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Journal of Cereal Science 105 (2022) 103462

Contents lists available at ScienceDirect

Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs

Traditional and new sources of grain protein in the healthy and sustainable Nordic diet

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ARTICLE INFO

Keywords:
Cereal food
Oats
Proteins
Healthy Nordic diet

ABSTRACT

Cereal foods provide carbohydrates and dietary fibre, but also protein. To support the goals of sustainable development, cereal grain proteins should be more efficiently used to replace animal proteins. In the Nordic countries, wheat is the major source of cereal protein, followed by rye, oats, and barley. Although oats have been traditionally consumed as many staple foods in the Nordic countries and new oat-based food concepts are emerging, the potential of oats as a healthy and sustainable protein source is still underused. Oat protein is high in nutritional quality, and oats also contain unique phytochemicals and dietary fibres with proven health effects. Therefore, utilization of traditional wholegrain oat products to replace animal protein sources would increase both health-supporting components and cereal diversity in Nordic diets. While novel oat-based meat, milk, and dairy analogues do not contribute as much to dietary fibre, vitamin and mineral intake as corresponding whole grain products, they provide valuable and effective means to reduce animal protein intake, and thus, the environmental burden.

Wholegrain (WG) foods constitute a central element in the healthy Nordic diet and food culture in the region. Because of the well-established health benefits of high WG consumption (Kwok et al., 2019; Reynolds et al., 2019) and acknowledged health risks of low WG consumption (Afshin et al., 2019), Nordic Nutrition Recommendations state that 75 g/10 MJ WGs should be consumed daily (Nordic Council of Ministers, 2012). The per person cereal consumption in the Nordic countries is about 106 kg per year (FAO/WHO, 2018), which corresponds to 290 g per day; 228 g, 28 g, 10 g, and 9 g are wheat, rye, barley, and oat products, respectively. Current daily WG intake varies between 42 and 80 g per person in the Nordic countries (Engeset et al., 2014; European Commission, 2021; Miller, 2020), which suggests that ca. 210–250 g refined grains are consumed daily. Cereal foods are important sources of carbohydrates and dietary fibre (DF), but also an important source of protein. In the Nordic countries, the daily intake of cereal protein is 26.7 g per person, which equates to ca. 22% of the total protein intake. Wheat is the major source of cereal protein (22.1 g/d), while rye, oats and barley provide on average 2.0 g, 0.8 g, and 0.6 g of protein per person per day, respectively.

Despite strong traditions of oat and rye consumption in the Nordic countries and emerging novel oat-based foods, wheat is the dominant cereal protein source in the Nordic countries. Oats represent a grain with underused potential for production of healthy and sustainable foods. Nordic oat production contributes to approximately 7% (i.e., 1.6 million tonnes per year) of oat production worldwide (FAO/WHO, 2018). Because of its mild taste, technological properties (Boukid, 2021), established health impacts, and health claims mainly related to oat β-glucan (EFSA, 2010, 2011), there has been increased development of oat products, and oat foods with health-supporting properties are now available in many staple food categories. Oat β-glucan has been shown to support both healthy gut microbiota and postprandial glycemic control (Tosh and Bordenave, 2021). In addition, oat phytochemicals may have anti-inflammatory effects (Sang and Chu, 2017). However, 66% of oats are used as animal feed globally (FAO/WHO 2018), although there have been active attempts to increase their human consumption. Oats also provide a safe option for many individuals with celiac disease (Aaltonen et al., 2017); while wheat protein consists mainly of gluten which causes immunological reactions and gut barrier disruption among gluten intolerant individuals, oats are naturally gluten-free. Oat proteins are of rather high nutritional quality. While cereal proteins often lack the

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https://doi.org/10.1016/j.jcs.2022.103462
Received 11 January 2022; Received in revised form 7 March 2022; Accepted 14 March 2022
Available online 8 April 2022

Table 1
Comparison of selected nutritional values of oat-based vs. animal-based food portions providing 5.8 g protein (THL, 2021). Iron, selenium, iodine, vitamin D, and folate have been identified as nutrients which might be deficient in the diets of Finnish adult population (Valsta et al., 2018). Traditional wholegrain (WG) products are written in italics, meat and meat analogues are written in bold.

	Minced meat (beef)	Milk, skimmed	Yogurt, 2.5% fat	*WG oat porridge, in water*	*Oat bread, 100% WG oats*	Minced meat analogue 1	Minced meat analogue 2	Oat drink, average[a]	Oat gurt, unflavoured[a]
amount (g)	**30.5**	190.0	195.0	*284.0*	*60.0*	**19.5**	**29.0**	488.0	270.0
portions, medium-sized	**0.2**	1	1	*1.25*	*2*	**0.2**	**0.4**	2.5	2
Energy nutrients									
protein (g)	**5.8**	5.8	5.8	*5.8*	*5.8*	**5.8**	**5.8**	5.8	5.8
energy (kcal)	**69**	64	106	*164*	*147*	**39**	**68**	221	141
carbohydrates (g)	**0.0**	9.3	9.4	*25.7*	*22.3*	**1.6**	**7.6**	35.0	22.8
fat (g)	**5.2**	0.2	4.9	*3.1*	*2.7*	**0.9**	**1.1**	5.3	2.2
fibre, total (g)	**0.0**	0.0	0.0	*4.3*	*5.0*	**0.7**	**1.8**	4.3	2.7
Micronutrients									
iron (mg)	**0.6**	0.1	0.1	*2.0*	*2.2*	**1.2**	**0.9**	1.9	1.3
iodine (μg)	**0.9**	34.9	29.2	*8.6*	*23.9*	**6.9**	**2.4**	8.2	64.8
selenium (μg)	**5.2**	5.2	5.5	*5.3*	*4.5*	**0.4**	**1.5**	5.1	3.4
vitamin D (μg)	**0.1**	0.0	0.1	*0.0*	*0.0*	**0.0**	**0.0**	2.0	3.0
folate (μg)	**1.5**	8.1	10.0	*18.7*	*19.4*	**1.7**	**6.0**	42.0	12.0

[a] Fortified with iodine and vitamin D2.

essential amino acid lysine which makes them potentially less digestible in the human digestion system in comparison to animal proteins, dehulled oats are well ranked in digestible indispensable amino acid scoring (DIAAS) (Cervantes-Pahm et al., 2014).

There is a recognized need to replace a portion of animal-based food in our diet with more sustainable options. In our recent review (Poutanen et al., 2021) we highlighted the global importance of grains as a dietary protein source and provided suggestions on how 10% of current daily animal protein consumption in Europe could be replaced with cereal protein. This indicates that cereal protein intake would need to be increased by 5.8 g per day, which corresponds to 19 and 22% more than the current intake in whole Europe or in the Nordic countries, respectively. Depending on food type, this replacement would have also other nutritional consequences in the diet; along with protein, different levels of carbohydrates, DF, and fibre-associated nutrients and bioactives would be ingested. For example, the target of 5.8 g of protein could be reached by replacing 0.2 portions of minced meat or 1 portion of skimmed milk with a large portion of WG oat porridge or 2 portions of WG oat bread (Table 1) (THL, 2021); in addition, 4–5 g of DF and ca. 19 μg of folate would be provided. However, an extra 22–26 g of carbohydrates would also be ingested, which would increase dietary energy intake in comparison to the animal-based protein sources.

Oats have recently proved to be an outstanding starting material for a multitude of new food concept innovations. The use of oat as an ingredient in meat and dairy food analogues (e.g., substitutes of minced meat, milk, yogurts, creams, ice cream etc.; Table 1) has expanded significantly. Oat-based meat and dairy analogues are rarely sources of WG oat ingredients, and they differ in nutrient profile and possible subsequent health effects in comparison to WG oats. However, they have gained consumer acceptance due to good palatability and sustainability issues. With oat-based minced meat analogues, the protein target of 5.8 g is easy to fulfil, as only 0.2–0.4 medium-sized portions would be needed (THL, 2021). However, that would only be accompanied by a minor 1–2 g of DF. Oat-based milk and dairy analogues are often low in protein, and to reach the target of 5.8 g per day, 2 portions of oat gurt or 2.5 portions of oat drink should be consumed. This would lead to an intake of additional 23–35 g of carbohydrates, but also to an intake of fair amounts of DF (3–4 g), selenium (3.5–5 μg) and folate (12–42 μg).

Replacing nutrient dense foods with high vitamin and mineral bioavailability, such as dairy and meat, with plant-based analogues with lower levels and bioavailability of such nutrients represents a major challenge in the shift towards sustainable diets. Fortification issues should be considered in the dietary shift (McLaren et al., 2021), especially when plant-based products are used to replace animal-based food items that have been fortified with certain nutrients. In certain Nordic countries, it is recommended (Finland, Norway) or mandatory (Sweden) to fortify milk and selected dairy products with vitamin D to ensure adequate intake in these high latitude countries with limited availability of sunlight during winter season (Itkonen et al., 2021). For example, in Sweden, it is also mandatory to fortify plant-based milk analogues with vitamin D (Itkonen et al., 2021), and in most Finnish oat drink and gurt products, vitamin D fortification is applied (Table 1). However, equivocal results have been observed on the stability, bioaccessibility, and bioavailability of vitamin D from fortified breads (Souza et al., 2022). Dairy products are among the most important sources of iodine in the diet and replacing them with unfortified plant-based alternatives may result in inadequate iodine intake (Bath et al., 2017). Furthermore, it is well acknowledged that the bioavailability of plant-derived non-heme iron is not as high as iron from animal-based foods (Lim et al., 2013). Thus, oats and oat-based products would need to be complemented with foods with higher bioavailability of iron to avoid risk of deficiency, due to the presence of iron absorption-inhibiting substances, such as phytate and calcium (Lim et al., 2013) which is often added to oat-based milk analogues.

One strategy to reach the suggested target of replacing 20% of the total animal protein intake with plant proteins, as suggested in our previous work (Poutanen et al., 2021), could be to replace 0.5 portions of minced meat (i.e., 70 g) with 0.5–1 portions of cereal-based meat analogue (i.e., 50–75 g). Oat-based milk analogues typically contain minimal oats, and therefore, do not contribute much to WG or cereal intake. However, the utilization of milk analogues instead of milk would enable moderation of protein intake in an adult Nordic population where protein intake is already at, or above, dietary recommendations (Nordic Council of Ministers, 2012; Valsta et al., 2018). Overall, milk and dairy analogues are primarily intended to give a similar consumer experience as the animal-based foods they would replace, although novel oat protein concentrates could also provide means to boost the cereal and protein content of these products (Mogensen et al., 2020).

In conclusion, consuming 5.8 g of oat proteins as traditional WG products provides benefits related to the unique components (β-glucans, bioactive plant metabolites etc.) of this cereal species. This would also contribute to overall WG intake and diversity of cereal grains in Nordic diets, now dominated by refined wheat. Novel meat, dairy, and milk analogues do not contribute to the diet with comparable amounts of DF, vitamins, and minerals as the corresponding WG would but are valuable tools in attempts to reduce animal protein and total protein intake and thus the environmental burden and adverse health effects of current dietary patterns.

Funding

This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of interests

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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