g/100 g	0.5
	Bipea	2005	Animal feed	19.8 g/100 g	1.5
Fat	NSFA	2004	Meat flour	2.98 g/100 g	-0.7
	NSFA	2004	Powder	18.7 g/100 g	-0.5
Fatty acids: Saturated fatty Monounsaturated Polyunsaturated	Bipea	1998-2004	Various oils	0.1 – 80 g/100 g	<±1.5
Fructose [a]	The American Association of	2004	Cereal based (flour)	0.14-1.3 g/100 g	0.29
Glucose [a]	Cereal Chemists	2004	Cereal based (flour)	0.21-2 g/100 g	1.1
Maltose [a]		2004	Cereal based (flour)	0.18-0.35 g/100 g	0.83
Saccharose [a]		2004	Cereal based (flour)	1.8-36 g/100 g	2.03
Starch [a]		2004	Cereal based (flour)	2-40 g/100 g	1.97
Dietary fiber [a]		2004	Cereal based (flour)	1.1-11.7 g/100 g	0.44
		2005	Cereal based (flour)	0.98-7.8 g/100 g	-1.56
Vitamin E	Bipea	1999	Diet cake	23.0 mg/100 g	-0.09
	Bipea	2004	Supplement	2.02 mg/100 g	-0.3
New method used in this project	Bipea	2004	Oil	α:13.7mg/100 g β:2.3 mg/100 g γ:59.7 mg/100 g	-0.8 -0.5 -0.5
Thiamin HCl (HPLC)	Bipea	2003	Supplement	0.27 mg/100 g	-1.1
	FAPAS	2004	Powdered milk	0.48 mg/100 g	0.8
	Bipea	2004	Supplement	1.19 mg/100 g	-0.3
Riboflavin (HPLC)	Bipea	2003	Supplement	0.52 mg/100 g	0
	FAPAS	2004	Breakfast cereal	1.53 mg/100 g	0.1
	Bipea	2004	Powdered milk	1.14 mg/100 g	-0.7
Niacin	Bipea	2002	Product rich in	3.5 mg/100 g	0.5
	Bipea	2004	fiber Powdered milk	5.3 mg/100 g	0
Vitamin B_6 HCl (HPLC)	Bipea	2003	Supplement	0.35 mg/100 g	0.2
	Bipea	2003	Diet powder	1.04 mg/100 g	1.3
	Bipea	2004	Powdered milk	0.5 mg/100 g	-0.7
Folate	Bipea	1998	Muesli	490 µg/100 g	0.6
	Bipea	2004	Powdered milk	0.14 mg/100 g	-0.3
Vitamin C	FAPAS	2002	Vitamin beverage	77.0 mg/100 ml	1.2
	Bipea	2003	Supplement	32.6 mg/100 g	0.3
	Bipea	2004	Baby food	36.3 mg/100 g	-0.4
Calcium	NSFA	2004	Corn flour mix	651.4 mg/100 g	0.1

Nutrient	Initiated by	Year	Test material	Concentration	Z-score
	NSFA	2005	Powder mix	666 mg/100 g	0.9
Iron	NSFA	2004	Corn flour mix	9.24 mg/100 g	-0.5
	NSFA	2005	Powder mix	9.1	0.6
Sodium	NSFA	2004	Corn flour mix	89.9 mg/100 g	0.6
	NSFA	2005	Powder mix	283 mg/100 g	-0.40
Potassium	NSFA	2004	Corn flour mix	183.8 mg/100 g	0.3
	NSFA	2005	Powder mix	661 mg/100 g	0.2
Magnesium	NSFA	2002	Fish meal	169 mg/100 g	-0.1
	Bipea	2004	Feed for pigs	130 mg/100 g	0.3
Zink	NSFA	2002	Corn Flakes	2.79 mg/kg	0
	Bipea	2002	Cereal products	4.9 mg/100 g	0.7
	NSFA	2004	Graham Flour	2.33 mg/100 g	-0.1
Selenium	NSFA	2001	Powder for	10 µg/100 g	N=3
	Bipea	2002	porridge	20 µg/100 g	N=3
			Baby food		
Copper	NSFA	2002	Corn Flakes	0.073 mg/100 g	-0.2
	NSFA	2004	Graham flour	0.37 mg/100 g	-0.5
Phosphorous	NSFA	2003	Oats	627 mg/100 g	-0.6
	NSFA	2005	Powder mix	476 mg/100 g	2.0

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

[a] Nutrients analyzed by subcontractor

Appendix 4: Analytical results

Table A4.1: Macronutrients in wheat flour.

Sample (sample identification number in parenthesis)	Sum macro	Water	Protein	Fat	Ash	SFA	MUFA	PUFA	CH	Glucose	Fructose	Maltose	Lactose	Sucrose	Starch	Fiber	Mono +Di
	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g
Household flour 2003:																	
Norgesmøllene, Vaksdal (2003-1)	101.0	12.8	11.5	1.5	0.6				71.5	<0.04	<0.04	0.21	<0.04	0.27	71,0	3.1	0.5
Norgesmøllene, Buvika (2003-2)	101.1	13.6	11.5	1.5	0.3				71.0	<0.04	<0.04	0.21	<0.04	0.28	70.5	3.2	0.5
Norgesmøllene, Skien (2003-3)	101.2	13.4	11.6	1.2	0.6				71.3	<0.04	<0.04	0.31	<0.04	0.30	70.7	3.1	0.6
Cerealia (2003-4)	100.4	12.5	11.5	1.6	0.3				71.1	<0.04	<0.04	0.26	<0.04	0.32	70.5	3.4	0.6
Industrial flour 2003:																	
Norgesmøllene, Vaksdal (2003-5)	101.1	13.3	11.7	1.5	0.4				70.8	<0.04	<0.04	0.28	<0.04	0.29	70.2	3.5	0.6
Norgesmøllene, Buvika (2003-6)	101.7	13.7	12.0	1.5	0.6				70.9	<0.04	<0.04	0.40	<0.04	0.30	70.2	3.0	0.7
Norgesmøllene, Skien (2003-7)	102.7	13.2	11.9	1.6	0.6				72.2	<0.04	<0.04	0.54	<0.04	0.35	71.3	3.2	0.9
Cerealia (2003-8)	101.9	13.5	11.5	1.4	0.3				72.0	<0.04	<0.04	0.90	<0.04	0.28	70.8	3.2	1.2
Household + industrial flour 2003:																	
Norgesmøllene (2003-9)		13.5			0.4	0.2	0.2	0.8									
Cerealia (2003-10)		13.3			0.4	0.2	0.2	0.9									
Stored household flour 2003:																	
Norgesmøllene+Cerealia, (2003-11)		7.1							76.4	<0.04	<0.04	1.4	<0.04	0.30	74.7		1.7
Household flour 2004:																	
Norgesmøllene, Vaksdal (2004-1)	103.4	10.4	11.7	1.6	0.6				75.8	<0.04	<0.04	0.28	<0.04	0.37	75.1	3.3	0.6
Norgesmøllene, Buvika (2004-2)	103.2	10.2	10.5	1.5	0.6				77.1	<0.04	<0.04	0.43	<0.04	0.33	76.3	3.4	0.8
Norgesmøllene, Skien (2004-3)	103.4	10.6	10.9	1.6	0.6				76.6	<0.04	<0.04	0.35	<0.04	0.38	75.9	3.1	0.7
Cerealia (2004-4)	106.6	10.5	11.4	1.6	0.6				79.3	<0.04	<0.04	0.38	<0.04	0.35	78.6	3.2	0.7
Industrial flour 2004:																	
Norgesmøllene, Vaksdal (2004-5)	103.8	10.3	11.7	1.6	0.6				76.6	<0.04	<0.04	0.41	<0.04	0.36	75.8	3.0	0.8
Norgesmøllene, Buvika (2004-6)	106.7	10.5	11.3	1.5	0.6				79.1	<0.04	<0.04	0.42	<0.04	0.40	78.3	3.6	0.8
Norgesmøllene, Skien (2004-7)	105.4	10.4	11.5	1.7	0.7				77.7	0.04	<0.04	0.64	<0.04	0.42	76.6	3.4	1.1
Cerealia (2004-8)	102.0	10.3	10.9	1.4	0.6				75.1	0.04	<0.04	0.52	<0.04	0.34	74.2	3.6	0.9
Household + industrial flour 2004:																	
Norgesmøllene (2004-9)		10.5				0.2	0.2	0.8									
Cerealia (2004-10)		10.4				0.2	0.2	0.7									

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; CH, carbohydrates calculated by summation of starch and + sugars; Mono+Di, sum of mono- and disaccharides

Table A4.2: Micronutrients in wheat flour.

Sample (sample identification number in parenthesis)	**Water**	**α-tocopherol**	**Thiamin**	**Ribo-flavin**	**Niacin**	**Vit B6**	**Folate**	**Vit C**	**Ca**	**Fe**	**Na**	**K**	**Mg**	**Zn**	**Se**	**Cu**	**P**
	g	mg	mg	mg	mg	mg	ug	mg	mg	mg	mg	mg	mg	mg	ug	mg	mg
Household flour 2003:																	
Norgesmøllene, Vaksdal (2003-1)	12.8	0.67	0.21				15.8	3.8		1.3					1		
Norgesmøllene, Buvika (2003-2)	13.6	0.64	0.19				16.2	4.3		1.1					0		
Norgesmøllene, Skien (2003-3)	13.4	0.75	0.25				16.7	6.0		1.2					3		
Cerealia (2003-4)	12.5	0.70	0.29				17.1	4.8		1.2					3		
Industrial flour 2003:																	
Norgesmøllene, Vaksdal (2003-5)	13.3	0.72	0.29				17.4	3.9		1.2					5		
Norgesmøllene, Buvika (2003-6)	13.7	0.68	0.24				17.7	4.5		1.2					5		
Norgesmøllene, Skien (2003-7)	13.2	0.77	0.26				17.5	4.3		1.3					6		
Cerealia (2003-8)	13.5	0.74	0.25				16.7	4.9		1.2					2		
Household + industrial flour 2003:																	
Norgesmøllene, (2003-9)	13.5			0.04	1.6	0.07			15		<0.29	174	32.7	0.87		0.15	135
Cerealia (2003-10)	13.3			0.04	1.3	0.07			16		<0.29	163	30.6	0.82		0.12	138
Stored household flour 2003:																	
Norgesmøllene, + Cerealia, (2003-11)	7.1	0.67	0.24				17.0	5.0									
Household flour 2004:																	
Norgesmøllene, Vaksdal (2004-1)	10.4	0.80	0.28				21.6	4.2		1.3					5		
Norgesmøllene, Buvika (2004-2)	10.2	0.79	0.22				16.2	4.9		1.3					1		
Norgesmøllene, Skien (2004-3)	10.6	0.87	0.28				21.7	5.3		1.3					2		
Cerealia (2004-4)	10.5	0.72	0.25				17.2	4.8		1.1					4		
Industrial flour 2004:																	
Norgesmøllene, Vaksdal (2004-5)	10.3	0.81	0.30				18.6	4.7		1.9					7		
Norgesmøllene, Buvika (2004-6)	10.5	0.92	0.26				18.6	3.6		1.2					6		
Norgesmøllene, Skien (2004-7)	10.4	0.94	0.28				21.1	6.2		1.4					7		
Cerealia (2004-8)	10.3	0.80	0.25				18.4	6.4		1.3					9		
Household + industrial flour 2004:																	
Norgesmøllene (2004-9)	10.5			0.04	1.4	0.08			22		1.1	160	36.6	0.98		0.14	126
Cerealia (2004-10)	10.4			0.04	1.5	0.08			19		0.8	165	36.8	0.93		0.15	136

Table A4.3: Fatty acids in wheat flour.

Fat/fatty acid(s), g/100 g wheat flour, sample identification number in parenthesis	Household + industrial flour 2003:		Household + industrial flour 2004:		Weighted mean [a]
	Norgesmøllene (2003-9)	Cerealia (2003-10)	Norgesmøllene (2004-9)	Cerealia (2004-10)	
Fat	1.5 [b]	1.5 [c]	1.6 [b]	1.5 [c]	1.5
SFA, sum	0.22	0.24	0.21	0.21	0.2
C14:0	<0.001	<0.001	<0.001	<0.001	<0.001
C15:0	<0.001	<0.001	<0.001	<0.001	<0.001
C16:0	0.20	0.23	0.20	0.19	0.2
C17:0	tr	tr	tr	tr	0.0
C18:0	0.01	0.01	0.01	0.01	0.01
C20:0	<0.001	<0.001	<0.001	<0.001	<0.001
C22:0	tr	tr	tr	tr	0.0
C24:0	<0.001	<0.001	<0.001	<0.001	<0.001
MUFA, sum	0.17	0.17	0.15	0.15	0.2
C14:1, n-9	<0.001	<0.001	<0.001	<0.001	<0.001
C16:1, n-9	<0.001	<0.001	<0.001	<0.001	<0.001
C16:1, n-7	tr	tr	tr	tr	0
C18:1, n-11	<0.001	<0.001	<0.001	<0.001	<0.001
C18:1, n-9	0.15	0.15	0.14	0.14	0.1
C18:1, n-7	0.01	0.01	0.01	0.01	0.0
C20:1, n-11	<0.001	<0.001	<0.001	<0.001	<0.001
C20:1, n-9	0.01	0.01	0.01	0.01	0.01
C20:1, n-7	<0.001	<0.001	<0.001	<0.001	<0.001
C22:1, n-11	<0.001	<0.001	<0.001	<0.001	<0.001
C22:1, n-9	<0.001	<0.001	<0.001	<0.001	<0.001
C24:1, n-9	<0.001	<0.001	<0.001	<0.001	<0.001
PUFA, sum	0.76	0.91	0.76	0.73	0.8
C16:2, n-4	<0.001	<0.001	<0.001	<0.001	<0.001
C16:3, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C16:4, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C18:2, n-6	0.71	0.86	0.71	0.68	0.7
C18:3, n-3	0.05	0.06	0.05	0.05	0.0
C18:4, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C20:2, n-6	<0.001	<0.001	<0.001	<0.001	<0.001
C20:3, n-6	<0.001	<0.001	<0.001	<0.001	<0.001
C20:3, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C20:4, n-6	<0.001	<0.001	<0.001	<0.001	<0.001
C20:4, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C20:5, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C22:5, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
C22:6, n-3	<0.001	<0.001	<0.001	<0.001	<0.001
Sum unidentified fatty acids	0	0	0	0	0
Sum identified fatty acids	1.2	1.3	1.1	1.1	1.2
Sum total fatty acids	1.2	1.3	1.1	1.1	1.2
Sum n-3	0.05	0.06	0.05	0.05	0.0
Sum n-6	0.71	0.86	0.71	0.68	0.7
Sum n-9	0.16	0.16	0.14	0.14	0.2

SFA, saturated fatty acids; MUFA, cis-monounsaturated fatty acids; PUFA, cis-polyunsaturated fatty acids; tr, trace (value between 0.01 and the limit of quantification (0.001 g))

[a] Weighed mean according to market shares for each year, and mean value from the 2003 and the 2004 crop.

[b] Calculated mean of 6 samples.

[c] Calculated mean of 2 samples.

Table A4.4: Tocopherols and tocotrienols in wheat flour.

Sample, sample identification number in parenthesis	**Tocopherols, mg/100 g**				**Tocotrienols, mg/100 g**			
	alpha	beta	gamma	delta	alpha	beta	gamma	delta
Household flour 2003:								
Norgesmøllene, Vaksdal (2003-1)	0.67	0.31	<0.005	<0.005	0.19	1.6	<0.005	<0.005
Norgesmøllene, Buvika (2003-2)	0.64	0.29	<0.005	<0.005	0.20	1.5	<0.005	<0.005
Norgesmøllene, Skien (2003-3)	0.75	0.33	<0.005	<0.005	0.21	1.7	<0.005	<0.005
Cerealia (2003-4)	0.70	0.33	<0.005	<0.005	0.19	1.6	<0.005	<0.005
Industrial flour 2003:								
Norgesmøllene, Vaksdal (2003-5)	0.72	0.32	<0.005	<0.005	0.19	1.5	<0.005	<0.005
Norgesmøllene, Buvika (2003-6)	0.68	0.30	<0.005	<0.005	0.20	1.5	<0.005	<0.005
Norgesmøllene, Skien (2003-7)	0.77	0.35	<0.005	<0.005	0.21	1.5	<0.005	<0.005
Cerealia (2003-8)	0.74	0.32	<0.005	<0.005	0.21	1.6	<0.005	<0.005
Stored household flour 2003:								
Norgesmøllene + Cerealia, Household flour. Stored. (2003-11)	0.67	0.29	<0.005	<0.005	0.17	1.6	<0.005	<0.005
Household flour 2004:								
Norgesmøllene, Vaksdal (2004-1)	0.80	0.33	<0.005	<0.005	0.26	1.8	<0.005	<0.005
Norgesmøllene, Buvika (2004-2)	0.79	0.28	<0.005	<0.005	0.26	1.7	<0.005	<0.005
Norgesmøllene, Skien (2004-5)	0.87	0.33	<0.005	<0.005	0.25	1.7	<0.005	<0.005
Cerealia (2004-6)	0.72	0.30	<0.005	<0.005	0.23	1.6	<0.005	<0.005
Industrial flour 2004:								
Norgesmøllene, Vaksdal (2004-7)	0.81	0.33	<0.005	<0.005	0.25	1.7	<0.005	<0.005
Norgesmøllene, Buvika (2004-8)	0.92	0.35	<0.005	<0.005	0.25	1.8	<0.005	<0.005
Norgesmøllene, Skien (2004-9)	0.94	0.38	<0.005	<0.005	0.27	1.9	<0.005	<0.005
Cerealia (2004-10)	0.80	0.30	<0.005	<0.005	0.25	1.8	<0.005	<0.005