DTU National Food Institute

Scientific background for updating the recommendation for whole-grain intake

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Memo

To Danish Veterinary and Food Administration

Reg. Project: Opdateret mængdeanbefaling for fuldkorn [Updated quantity recommendation for whole grain) J.no. 22/1000767

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Scientific background for updating the recommendation for whole-grain intake

Conclusion

The aim of this memo is to provide the scientific background for updating the recommendation for whole-grain (WG) intake in Denmark in order to take the latest knowledge about health and sustainability into account.

What amount of whole grain is related to health benefits in Denmark and comparable food cultures?
Several reviews, including the umbrella review performed in the WholEUGrain-report, conclude that there is strong and consistent evidence that eating higher amounts of whole grain is associated with a lower risk of disease and mortality.

The WholEUGrain-report found evidence that an intake of about three servings (90 g) WG products per day significantly reduces the risk of disease (cardiovascular (CVD) and coronary heart disease (CHD), type 2 diabetes, colorectal cancer) and all-cause mortality. An intake of up to 200-225 g WG products per day showed further risk reduction for some of the diseases (CVDs and for all-cause mortality up to 165 g/d, although not a strong association). These quantities were estimated to correspond to 48-120 g of whole grains per day.

Focusing only on cohort studies from Denmark and comparable food cultures in Northern Europe, the few studies publishing intake levels of WG and/or WG-products point to a health effect of 60-100 g of whole grains per day. This supports the level of the current recommendation of 75 g/10 MJ/d or more. Some of the studies also demonstrate a dose-response effect implying that there is an effect at both a lower and higher intake.

What amount of whole grain is needed in a Danish adapted plant-rich diet to reach the NNR 2012 recommended nutrient density?
The Danish adapted plant-rich diet (6-65 y) contains almost 400 g of cereal grain products per 10 MJ/d (all bread, breakfast cereals, rolled oats, flour, cooked pasta and rice) including 250 g WG products (at least 30 g whole grain per 100 g product (ready to eat)). The content of whole grain as an ingredient is close to 120 g/10 MJ/d and approximately 65% of the cereal grain products are WG products (250 g/10 MJ/d). Investigation of the robustness of different compositions of the cereal grain food group in three scenarios of the plant-rich diet showed that the diet can reach the nutrient density target with a proportion of WG products corresponding to a little more than half of cereal grain products and a WG content of approximately 80-100 g/10 MJ/d.

The Danish adapted plant-rich diet was developed for people aged 6-65 and adjusted to 2-5 year old children and 65+ year old adults. With regard to 2-5 year old children, the robustness tests showed a WG content between approximately 75 and 100 g/10 MJ/d to be able to match the nutrient recommendations. Approximately 50 to 60% of the cereal grain products were WG products. As for the age group of 65+ year old adults, increasing the content of protein to 18 E% showed that an amount of 75 g of whole grain per 10 MJ/d was adequate to fulfil the nutrient recommendations.

In conclusion, taking both health benefits and sustainability into account, according to the Danish adapted plant-rich diet, an appropriate amount of whole grain lies between 75 and 100 g and possibly more. At an amount of 75 g/10 MJ/d, there is a significantly reduced risk of disease. Further risk reduction can be achieved by increasing intake while an intake of 100 g/10 MJ/d also increases the likelihood that a plant-rich diet has an adequate nutrient density.

Furthermore, an appropriate amount of WG products is between 150 and 250 g, and an appropriate amount of cereal grain products in total is between 300 and 400 g (cooked weight). All values are per 10 MJ/d and should be adjusted to the energy need of the specific age group. Finally, an appropriate percentage of WG products compared with the total cereal grain product content lies between 50 and 70%. It is not sufficient only to eat the specified amount of whole grain since refined grain products also contribute to dietary protein and micronutrient intake.

Note that these amounts of whole grain require individuals to also eat the amounts of pulses, nuts, vegetables, fruit, meat, fish, milk etc. included in the recommended diet and to limit the content of discretionary foods and drinks to approximately 5% of their energy intake. In addition, eating a variety of cereal grains is recommended since the different kinds of cereal grains (rye, wheat, oats, rice etc.) and the different kind of products (e.g. rye bread, wheat bread, with/without seeds) contribute different amounts and nutrients.

How large an intake of whole grain is realistic in the Danish food culture?
The mean daily WG content in the diet of Danes is 62 g/10 MJ/d (4-75 year-olds) based on data from 2011-2013. The mean WG content in the diet of the 25% of Danes having the highest WG content is 105 g/10 MJ/d. The minimum content in this WG group is 80 g/10 MJ/d and the maximum is 241 g/10 MJ/d. Both values are higher than the current recommendation, indicating that a higher WG recommendation would be compatible with diets in the Danish food culture.

Uncertainties and limitations

The starting point of the calculations has been the Danish adapted plant-rich diet [1] and since the focus of the project has been to investigate how WG products contribute nutrients to the diet, we have modelled on the composition of cereal grain food groups, i.e. the amounts of vegetables, fruit, potatoes, meat, fish, discretionary foods and drinks etc. are unchanged and are necessary to keep the level of nutrients at the recommended density.

The content of whole grain in WG products is difficult to estimate accurately. The WholEUGrain-report used the following definition of a serving and content of whole grain: 1 serving = 16 g whole grains = 30 g whole-grain product [2] (i.e. approximately 51%). However, the content of whole grains in the cereal grain products consumed in the 1990s and early 2000 in Denmark was typically lower, e.g. 16 g whole grain in 50 g WG rye bread and 41 g in 125 g cooked WG pasta [3] (i.e. approximately 30%). This can explain why we do not find exactly the same amounts of whole grains in the reviewed cohort studies as the WholEUGrain-report does.

The scenario calculations have been made on the basis of the available data on WG content from 2017, but some of the data on nutrient content can be older, which can affect the association between the content of whole grain and nutrients.

To test the robustness with regard to the content of whole grain in bread and breakfast cereals a variation of ±20 percent was tested. This was based on the variation for the data on dietary fiber in the Danish food database [4]. The content of whole grain was estimated at 101 g/10 MJ/d with a 20% lower content of whole grain and at 134 g/10 MJ/d with a 20% higher content. This affects the certainty of the amount of whole grain to be recommended, making it relevant to consider a level of whole grain instead of an exact amount.

The global consensus definition of whole grain includes 'pseudo-cereals' (amaranth, buckwheat and quinoa) because their nutritional profile and uses are similar to cereal grains [5]. This still has to be confirmed in Denmark, and since the intake of 'pseudo-cereals' currently is low in Denmark, they have not been included in the calculations.

It has not been possible to take into account the Nordic Nutrition Recommendations update expected to be published in 2023 [6]. The memo does not include a risk assessment of unwanted substances and contaminants in WG products.

The WholEUGrain-report has documented that WG intake is associated with a reduced risk of CVD, CHD, type 2 diabetes, colorectal cancer, and mortality from all causes. However, it is essential that the study population be representative of the population of interest with comparable dietary patterns, WG- and WG type intake. Most available cohort studies are American. In comparison, Northern European cohort studies including suitable data are scarcer. Only few (11) cohort studies had suitable data to support a recommended level of WG intake for the Danish population. The low number of studies with suitable data available from Northern Europe weakens observable responses. Therefore, caution in the interpretation of these findings is required.

Limitations of the diet-disease relationship studies

Most of the cohort studies looked at in this memo have measured diet intake with a food frequency questionnaire (FFQ). This method has several limitations. Firstly, the number of foods one can ask about is limited, e.g. if a specific cereal grain product is not on the food list they are not included in the answers, and usually it is not possible to add an open answer. Many details of the diet are not measured, e.g. what kind of pasta, rice or wheat bread was eaten. WG bread is not asked about, but sometimes coarse bread is.

The FFQ is not quantitatively precise and generally queries about usual portion size. Furthermore, the answers are given in categories. This limits the intake data range when converting food intake to grams per day, i.e. if '>4 times per day' is translated by researchers to 6 times per day everyone who has answered this category will be calculated as 6 times per day even if they eat 10 portions per day. Furthermore, if 'never' is not included, all persons will get a WG intake. Therefore, this narrows the range of intakes when converted to grams per day.

In addition, the usual frequency of intake questions are cognitively difficult to answer for a reference period of a year. Many of the dietary assessments included in the studies are also conducted with another goal than to assess WG intake, and done in a different time period than when the WG content of the reported cereal grain products have been estimated. Most of the cohorts started in the 1990s

(with follow up in the 2000s), and some as early as in the 1960s (with follow up in the 1970s). The studies on whole grain and disease relationships were published 10-20 years later. In the studies, they have not defined WG products with regard to the content of whole grain. This causes uncertainty about the amount of whole grain in the reported amounts of WG products.

Furthermore, if the FFQ does not cover the whole diet, it is not possible to estimate an energy intake and not all studies included this information. Therefore, it is not always clear for which energy level the WG intake is estimated.

Looking at the results from the cohort studies from Denmark and comparable food cultures in Northern Europe, only some of the studies are adjusted according to a number of factors, including some dietary factors. Most studies have adjusted for age, sex, education, physical activity, energy intake, BMI and smoking. However, adjustments for dietary factors such as fruits and vegetables were less frequent. Fruits, vegetables and whole grains have a preventive effect on some of the same life-style diseases, e.g. type 2 diabetes and CVD [7]. The intake of both may also be correlated in the same persons. The effects of whole grain can therefore be mixed with the effects of additional dietary factors such as fruits and vegetables in some studies.

Finally, most FFQ used in the studies were validated by comparison with e.g. multiple 24-h recalls or weighed diet records [8], [9]. Plasma alkylresorcinols (or their metabolites) has been suggested as a biomarker to improve estimation of WG intake from wheat and rye products [10], [11]. None of the included studies validated the WG intake by this objective biomarker since the cohorts normally aim to capture the general diet with the FFQ, and are not designed to specifically capture WG intake. Some studies have used data from cohort studies to investigate the association between alkylresorcinol biomarkers and incidence of disease and changes in anthropometry [12], [13]**.**

Introduction

The Danish recommendation for WG intake (minimum 75 g/10 MJ/d) was established in 2008. It was formulated in connection with the work published in the report ‘Wholegrain. Definition and scientific background for recommendations of wholegrain intake in Denmark’ [3]. The recommendation is partly based on the evidence for health effects of whole grain and partly on a model diet, which takes into account the contribution of cereal grain products to the supply of nutrients in an average Danish diet, especially the intake of dietary fiber.

Since 2008, new knowledge has emerged about the relationship between whole grain and disease risk. In addition, ‘The Official Dietary Guidelines - good for health and climate’ [14] was launched in 2021. Therefore, it has become relevant to incorporate knowledge about sustainability in relation to advising Danes about a healthier and more climate-friendly diet [15].

Whole grains are defined as intact grains or processed grains (e.g. ground, cracked or flaked) where the three fractions endosperm, germ and bran are present in the same relative proportion as in the intact grains [5]. The definition includes commonly eaten seeds from species from the grass family, i.e. wheat, rye, oat, barley, maize, rice, millet, sorghum/durra, teff and wild rice [16]. In addition, the global consensus definition includes ‘pseudo-cereals’ (amaranth, buckwheat and quinoa) [5]. The WholeEUGrain-report suggests that whole grain should be the main ingredient in WG food products, i.e. whole grain should constitute more than 50% of the dry matter [17]. This definition is in compliance with the definition from the Whole Grain Initiative Working Group on Definitions [5].

In The Official Dietary Guidelines [14], it is recommended to limit the intake of animal products. The Danish adapted plant-rich diet that is the basis for the new guidelines was modelled starting from the amounts in the EAT-Lancet reference diet [18] and the average Danish diet. In addition, further discussion of the evidence with regard to food groups, disease risk and nutrient adequacy in a Danish context were included, i.e. using nutrient content for foods on the Danish market from the Danish Food Database [1]. The content of animal products was reduced while the content of plant-based products was increased in order to comply with the health evidence, the nutrition recommendations and to reduce climate impact, compared with the average Danish diet. With regard to cereal grain products the health-based recommended amount of 75 g whole grain per 10 MJ/d was first included in the diet modelling (as point of departure) and then during the modelling the content was increased by almost 60% and the content of whole grain almost doubled compared with an average Danish diet (to just under 120 g/10 MJ/d). Overall, the role of the content of cereal grain products was to maintain an isocaloric content in the diet, while the composition of the cereal grain food group was changed towards more WG products (compared with the average Danish diet) to reach the recommended level of zinc and iron, in particular [1].

Climate impact of a plant-rich diet and of cereal grain products

The Danish adapted plant-rich diet is estimated to have a reduction potential on the climate impact of 31% or more compared with the average current Danish diet [19]. Cereal grain products, including bread, flour, rolled oats, breakfast cereals, pasta and rice, are among the food groups with the lowest climate impact per kg [20], [21]. Most diets contain a relatively large proportion of cereal grain products, but nevertheless cereal grain products still make up a relatively small part of the climate impact of a western diet, due to the higher climate impact from most animal products − e.g. in the Danish adapted plant-rich diet around 400 g cereal grain products and 45 g meat each accounted for 13% of the carbon footprint [19].

Health benefits from whole-grain consumption

The report from the WholEUGrain-project concludes that there is strong epidemiological evidence that consumption of higher amounts of whole grain is associated with a lower risk of CVD, CHD, type 2 diabetes, colorectal cancer and all-cause mortality [21]. In addition, the Dietary Guidelines Advisory Committee in the USA concludes in their 2020 report that whole grains are now identified with almost the same consistency as vegetables and fruits as beneficial for the outcomes examined (CVD, body weight, type-2 diabetes, cancer and all-cause mortality), suggesting that these three food groups are fundamental constituents of a healthy dietary pattern [22]. This is a noteworthy difference from the 2015 Committee report [23] and the evidence has been strengthened since the Danish report from 2008 [3].

In addition, the Global Burden of Disease Study 2017 found that a diet low in whole grain was the second-leading dietary risk factor for attributable DALYs[1]. A diet low in whole grain was defined as mean daily consumption of whole grain (bran, germ, and endosperm in their natural proportion) from breakfast cereals, bread, rice, pasta, biscuits, muffins, tortillas, pancakes and other sources lower than 125 g (100–150) per day [24].

Furthermore, whole grains can improve the nutritional profile of diets with regard to protein, dietary fibre and micronutrients, and can contribute to planetary health with their relatively low climate impact

[1] One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population [48].

in a diet. Therefore, it is relevant to investigate if the current recommendation for WG intake in Denmark should be updated.

Aim

The aim of this memo is to provide the scientific background for updating the recommendation for WG intake in order to take into account the latest knowledge about health and sustainability. The main questions to answer are:

- What amount of whole grain is related to health benefits in Denmark and comparable food cultures in Northern Europe?
- What amount of whole grain is needed in a Danish adapted plant-rich diet to reach the NNR 2012 recommendation for nutrient density?
- How large an intake of whole grain is realistic in the Danish food culture?

Methods

Overall, the method was based on the process for establishing a quantitative recommendation for WG intake described by Mejborn et al. [25]. This includes taking both health effects, nutrient supply and local dietary habits into account. In addition, sustainability aspects are taken into account as the calculations are based on a Danish adapted plant-rich diet [1] estimated to have a reduction potential on the climate impact of 31% or more compared with the average Danish diet [19].

Intake levels of whole grain and health benefits

The starting point for the quantification is the evidence that consumption of higher amounts of whole grains is associated with a lower risk of CVD, CHD, type 2 diabetes, colorectal cancer, and all-cause mortality [21].

As far as possible, dietary guidelines, including amounts of whole grains, should be appropriate for the food culture of the target population [25]. Therefore, we identified studies relevant for the Danish population from the WholEUGrain-report, and only Danish, Norwegian, Swedish, Finnish and German studies reporting a considerable intake of WG types such as rye and oats in addition to wheat, were included in the present study.

We identified the amounts of WG products and, if possible, also the amount of whole grain that was associated with a reduction of disease risk and all-cause mortality from the studies.

Quantities and robustness of whole-grain content in a plant-rich diet

The scientific background for ‘The Official Dietary Guidelines - good for health and climate’ includes modelling a Danish adapted plant-rich diet [1]. In this memorandum the robustness of the plant-rich diet in relation to the composition of the cereal grain food group was tested by calculating the lowest content of whole grain needed to make the nutrient density comply with the nutrient density targets in four scenarios, assuming that in every scenario all other foods and food groups were consumed according to the modelled diet.

The scenarios were selected to represent both extreme and realistic intakes reflecting different cereal grain preferences:

- Scenario 0: Original model of the plant-rich diet adjusted to reflect the rounded amounts in the dietary guidelines; i.e. meat adjusted from 45 g to 50 g and discretionary foods and drinks adjusted from 7% to 5% of energy intake.

- Scenario 1: The content of cereal grain products was changed to include all sorts of bread, rolled oats were reduced, refined breakfast cereals were increased, and only refined pasta and rice were included.
- Scenario 2: The content of cereal grain products was changed to include all sorts of wheat bread but no rye bread, to include rolled oats and refined breakfast cereals only, and to include refined pasta and rice only.
- Scenario 3: The content of cereal grain products was changed to include all sorts of bread, but no rolled oats, breakfast cereals, pasta or rice.

After constructing scenario 1, 2 and 3, the content of WG products was reduced and the content of refined grain products increased as much as possible while maintaining an adequate nutrient density. The energy contribution from cereal grain products was not changed. The key nutrients were calcium, iron, zinc and selenium, since these are the key minerals that WG products contribute in the plant-rich diet.

The original Danish adapted plant-rich diet was developed for people aged 6-65 y. To test the robustness in relation to different age groups the scenarios were repeated for 2-5 year old children and for 65+ year old adults. But, as input, the specific plant-rich diets modelled for these age groups as a part of the scientific background for 'The Official Dietary Guidelines - good for health and climate' were used [26], [27].

The calculations were done in Microsoft Excel and the scenarios were based on the same data as described by Lassen et al. [1]. Nutritional composition data of the foods were obtained from The Danish Food Database [4] and updated as described by Lassen et al. [28]. A 10% vitamin loss and a 2.5% mineral loss due to cooking of the whole diet were subtracted based on an estimated percentage of foods in the model being cooked (50%). The raw, uncooked amount of pasta, rice, flour and half of the rolled oats were changed to cooked weight by multiplying by a factor of 2.5.

The NNR 2012 recommendation for nutrient density (per 10 MJ) to be used for planning diets for groups of individuals 6–65 years of age [29] was used as a starting point for the nutrient density in the scenarios. Since the NNR values are adapted to the reference person requiring the highest dietary nutrient density, a 5% lower nutrient density was used as a target in the scenarios for the 6-65 year old age group. The scenarios for the 2-5 year old children and 65+ year old adults were compared with the age-specific recommended nutrient intake modified to per 10 MJ [29].

In the scenario calculations, WG food products were defined as products with at least 30 g whole grain as an ingredient per 100 g product (ready to eat). The content of whole grain was estimated from data collected from producers and ingredient lists on products available on the Danish market around 2017 (A-Table 1).

Intake levels in the Danish diet

To establish if a new recommendation considering sustainability, higher than 75 g/10 MJ/d is compatible with the Danish food culture, the distribution of the WG content of diets of 4-75 year-olds is considered by dividing the WG content into quartiles (Interquartile range). The quartiles are divided into three groups of WG content, i.e. low (Q1: lowest quartile), mid (Q2+Q3: two middle quartiles) and high (Q4: highest quartile). The interquartile range is a robust statistic when quantifying the statistical distribution in a sample of numerical data while resisting outliers. Therefore, it is a useful distribution when comparing a WG recommendation to the intake of the Danish population e.g. it is a bulk of intake values in accordance with the recommendation.

The data originates from the Danish national survey of diet and physical activity 2011-2013 (DANSDA 2011-2013).

Results

Intake levels found in the WholEUGrain-report

The researchers behind the WholEUGrain-report conducted an umbrella review on the associations between WG intake and the development of CVDs, type 2 diabetes, cancer, risk of all-cause mortality, and overweight [2]. The report found evidence that an intake of approximately 90 g WG products per day significantly reduces the risk of disease and overall mortality. An intake of up to 200-225 g WG products per day showed further risk reduction for some of the diseases (CVDs and for all-cause mortality up to 165 g/d, although not a strong association). These quantities were estimated to correspond to 48-120 g whole grain per day.

The cohorts included in the reviews in the WholEUGrain-report are dominated by studies from the USA. The intake of WG products in the USA is at a lower level compared with countries from Northern Europe. E.g., data from the Global Dietary Database shows that the level of intake is 48 g/d in USA and 74-83 g/d in Scandinavian countries - 65% higher than USA [30]. It is important to know the WG intake levels by the study populations included in the analysis. In a cohort with a lower range of WG intake, this intake range might not include the optimal WG intake that would give the highest benefit to prevent disease. However, high vs low quartiles may be tested and a dose-response effect might be found for the specific intake range.

Intake levels in Danish, Swedish, Norwegian, Finnish and German cohorts

In total, 28 studies from the reviews in the WholEUGrain-report were included in this memo (being Danish, Norwegian, Swedish, Finnish and German studies reporting a considerable intake of WG types such as rye and oats in addition to wheat). A summary of the 28 studies including further details is reported in the Supplementary material. Of these, 11 studies specified quantifiable intake levels as reported in Table 1. All these studies included whole grain, WG products and total cereal grain products as part of dietary patterns. While most studies showed positive health benefits for whole grain and WG products (n=22), there were also a few studies showing no effect (n=6).

In most studies the initial goal and data-gathering was not to assess the effect of whole grain on health and disease. Not being able to estimate whole grain or WG product intake may have resulted in several of the studies analyzing non-refined fiber-rich bread, rye bread, hard bread, fiber-rich bread, oatmeal etc., and not WG or WG product intake. Other studies did not mention the specific quantities they tested, but mentioned portions or servings.

Table 1 Intake levels from 11 studies[1] that have published these in relation to risk of disease/health benefits.

	WG products[2] **Reduced risk at: (risk reduction)**	**Whole grain[2]** **Reduced risk at: (risk reduction)**
Cardiovascular diseases	Men: 224 vs 66 g/d (23% ↓) Women: 201 vs 63 g/d (29% ↓) Dose-response for 50 g increment: Men: 42.3-277.1 g/d (6% ↓) Women: 37.0-234.9 g/d (10% ↓)[9]. Men: 2.86 vs 0.05 portions/d (21% ↓) Women: 2.28 vs 0.05 portions/d (8% ↓) [31]. Above vs below the median of 3.0 servings/d (12% ↓) [8].	Men: 74 vs 22 g/d (25% ↓) Women: 63 g/d vs 20 g/d (27% ↓) Dose-response for 25 g increment: Men: 12.0-86.6 g/d (12% ↓) Women: 10.6-75.8 g/d (13%↓) [9].
Type 2 diabetes	Men: 2.3 vs 0.01 portions/d (16% ↓) Women: 2.0 vs 0.01 portions/d (15% ↓) [32]. 302 vs 79 g/d (35% ↓) [33].	59.1 vs 30.6 g/d (22% ↓) Dose-response per 30 g increment (men: 15% ↓) [34].
Colorectal cancer	>160 vs ≤75 g/d (men: rectal 12%/ colon 39% ↓) Dose-response per 50 g increment: Men: 42-267 g/d (rectal 10%/colon 15% ↓) [35]. Men: >189 vs ≤85 g/d. Women: >180 vs ≤90 g/d (All: 23% ↓) Dose-response per 50 g increment: All: 35-263 g/d (6% ↓) [36]. ≥4.5 vs <1.5 servings/d (33% ↓) Dose-response for 1 serving increment (hard whole rye bread 12% ↓) [37].	Dose-response per 25 increment: All: 13-102 g/d (non-significant) [36]
All-cause mortality	Men: 222 vs 64 g/d (25% ↓) Women: 201 vs 56 g/d (32% ↓). Doubling the median intake: Men: 131 g/d (≈ 262 g/d) (11% ↓) Women 121 g/d (≈242 g/d) (11% ↓) [38]. Above vs below median: Men: 93 g/d Women: 74 g/d (All: 15% ↓) [39].	Men: 80 vs 21 g/d (25% ↓) Women: 74 vs 20 g/d (26% ↓) Doubling the median intake: Men: 48 g/d (≈96 g/d) (12% ↓) Women: 47 g/d (≈94 g/d) (12% ↓) [38].

1: Identified from 28 studies of the association between whole grain/WG products and disease/mortality [2]
2: As defined by the studies see Supplementary material

Cardiovascular diseases

The studies suggest that eating WG products and whole grain reduces the risk of CVD diseases[2]. A reduced risk of 23-29% is suggested at 100 g WG product per day and up to as high as 224 g WG product per day vs eating 63-66 g/d. The results also suggest a reduced risk of 12% when consuming over 3 servings vs consuming under 3 servings of WG products per day. A 50 g/d increment in WG product intake was associated with a 6-10% lower risk. For whole grain a reduced risk of 25-27% was

[2] Includes cardiovascular disease (all types of diseases that affect the heart or blood vessels), coronary heart disease (clogged arteries), stroke and heart failure

seen for approximately 63-74 g WG intake vs 20-22 g/d. A 25 g/d increment in WG consumption was associated with a 12-13% lower risk in the range tested [8], [9].

Type 2 diabetes
The studies suggest that eating whole grains reduces the risk of type 2 diabetes with a higher consumption of WG products. The results are close to what is seen for CVD diseases. E.g., one study found that a WG product intake of 302 vs 79 g/d was associated with reduced risk of 35% and another reported that a WG intake of 59 vs 31 g/d was associated with a reduced risk of 22% for disease. A 30 g/d increment in WG consumption was associated with a 15% lower risk in men in the range tested [33], [34].

Colorectal cancer
These studies suggest that eating WG products reduces the risk for colorectal cancers with high consumption of WG products. A reduced risk for colon cancer of 23-39% was seen at 160-189 vs 75-85 g/d of WG product intake, and at approximately 4.5 vs 1.5 servings per day. A 50 g/d increment in WG product consumption was associated with a 6-15% lower risk of colorectal cancers in the range tested [35]–[37]. This is also in the same range as is seen for CVD and type 2 diabetes.

All-cause mortality
These studies suggest that eating whole grain reduces the risk of all-cause mortality[3] with high consumption of whole grain and WG products. A reduced risk of 15-31% was seen at levels over 74 g WG products per day and up to 222 vs 64 g/d. For whole grain a reduced risk of 25–26% was seen at approximately 74-80 vs 20-21 g/d and a reduced risk of 12% for the study comparing a median intake of 48 g/d to a doubling of the intake (96 g/d) [38], [39].

Conclusion
In conclusion, the few studies point to a health effect of a WG intake at the level of 60-100 g/d and possibly more. This supports the level of the current recommendation of 75 g/10 MJ/d or more. A dose-response effect, i.e. the relationship between disease risk and WG dose was seen for each additional 25-30 g/d increment along the WG intake ranges tested (10-90 g/d, reported by one study), implying a reduced risk when consuming 25-30 g/d compared with consuming none or a very low intake, and that higher intakes could confer greater benefit. Based on the few studies it was not possible to identify an exact amount of whole grain that would give the highest benefit to prevent disease or a level with no additional benefits. Some meta-analyses suggest a non-linear response between WG intake and risk of disease [40], [41]. Likewise it was not possible to identify an upper limit for any adverse effects.

A high intake of WG products of 100-260 g/d and possibly more is associated with a reduced risk of disease in the Danish food culture. A dose-response effect was seen per 50 g increment or 1 serving along the WG product intake ranges (40-280 g/d, reported by 3 studies), implying a reduced risk when consuming 50 g or one serving compared with consuming none or a very low intake, and that higher intakes could confer greater benefit. Based on the few studies it was not possible to identify an exact amount of WG products that would give the highest benefit to prevent disease or a level with no additional benefits. Several meta-analyses suggest a non-linear response between WG product intake and risk of disease [42]–[44]. Likewise it was not possible to identify an upper limit for any adverse effects.

[3] The death rate from all causes of death for the population in a given time period – the follow up period

Quantities in the Danish adapted plant-rich diet

The original Danish adapted plant-rich diet contained approximately 300 g of the food products bread, pasta, rice, breakfast cereals, flour and groats (≈370 g cooked) [1]. Around 70% were WG products and the content of whole grain was just under 120 g/10 MJ/d. In the plant-rich diet the content of meat was 45 g/10 MJ/d and the energy from discretionary foods and drinks was 700 kJ/10 MJ/d. To match 'The Official Dietary Guidelines - good for health and climate', the amount of meat was adjusted to 50 g [14] and the energy from discretionary foods and drinks was reduced to 500 kJ [45].

With this adjustment, the content of whole grain remained just below 120 g/10 MJ/d (Table 2). Cereal grain products contributed e.g. 35% of the energy, 26% of the protein, 48% of the dietary fiber and 19% of the n-3 fatty acids (A-Table 2), as well as 13% of calcium, 34% of iron, 36% of zinc and 18% of selenium in scenario 0. All types of cereal grain products play a significant role in the plant-rich diet by providing e.g. selenium. WG products contribute dietary fiber, iron and zinc, and especially WG products containing other seeds such as flaxseed, sunflower seeds, pumpkin seeds and sesame seeds contribute n-3 fatty acids (data not shown).

Table 2 Content of cereal grain products[1] and whole grain (per 10 MJ/d) in a plant-rich diet (scenario 0 modified from the original Danish adapted plant-rich diet)

	Whole-grain bread[2]	Other whole-grain products	Refined bread	Other refined grain products	Total
Cereal grain product (g)	182	40	65	30	317
Whole grain (g)	74	40 (28 g rolled oats)	4	0	118

1: Mix of cooked (bread, breakfast cereals) and uncooked (rice, pasta, flour, groats)
2: At least 30 g whole grain per 100 g.

A test where the content of whole grain was reduced until reaching the nutrient density targets of iron and zinc showed that the percentage of WG products could be reduced from 65% in scenario 0 to 41%, corresponding to a WG content of 80 g/10 MJ/d. With this content of whole grain, the nutrient densities regarding calcium, iron, zinc and selenium were above the target (5% lower than NNR 2012 recommended nutrient density) (A-Table 3).

Robustness in relation to the composition of the cereal grain food group

The composition of the group of cereal grain products originates from the Danish average intake of rye bread, wheat bread, breakfast cereals, flour, groats, pasta and rice registered in DANSDA 2011-2013 and was then changed towards more WG products in the plant-rich diet. In order to test the robustness of the plant-rich diet we further tested three scenarios. The results of these scenarios are listed in the appendix (A-Table 3).

In scenario 1, the content of WG products could be reduced to 51% of the total cereal grain product content and the content of whole grain ended at 80 g/10 MJ/d. The limiting mineral was zinc, but the content of calcium was also reduced significantly when exchanging rolled oats and WG pasta/rice/breakfast cereals with the refined versions.

Some people may not eat rye bread and only eat wheat bread, rolled oats and refined pasta and rice. This was calculated in scenario 2. With this composition of cereal grain products, the percentage of WG products ended at 58% and the content of whole grain at 94 g/10 MJ/d.

Finally, some people might get their cereal grain products from bread alone, and this was calculated in scenario 3. When including only bread, the calculation ended at 67% of WG products and 104 g of whole grain per 10 MJ/d before reaching the limiting minerals (iron and zinc).

In summary, the percentage of WG products can be reduced to 51% in one scenario and to almost the same (58%) in a second scenario. These contents correspond to a WG content of 80 and 94 g/10 MJ/d. Only eating bread required the highest amount of whole grain, since a percentage of 67% of WG products corresponding to 104 g of whole grain per 10 MJ/d is needed to reach the nutrient density target. With these contents of whole grain the nutrient densities regarding calcium, iron, zinc and selenium were above the targets (A-Table 3).

2-5 y

The original Danish adapted plant-rich diet was developed for people aged 6-65 y. To match the nutritional recommendations regarding calcium and the foods eaten by 2-5 year old children, the plant-rich diet was changed as described by Christensen et al. [26]. Alcohol, coffee and tea were removed, the amount of energy for discretionary foods and drinks reduced to 4% [45], the content of milk increased to 250 ml/d (corresponding to 470 ml/10 MJ), the content of pulses and dark green vegetables reduced by 25% (and the other vegetables increased), and finally rolled oats were doubled and other WG products reduced. With this diet, the recommended nutrient density was reached and the content of whole grain ended at 121 g/10 MJ/d (A-Table 4 scenario 0 2-5 y). A test aiming at reducing the content of whole grain and at the same time fulfilling the nutrient recommendations ended at a content of 99 g of whole grain per 10 MJ/d, while the percentage of WG products were reduced from 64% to 51% (scenario 0 test 2-5 y).

In scenario 1 2-5 y, with reduced content of rolled oats and only the refined versions of pasta, rice and breakfast cereals, the content of WG products could be reduced to 47% after which the content of whole grain was reduced to 77 g/10 MJ/d.

Some children may not eat rye bread and only eat wheat bread, rolled oats and refined pasta and rice (scenario 2 2-5 y). With this composition of cereal grain products, the percentage of WG products ended at 59% and the content of whole grain at 103 g/10 MJ/d.

Finally, some children might get their cereal grain products from bread alone, and this was calculated in scenario 3 2-5 y. When only including bread for this age group, the cereal component was 87% WG products and 127 g of whole grain per 10 MJ/d before reaching the limit of specific minerals (iron and zinc).

In summary, with an increased content of milk the recommended nutrient density for calcium was fulfilled. Instead, when reducing the content of WG products the limiting minerals are iron and zinc. The content can be reduced to approximately 75 g/10 MJ/d in one scenario, to approximately 100 g/10 MJ/d in two scenarios and to just under 130 g/10 MJ/d in one scenario. However, the latter scenario (only bread) is also the least likely for this age group. The content of cereal grain products was around 350 to 375 g/10 MJ/d (cooked weight) in all scenarios since the energy contribution from cereal grain products was kept constant.

65+ y

To match the nutritional recommendations with regard to vitamin A, selenium and protein for healthy 65+ year old adults, the plant-rich diet 6-65 y (scenario 0) was changed as described by Christensen et al. [27]. The amount of energy for discretionary foods and drinks was adjusted to 4.5% [45], protein-rich foods were increased (milk, cheese, meat, eggs, fish and pulses) and the proportion of protein-rich milk and offal increased. With this diet, the recommended nutrient content was reached and the content of whole grain ended at 103 g/10 MJ/d (A-Table 5 scenario 0 65+). A test reducing

the content of whole grain to the limiting nutrient showed that the content of whole grain could be reduced to 75 g/10 MJ/d while the percentage of WG products was reduced from 65% to 45% (scenario 0 test 65+).

In scenario 1 65+, with reduced content of rolled oats and only the refined versions of pasta, rice and breakfast cereals, the content of WG products could be reduced to 53% after which the content of whole grain ended at 75 g/10 MJ/d. Scenario 2 and 3 65+ ended at almost the same percentage of WG products (54%) when reducing to 75 g whole grain per 10 MJ/d (A-Table 5). In all scenarios, the amount of whole grain needed for health effects and not the content of minerals and protein was the limiting factor.

Conclusion
In conclusion, approximately 75 g of whole grain per 10 MJ/d can be sufficient in a Danish adapted plant-rich diet (2-65+ years) but it is not enough to reach the nutrient density targets in all the tested scenarios for all age groups. An amount of up to approximately 100 g/10 MJ/d is considered necessary to better secure the necessary nutrient targets for iron and zinc in particular.

Cereal grain products and whole grain in the diets of the Danish population
Based on DANSDA 2011-2013 the mean daily WG content in the diet of Danes is 62 g/10 MJ/d for 4-75 year old Danes. For children (4-14 years old) it is 70 g/10 MJ/d and for adults 15-75 years old it is 60 g/10 MJ/d.

Newer data exists from the Diet, Cancer and Health-Next Generations cohort study. The study included 39.554 adult (≥18 years) participants with a response rate of 22%. Data were collected between 2015 and 2019. The study found a mean intake of whole grains of 69 g/d and 82 g/10 MJ/d [46], [47], substantially higher than those from DANSDA 2011-2013. However, they used the FFQ dietary assessment method as most of the cohort studies mentioned in this memo with the same limitations. Furthermore, the study is not representative for Danish children and adults. This is why it was decided to report the data from DANSDA 2011-2013.

As seen from Table 3, those with a diet high in WG content have a higher average content of cereal grain products in their diet, i.e. almost 100 g/10 MJ higher per day compared with those with a low WG content in their diet. However, the total content of cereal grain products is a mixture of raw ingredients such as flour, uncooked pasta and rice and ready to eat products such as bread. If the total cereal grain food group were converted to ‘ready to eat’, the content of cereal grain products in the diets would be approximately 25% higher. E.g., the average intake of 18-64 year-olds is 196 g/10 MJ/d; in ready to eat form, this is estimated to 243 g/10 MJ/d (data not shown).

As seen from Table 3 the WG content in the patterns of the 25% with the highest WG content is 105 g/10 MJ/d. This is well above the recommendation of 75 g/10 MJ/d. The minimum content in this WG group is 80 g/10 MJ/d and the maximum is 241 g/10 MJ/ d. Both values are over the present recommendation, indicating that a higher recommendation would be compatible with diets in the Danish food culture. Furthermore, the dietary patterns of those 25% with the highest WG content shows that, the WG content primarily comes from rye and oats. The high WG group have a high content of Danish rye bread and rolled oats in their diet - each contributing to approximately one third of WG content, i.e. two thirds in total. They eat more rye bread than wheat bread, and when they eat wheat bread, they more often choose WG varieties. When eating pasta and rice, they also more often choose WG varieties compared with the other two groups (Table 3).

There is a difference in energy intake among the groups with high and low WG intake. Going from the group with lowest intake to highest content the difference is -900 kJ/d. There is a risk that the lower energy intake in the high intake group have inflated the values per 10 MJ/d. However, as seen from Table 3, this is not the case since the WG intake in g per day is still larger in the high content group.

Table 3 Intake of cereal grain products and whole grain (WG), and contribution of cereal grain products to total WG content in diets of Danish children and adults (4-74 years) stratified by content of whole grain in the diet[1]

	Low WG content (n=985)		Mid WG content (n=1972)		High WG content (n=985)	
	Mean (SD)	**WG % to total**	**Mean (SD)**	**WG % to total**	**Mean (SD)**	**WG % to total**
Age, mean years	39 (20)		40 (21)		35 (22)	
Gender, (% males)	54		46		51	
Energy, MJ/d	9.9 (3)		9.5 (3)		9.0 (3)	
Total WG intake, g/10MJ/d	27 (9)		58 (12)		105 (24)	
Total WG intake, g/d	27 (13)		55 (20)		95 (36)	
Total intake of cereal grain products, g/10 MJ/d[2]	186 (51)		233 (28)		282 (51)	
Rolled oats, g/10 MJ/d	1 (3)	2	6 (11)	10	34 (32)	32
Other breakfast cereals, g/10 MJ/d	4 (9)	5	8 (14)	6	10 (17)	7
Bread/buns refined, g/10 MJ/d	55 (43)	8	42 (37)	3	28 (30)	1
Bread/buns coarse, g/10 MJ/d	16 (22)	17	40 (40)	20	51 (47)	13
Rye bread, g/10 MJ/d	33 (23)	50	64 (36)	46	87 (51)	36
Pasta/rice, refined g/10MJ/d	31 (44)	0	27 (38)	0	25 (36)	0
Pasta/rice brown, WG, g/10MJ/d	2 (8)	2	6 (15)	3	16 (31)	5

1: Not all cereal grain products are shown. Food shown covers at least 85% of total WG intake
2: Intake is a mix of raw ingredients of flour used in e.g. cakes, sauces etc., uncooked grains and ready to eat products as bread. In prepared quantities, the intake would be higher.

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Appendix

A-Table 1 Content of whole grain in the cereal grain products used in the plant-rich diet scenarios

Food Group[1]	Name[1]	Content of whole grains[2] (g/100 g)
Bread	Crispbread, knackebrot, wheat, fine	0
Bread	Crispbread, knackebrot, rye, fine	0
Bread	Bread-crumbs	0
Bread	Bread, roll, danish	0,5
Bread	Bread, white, roll	0,5
Bread	Baguette, wheat, fine, industrially produced	2,6
Bread	Wheat bread, for toasting, industrially produced	2,7
Bread	Rolls, Italian type, industrially produced	2,8
Bread	Wheat bread, Italian type, industrially produced	2,8
Bread	Wheat bread, high fat seeds, industrially produced	3,4
Bread	Rolls, white, industrially produced	3,4
Bread	Wheat bread, white, industrially produced	3,4
Bread	Rye bread, fine with wheat flour and high fat seeds, industrially produced	5,2
Bread	Rye bread, fine with wheat flour, industrially produced	5,2
Bread	Wheat bread, sandwich/toast type, high fat seeds, industrially produced	20,4
Bread	Wheat bread, with coarse meal, for toasting, industrially produced	21,9
Bread	Wheat bread, with coarse meal, industrially produced	38
Bread	Rye bread, dark with high-fat seeds and whole kernels, industrially produced	34,2
Bread	Rye bread, with siftings (soft) and high-fat seeds, industrially produced	34,2
Bread	Rye bread, soft, no high-fat seeds, industrially produced	34,2
Bread	Rolls, wheat with coarse meal, high-fat seeds, industrially produced	35
Bread	Rolls, wheat with coarse meal, industrially produced	38
Bread	Rye bread, dark, whole grains, industrially produced	50
Bread	Rye bread, dark, industrially produced	50
Bread	Crispbread, knackebrot, wheat, coarse	88,1
Bread	Crispbread, knackebrot, rye, coarse	88,1
Bread	Crispbread, wheat	92
Breakfast products	Corn flakes, frosted	0
Breakfast products	Corn flakes, average values	0

Food Group[1]	Name[1]	Content of whole grains[2] (g/100 g)
Breakfast products	Breakfast cereal, müsli, average values	100
Flour	Buckwheat flour	0
Flour	Wheat flour	0
Flour	Corn flour	0
Flour	Corn starch	0
Flour	Rice flour	0
Flour	Wheat, flour, wholemeal	100
Flour	Wheat, kernels, whole/cracked	100
Flour	Rye flour, dark, whole meal	100
Groats	Rice groats, raw	0
Groats	Oats, rolled, average values	100
Groats	Rice groats, brown, raw	100
Pasta	Pasta, raw	0
Pasta	Macaroni, spaghetti, whole meal, raw	100
Species of grain	Wheat, cracked kernels, parboiled (bulgur), raw	0
Species of grain	Wheat bran	0
Species of grain	Rice, parboiled, raw	0
Species of grain	Rice, polished, raw	0
Species of grain	Rice bran	0
Species of grain	Rice, brown, raw	100

1: Grouping and names from the Danish Food Composition Database [4].
2: Content of whole grains estimated from producers and ingredient lists in 2017.

A-Table 2 Weight and contribution of energy, protein and selected minerals from food groups in the plant-rich diet age 6-65 y per day (scenario 0)

	Weight[1]	Energy	Protein	Dietary fiber	n-3 fatty acids	Calcium, Ca	Iron, Fe	Zink, Zn	Selenium, Se
Whole-grain products[2]	222 g	23%	17%	40%	17%	9%	26%	29%	12%
Refined grain products	95 g	12%	9%	8%	2%	4%	8%	7%	6%
Other plant-based products	789 g	32%	32%	51%	19%	26%	53%	31%	21%
Animal-based products	411 g	18%	40%	0%	35%	44%	9%	29%	59%
Fats	29 g	9%	0%	0%	26%	0%	0%	0%	0%
Beverages, discretionary foods and drinks, spices etc.	2060 g	6%	2%	1%	1%	17%	4%	3%	2%
Total	**3606 g**	**10 MJ**	**94 g (16 E%)**	**44 g**	**3,6 g (1,3 E%)**	**1006 mg**	**16 mg**	**12 mg**	**56 µg**
NNR 2012 recommendations			15 E%	≥30 g	≥1 E%	1000 mg	16 mg	12 mg	57 µg

1: Mix of cooked and uncooked.
2: At least 30 g whole grain per 100 g

A-Table 3 Content of whole grain and selected nutrients in scenarios for 6-65 year olds with different content of whole-grain products and refined grain products

		Scenario 0	Scenario 0 test	Scenario 1	Scenario 2	Scenario 3	
Per 10 MJ/d	**Original Danish adapted plant-rich diet**	**Dietary guidelines Meat increased, discretionary foods and drinks reduced, refined grains increased**	**Scenario 0 + Reduced whole-grain products and increased refined grain products**	**Scenario 0 + Bread unchanged, only refined pasta, rice and breakfast cereals, no rolled oats**	**Scenario 0+ Only wheat bread (no rye bread), only refined pasta, rice and breakfast cereals, rolled oats unchanged**	**Scenario 0 + Only bread, reduced whole-grain bread and refined bread**	**NNR 2012**
Whole-grain products[1,2], g	251	251	158	185	208	236	
Refined grain products[2], g	119	134	231	179	151	115	
In total, g	370	385	389	364	359	351	
Whole-grain products, %	68	65	41	51	58	67	
Whole grain, g	***118***	***118***	***80***	***80***	***94***	***104***	
Dietary fibre, g	44	44	40	41	38	45	≥30
n-3 fatty acids, E%	1,3	1,3	1,3	1,3	1,2	1,4	≥1
Selected minerals[3]							**NNR 2012 6-65 y (-5%)[4]**
Calcium, mg	1011	1006	999	974	1014	999	1000 (950)
Iron, mg	16	16	15	16	15	15	16 (15)
Zinc, mg	11	12	11	11	11	11	12 (11)
Selenium, µg	55	56	56	56	59	56	57 (54)

1: At least 30 g whole grain per 100 g
2: Cooked weight by multiplying pasta, rice, flour and half of the rolled oats with a factor 2.5
3: Mineral loss (2.5%) due to cooking is subtracted
4: Mineral contents above the NNR 2012 recommended nutrient density written in green and contents above NNR 2012 minus 5% written in yellow

A-Table 4 Content of whole grain and selected nutrients in scenarios for 2-5 year olds with different content of whole-grain products and refined grain products

	Scenario 0 2-5 y	Scenario 0 test 2-5 y	Scenario 1 2-5 y	Scenario 2 2-5 y	Scenario 3 2-5 y	
Per 10 MJ/d	**Scenario 0 + removed alcohol, coffee and tea, increased milk, reduced discretionary foods and drinks, pulses and dark green vegetables and increased other veg, increased rolled oats and reduced other whole-grain products**	**Scenario 0 2-5 y + reduced whole-grain and increased refined grain products**	**Scenario 0 2-5 y + Bread unchanged, only refined pasta, rice and break-fast cereals, changed 65% of oatmeal to refined break-fast cereals**	**Scenario 0 2-5 y + Only wheat bread (no rye bread), only refined pasta, rice and break-fast cereals, rolled oats unchanged**	**Scenario 0 2-5 y + Only bread, increased whole-grain bread and reduced refined bread**	**NNR 2012**
Whole-grain products[1,2], g	239	191	164	209	307	
Refined grain products[2], g	134	184	182	146	45	
In total, g	374	375	346	355	352	
Whole-grain products, %	64	51	47	59	87	
Whole grain, g	***121***	***99***	***77***	***103***	***127***	
Dietary fibre, g	41	39	38	37	46	20-30
n-3 fatty acids, E%	1,3	1,2	1,2	1,2	1,4	≥1
Selected minerals[3]						**NNR 2012 2-5 y[4]**
Calcium, mg	1237	1230	1197	1243	1211	1132
Iron, mg	15	15	15	15	15	15
Zinc, mg	12	12	11	12	12	11
Selenium, µg	58	58	53	60	58	47

1: At least 30 g whole grain per 100 g
2: Cooked weight by multiplying pasta, rice, flour and half of the rolled oats with a factor 2.5
3: Mineral loss (2.5%) due to cooking is subtracted
4: Mineral contents above the NNR 2012 recommended nutrient intake written in green

A-table 5 Content of whole grain and selected nutrients in scenarios for 65+ year olds with different content of whole-grain products and refined grain products

	Scenario 0 65+ y	Scenario 0 test 65+y	Scenario 1 65+ y	Scenario 2 65+ y	Scenario 3 65+ y	
Per 10 MJ/d	**Scenario 0 + increased milk, cheese, meat, eggs, fish and pulses, reduced discretionary foods and drinks, increased proportion of protein-rich milk and offal**	**Scenario 0 65+ y + reduced whole grain as much as possible (75 g/ 10 MJ)**	**Scenario 0 65+ y + Bread unchanged, only refined pasta, rice and break-fast cereals, changed 75% of oatmeal to refined break-fast cereals**	**Scenario 0 65+ y + Only wheat bread (no rye bread), only refined pasta, rice and break-fast cereals, rolled oats unchanged**	**Scenario 0 65 y + Only bread, reduced whole-grain bread and increased refined bread (75 g/ 10 MJ)**	**NNR 2012**
Whole-grain products[1,2], g	218	150	172	168	160	
Refined grain products[2], g	117	187	149	143	137	
In total, g	335	337	321	311	297	
Whole-grain products, %	65	45	53	54	54	
Whole grain, g	***103***	***75***	***75***	***75***	***75***	
Dietary fibre, g	42	39	40	37	41	≥30
n-3 fatty acids, E%	1,4	1,3	1,4	1,3	1,4	≥1
Selected minerals[3]						**NNR 2012 61+ mod.[4]**
Calcium, mg	1051	1045	1029	1052	1043	1000
Iron, mg	16	15	16	15	15	11
Zinc, mg	12	11	11	11	11	9
Selenium, µg	62	62	62	64	62	62

1: At least 30 g whole grain per 100 g
2: Cooked weight by multiplying pasta, rice, flour and half of the rolled oats with a factor 2.5
3: Mineral loss (2.5%) due to cooking is subtracted
4: Mineral contents above the NNR 2012 recommended nutrient intake written in green