The Next Generation Whole Grain Products

A Mineral Shift for Health and the Planet

Results from The Mineral Shift Project: Hydrothermal treatment of grains makes it easier for the body to absorb minerals.

AXFOUNDATION

Hidden in Grains

MatLust

Södertälje kommun

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The Next Generation Whole Grain Products – A Mineral Shift for Health and the Planet

Our bodies can only absorb a fraction of certain minerals found in grain products, unlike meat where we can absorb significantly more. While we need to get enough nutrients, we also need to eat more plant-based and whole grain foods for both the planet and our health.

To balance this equation, a mineral shift is needed where the bioavailability of minerals in plant-based products is increased. In the Mineral Shift project, an innovative technique has been further developed and tested in the next generation of tasty and nutritious whole grain products. This method is called hydrothermal treatment, and the result is that the body can absorb almost as much iron and zinc from whole grains as from meat.[1]

9 out of 10 Swedes eat too little whole grain

One of the most important changes for a sustainable food consumption is reducing meat consumption and eating more plant-based foods, including an increased intake of whole grains and legumes.[2] Today, 9 out of 10 people in Sweden eat less whole grains than recommended,[3] while the consumption of red meat and processed meats is significantly higher than recommended. To achieve a nationally sustainable and healthy food consumption, Swedish authorities suggest that whole grain consumption should be doubled, and meat consumption should be reduced by 30% by 2035.[4]

Reduce meat consumption by 30%

Consumers are sometimes concerned that a shift to more plant-based foods would provide too little protein,[5] but this risk is considered low.[6] However, several researchers highlight the risk of deficiency in certain minerals, such as iron and zinc.[7] In Europe, only 20–35% of the women in reproductive age have sufficient iron stores to complete a pregnancy without iron supplements,[8] and vegetarians generally have a lower iron status.[9] Meat is an important source of iron, but actually grains are the main food group contributing to iron intake (20–49%) in most European countries.[10] The problem is that the minerals in grains such as wheat, rye, oats, and barley are bound to the antinutrient phytic acid and therefore difficult for the body to absorb.[11]

25–30% of European girls and young women are at risk of iron deficiency

By increasing the availability of minerals in grains and making flavorful, sustainable, and nutritious food products, there is great potential to replace meat as a source of minerals.

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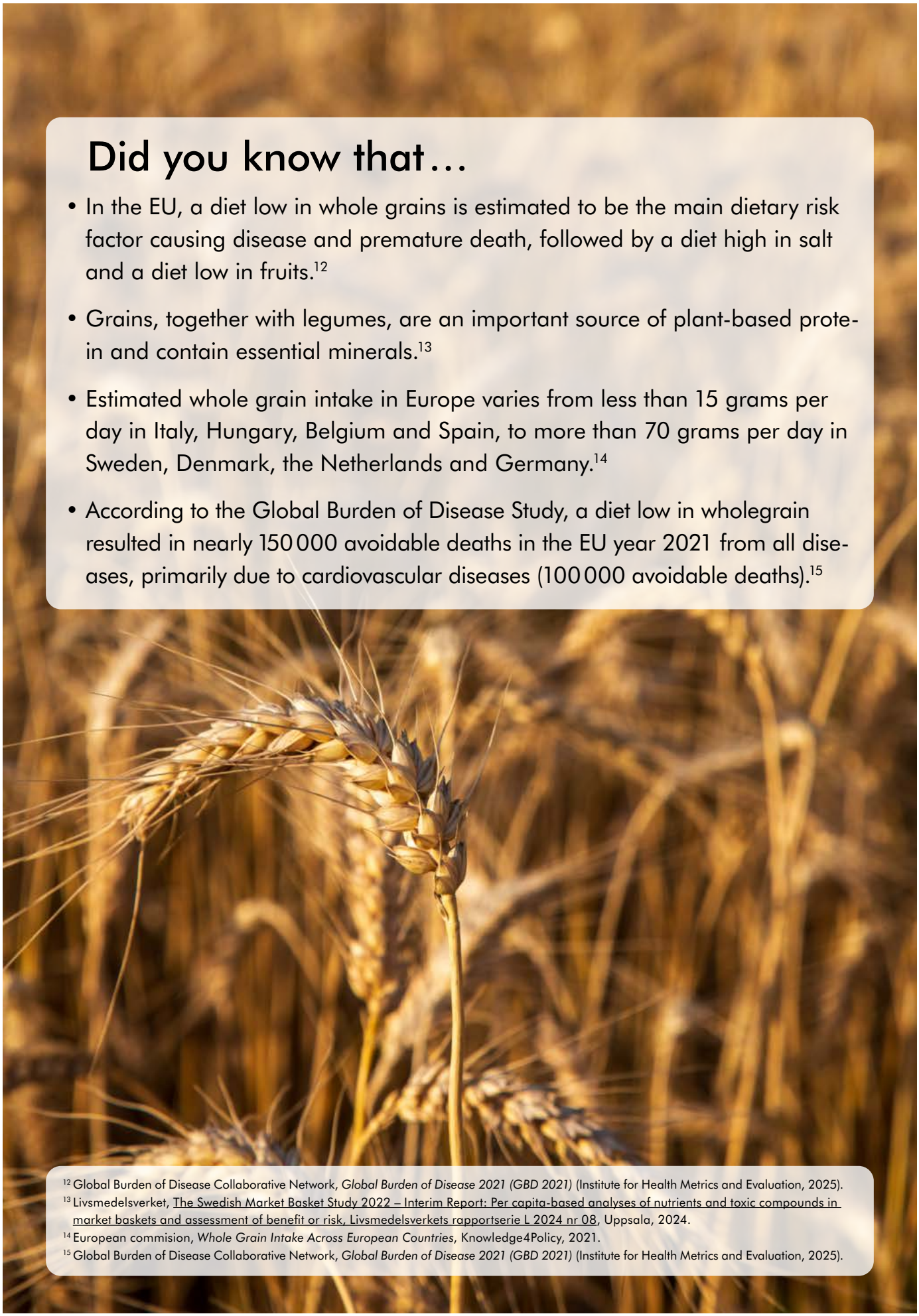
[1] Anna Sandberg, Rätt beredning och processning av växtbaserade livsmedel minskar risk för brist på järn och zink, Nutritionsfakta.se, 2020.
[2] EAT-Lancet Commission, Healthy Diets From Sustainable Food Systems Food Planet Health, 2019.
[3] Livsmedelsverket, Riksmaten ungdom 2016–17 – Del 2: Näringsintag och näringsstatus bland ungdomar i Sverige, 2018.
[4] Folkhälsomyndigheten och Livsmedelsverket, En hållbar och hälsosam livsmedelskonsumtion, 2024.
[5] Ingrid Fredriksson och Paulina Ilieva, Uppfattningar om växtbaserad kost: *En kvalitativ studie*, 2022.
[6] Ólöf G. Geirsdóttir och Anna-Maija Pajari, 'Protein – a scoping review for Nordic Nutrition Recommendations 2023. *Food & Nutrition Research*, vol. 67, 2023.
[7] Anna Sandberg, Rätt beredning och processning av växtbaserade livsmedel minskar risk för brist på järn och zink, Nutritionsfakta.se, 2020.
[8] Nina Milman, Christine L. Taylor, Jill Merkel och Patricia M. Brannon, 'Iron status in pregnant women and women of reproductive age in Europe', *The American Journal of Clinical Nutrition*, vol. 106, suppl. 6, 2017, pp. 1655S–1662S.
[9] Anna Floegel et al., 'Cohort-Based Reference Values for Serum Ferritin and Transferrin and Longitudinal Determinants of Iron Status in European Children Aged 3–15 Years', *The Journal of Nutrition*, vol. 154, nr. 2, 2024, pp. 658–669.
[10] European Food Safety Authority (EFSA), 'Scientific opinion on dietary reference values for iron', *EFSA Journal*, vol. 13, nr. 10, 2015, p. 4254.
[11] R.F. Hurrell, M.B. Reddy, J. Burri och J.D. Cook, 'Phytate degradation determines the effect of industrial processing and home cooking on iron absorption from cereal-based foods', *British Journal of Nutrition*, vol. 88, nr. 2, 2002, pp. 117–123.



Did you know that…

- In the EU, a diet low in whole grains is estimated to be the main dietary risk factor causing disease and premature death, followed by a diet high in salt and a diet low in fruits.[12]
- Grains, together with legumes, are an important source of plant-based protein and contain essential minerals.[13]
- Estimated whole grain intake in Europe varies from less than 15 grams per day in Italy, Hungary, Belgium and Spain, to more than 70 grams per day in Sweden, Denmark, the Netherlands and Germany.[14]
- According to the Global Burden of Disease Study, a diet low in wholegrain resulted in nearly 150 000 avoidable deaths in the EU year 2021 from all diseases, primarily due to cardiovascular diseases (100 000 avoidable deaths).[15]

[12] Global Burden of Disease Collaborative Network, *Global Burden of Disease 2021 (GBD 2021)* (Institute for Health Metrics and Evaluation, 2025).
[13] Livsmedelsverket, The Swedish Market Basket Study 2022 – Interim Report: Per capita-based analyses of nutrients and toxic compounds in market baskets and assessment of benefit or risk, Livsmedelsverkets rapportserie L 2024 nr 08, Uppsala, 2024.
[14] European commision, *Whole Grain Intake Across European Countries*, Knowledge4Policy, 2021.
[15] Global Burden of Disease Collaborative Network, *Global Burden of Disease 2021 (GBD 2021)* (Institute for Health Metrics and Evaluation, 2025).

Solution and Results

Since 2021, the Mineral Shift project has brought together a wide range of stakeholders to address the issue of low mineral bioavailability and to develop the next generation of flavorful and nutritious whole-grain products using barley, rye, and wheat.

At the core of the Mineral Shift project lies an innovative hydrothermal treatment method, developed by the researchers behind the company Hidden in Grains. This technique is inspired by traditional preparation methods that have been used for centuries. It has been optimized with modern technology at Axfoundation's development center, Torsåker Farm. Simply put, the method involves soaking grains under controlled time and temperature conditions, triggering the seed's natural processes – or tricking it into believing that spring has arrived, and it is time to release its stored nutrients.

Through hydrothermal treatment, it becomes easier for the body to absorb essential minerals such as iron and zinc.[16] The project has demonstrated that even in large-scale processing of whole grains, up to 99% of the antinutrient phytic acid can be broken down (see table on page 8). This means that the phytic acid is degraded and has released its minerals, making up to four times more iron and zinc available for absorption.[17] Previous studies have shown a 95% breakdown of phytic acid, resulting in up to seven times more available iron and nine times more available zinc.[18] This significantly enhances the absorption of iron,[19] and zinc in plant-based meals.[20]

The grains used in the Mineral Shift project include Swedish-grown barley and rye, as well as wheat from heritage grain varieties such as einkorn wheat, emmer wheat, Dalawheat, spelt, and others. The choice of grains was based on taste, application, and cost to ensure a sustainable business model. The selection also considered the nutritional content of the grains, as a higher mineral content in the raw material can be crucial to the final product's value.

[16] R.F.Hurrell, M.B. Reddy, M.A. Juillerat and J.D. Cook, 'Degradation of phytic acid in cereal porridges improves iron absorption by human subjects', *American Journal of Clinical Nutrition*, vol. 77, no. 5, 2003, pp. 1213–1219.

[17] Hidden in Grains, se table on p.8.

[18] Elien Lemmens et al., 'The impact of steeping, germination and hydrothermal processing of wheat (Triticum aestivum L.) grains on phytate hydrolysis and the distribution, speciation and bio-accessibility of iron and zinc elements', *Food Chemistry*, vol. 264, 2018, pp. 367–376.

[19] R.F. Hurrell, M.B. Reddy, M.A. Juillerat and J.D. Cook, 'Degradation of phytic acid in cereal porridges improves iron absorption by human subjects', *American Journal of Clinical Nutrition*, vol. 77, no. 5, 2003, pp. 1213–1219.

[20] Kerstin Fredlund et al., 'Absorption of zinc and retention of calcium: dose-dependent inhibition by phytate', *Journal of Trace Elements in Medicine and Biology: Organ of the Society for Minerals and Trace Elements (GMS)*, vol. 20, no. 1, 2006, pp. 49–57.

The choice of grains, combined with hydrothermal treatment, provides several added benefits: improved profitability for Swedish grain producers and processors, more efficient use of resources, and contributions to the national environmental goal *A Varied Agricultural Landscape*.[21]
The project has led to the development of new meals and products using hydrothermally treated barley, rye, and wheat. *Hidden in Grains* has introduced new whole grain products to the market, while Axfoundation's innovation team at Torsåker Farm has developed new meals and food products. Additionally, MatLust Development Node, in collaboration with Södertälje Municipality's testbed, has tested new dishes in school kitchens and cafeterias.

The result is a variety of new, tasty, sustainable, and nutrient-rich food products for both consumers and the food service sector. This work continues to support a mineral shift and accelerate the transition to a more sustainable food system.

Partners
The Mineral Shift project has been led by **MatLust Development Node**, run by **Södertälje Municipality**, in collaboration with **Axfoundation**, **Hidden in Grains**, and **Warbro Kvarn**. **The Food Science division at Chalmers University of Technology** has also participated as a collaboration partner. The initiative has further collaborated with a wide range of researchers from several institutions, as well as stakeholders in retail and food service sectors, including **Middagsfrid**, **Urban Deli**, and **Dagab** (part of Axfood).
The project has been partly funded by Sweden's innovation agency **Vinnova** as a part of their initiative to support the future of tasty, healthy, and sustainable plant-based food.

Key Concepts

Antinutrients occur naturally in all seeds, including grains, legumes, and nuts. They inhibit the absorption of nutrients from food and, in large amounts, can lead to deficiencies of minerals and other essential nutrients.

Phytic acid is an antinutrient that can bind to minerals such as iron and zinc. In grains, phytic acid is found in the outer part of the kernel, where many minerals and other nutrients are also located. Since phytic acid is not degraded in the stomach, humans are unable to absorb the bound minerals, thereby, mainly passing through the digestive system without being utilized.

Bioavailability refers to the proportion of a nutrient that the body can absorb and use for physiological processes.

Whole grain means that all parts of the grain kernel are included—whether as whole grains, crushed or cut grains, or ground flour. People who consume a high amount of whole grains have a lower risk of developing type 2 diabetes, colorectal cancer, and cardiovascular disease.

[21] Ett rikt odlingslandskap, Sveriges miljömål, Naturvårdsverket, 2023.

"Almost everyone would benefit from eating more whole grains. That's why we need accessible products on the market that are both delicious and sustainable, allowing us to truly reap the nutritional benefits of whole grains. Moreover, whole grains are among the most environmentally friendly foods we can eat, having a low impact on the climate and also a low use of pesticides compared with e.g. many vegetables."

Veronica Öhrvik, Project Manager at Future Food, Axfoundation.

How the Tests Were Conducted at Torsåker Farm

Optimization for Taste and Resource Efficiency

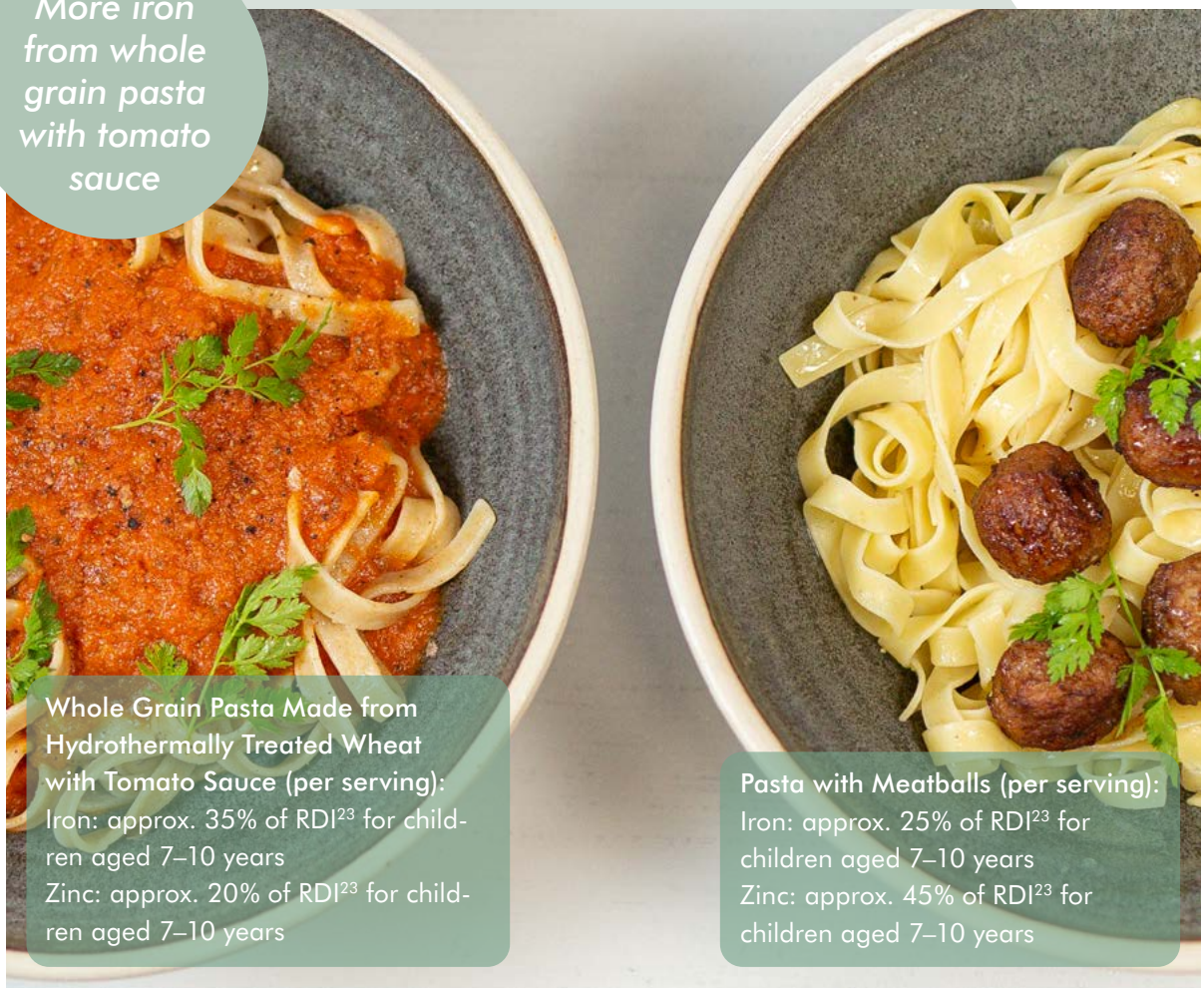
At Axfoundation's development center Torsåker Farm north of Stockholm, Hidden in Grains has optimized its hydrothermal treatment with a focus on taste and resource-efficient scaling – without compromising the results. In the test kitchens, the hydrothermal treatment of various grains has been improved by adjusting parameters such as temperature, time, and pH value. The results from the upscaling process show that the breakdown of phytic acid has been optimized for excellent mineral availability, while the method has been made more energy-efficient by reusing both heat and water.

The method works very well for wheat, barley, and rye but has proven less effective for oats. The treatment leaves the grain relatively unchanged, allowing it to be milled, crushed, or flaked in a regular mill.

More Iron from Pasta with Tomato Sauce than from Meatballs

Iron absorption depends partly on each individual body's iron stores, and will increase for people with iron deficiency. A portion of hydrothermally treated whole-grain pasta with tomato sauce can theoretically provide more available iron than a traditional portion of pasta with meatballs.[22]

More iron from whole grain pasta with tomato sauce



Whole Grain Pasta Made from Hydrothermally Treated Wheat with Tomato Sauce (per serving):
Iron: approx. 35% of RDI[23] for children aged 7–10 years
Zinc: approx. 20% of RDI[23] for children aged 7–10 years

Pasta with Meatballs (per serving):
Iron: approx. 25% of RDI[23] for children aged 7–10 years
Zinc: approx. 45% of RDI[23] for children aged 7–10 years

[22] The comparison is based on nutritional data and portion sizes from the Swedish Food Agency's food database, version 2023-06-13.
[23] RDI – Recommended Daily Intake. Based on Nordic Nutrition Recommendations 2023 (NNR 2023).

Optimization of Hydrothermal Treatment

Grain	Variety	Latin Name	Optimized level of phytic acid degradation	Estimated increased uptake of zinc	Estimated increased uptake of iron	Tested Products
Rye	Amilo	*Secale cereale L.*	99%	up to 4x	up to 4x	Snack with rye, cheese, and berries
Wheat (landrace)	Jacoby borst	*Triticum aestivum subsp. Aestivum*	96%	up to 4x	up to 4x	Flour (pan-cakes, pasta and cakes)
Barley (with husk)	Planet	*Hordeum vulgare*	86%	up to 4x	up to 4x	Barley bulgur
Wheat	Einkorn	*Triticum mono-coccum subsp monococcum*	95–99%	up to 4x	up to 4x	Porridge and gruel for baby food, crispbread, cookies, etc
Wheat	Spelt (Dinkel Oberkulmen Rotkorn)	*Triticum aestivum subsp. spelta*	82%	up to 4x	up to 4x (with vitamin C or lactic acid)	Pancakes
Barley (hulled)	Irina	*Hordeum vulgare*	94–99 %	up to 4x	up to 4x	Barley bulgur
Rye	Schmidt	*Secale cereale L.*	95%	up to 4x	up to 4x	Crushed grains for porridge
Swidden rye	Swidden rye	*Secale cereale L.*	93%	up to 4x	up to 4x	Works very well in bread and porridge when crushed/ coarsely ground
Rye	Rye Warbro	*Secale cereale L.*	85–89%	up to 4x	up to 4x	Bulgur and coarse flour
Rye	Rye Fulltofta	*Secale cereale L.*	88%	up to 4x	up to 4x	Bulgur and coarse flour

Figure 1: Examples and results for some of the hydrothermally treated grains in the Mineral Shift project.
Source: Hidden in Grains and Fredlund K. et al. Absorption of zinc and calcium: dose-dependent inhibition by phytate. Journal of Trace Elements in Medicine and Biology 2006; 20(1), 49–57.

Innovative Meals and Food Products

In the test kitchen at Torsåker Farm, Axfoundation's innovation team has developed new meals and products using hydrothermally treated grains. MatLust Development Node and Södertälje Municipality's testbed have also experimented with new ingredients and dishes. The result is a range of new, tasty, and sustainable food products on the market, as well as a selection of meals tailored for restaurants and public kitchens.

The Snack of the Future – Råggyberry

In collaboration with the meal-kit company Middagsfrid, Axfoundation has developed what could be the snack of the future. The core recipe was developed at Torsåker Farm and is primarily made from Swedish ingredients, including hydrothermally treated rye, a by-product from white cheese production, yogurt, apples, and blackcurrants. The product is designed for children and meets the nutritional criteria set by Generation Pep for a healthy snack—containing whole grains, protein, and fruit or berries.[24]

A total of 50 families tested the product together with Middagsfrid, with highly positive feedback. The snack was also successfully introduced at Generation Pep Day, where 2,000 children and adults sampled it in two different compote flavors: apple/rhubarb/cinnamon and apple/blackcurrant. Due to the overwhelmingly positive response, the snack was then tested in retail stores during 2024 in collaboration with Dagab (part of Axfood) and Urban Deli. The snack was also served at the 2025 Alpine World Cup in Åre where top skiers had the chance to try it.
The product, named Råggyberry, will be launched in selected stores, including Willys, Hemköp, and Urban Deli.

Results from Middagsfrids test

80% thought that the snack of the future was tasty or super tasty

75% reported that they felt just the right amount of full

85% reported that they understand the benefits of hydrothermal treatment*

*Based on the information: "Hydrothermal treatment is a gentle yet effective processing of the grain that makes it easier for us to access the nutrients. Through heat, lactic acid, and water, the grain's phytic acid is broken down, making minerals like iron, zinc, and calcium easier for the body to absorb."
Source: Middagsfrid & Axfoundation

[24] *Pep-kiosk: Så kan du göra skillnad med bättre mat i kiosken*, Generation Pep.

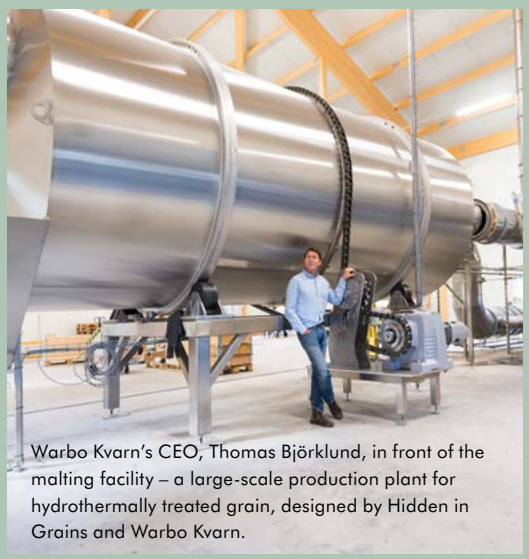
From Crispbread to Pancakes

A variety of meals and products have been tested at Torsåker Farm, ranging from granola and porridge to pasta, pancakes, crispbread, cookies, and even sausages – all with highly successful results.

Workshop with test cooking in Nykvarn Municipality – bulgur with cracked barley on the menu.

Bulgur

As part of the project, MatLust has evaluated how schoolchildren in Södertälje respond to products made from hydrothermally treated grains. Both the children and the chefs and kitchen managers gave their approval. Hidden in Grains products have been successfully tested in dishes such as bulgur, tabbouleh, and as an ingredient in meat-based dishes. The product is sold under the name “Barley Bulgur” and is available for purchase through wholesalers. The primary target group for the bulgur is public food services. Interest has been strong, supported by an initiative featuring lectures and cooking demonstrations developed by MatLust and Hidden in Grains.



Warbo Kvarn’s CEO, Thomas Björklund, in front of the malting facility – a large-scale production plant for hydrothermally treated grain, designed by Hidden in Grains and Warbo Kvarn.

Micronization

Through micronization, a process that finely grinds whole grains, sifted wheat flour can be completely or partially replaced with whole grain flour in products such as pasta, pancakes, cookies, and bread. Micronization provides the health benefits of whole grains while offering a taste and texture that many consumers find more appealing than traditional whole grain flour. This process makes products more accessible and easier to work with compared to conventional whole grain flour, opening new possibilities for nutrient-rich everyday foods. In the Mineral Shift project, a similar method called air vortex milling was used, offering comparable advantages.

"The results show that the products are both flavorful and easy to use – and that we can achieve significant value addition at a very low climate and energy cost."

David Fredlund, CEO of Hidden in Grains

Hidden in Grains, together with Warbro Kvarn, has launched hydrothermally treated grains, including barley bulgur.

The first phase of the Mineral Shift project was carried out from 2021 to 2024 by MatLust Development Node, run by Södertälje Municipality, in collaboration with Axfoundation, Hidden in Grains, and Warbro Kvarn. Chalmers University of Technology's Food Science division also participated as a partner. The initiative was partially funded by Sweden's innovation agency Vinnova and aimed to develop the nutritious and flavorful grain products of the future.

Axfoundation is an independent, non-profit organization that innovates and accelerates practical solutions for a sustainable society. We believe in business as a force for change, and in broad collaborations with relevant stakeholders across society. Together with more than 300 partners, we tackle practical challenges related to the things we buy, the food we eat, and the resources we use.

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