Let's make grain great again

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The Landrace

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Table of contents

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News from Landsorten

In the spring, Landsorten hired Henriette Winther as its new director. Henriette's hard work has been crucial to the development of the organisation this year. Unfortunately, Henriette had to call in sick in September with immediate effect. At the same time, Johan Lund is on leave to complete his education, and Bjarne Hansen has therefore been left alone to work with the seed alongside his work at Aurion and ORIGENAL. Landsorten has therefore been under pressure this autumn and will be so for the rest of the year. This is also the reason why we have not been able to publish this newsletter as often as planned. We also hope for your understanding if you have experienced extended response times. On the other hand, we are pleased to announce that Henriette is expected back at the helm of Landsorten during the winter, when Johan will also return. Until then, please direct all enquiries to Anders Borgen at anders@landsorten.dk or our front person Emilie at emilie@landsorten.dk

The future secured for Landsorten until 2026

As long as the grain from Landsorten only has a relatively small distribution, Landsorten's finances are entirely dependent on private and public foundations and others who see the sense in supporting our work. Therefore, both last year and this year, we have applied for several projects in the Plant Foundation, which was established to promote Danish plant-based foods. We have been fortunate that this year the Plant Foundation has chosen to support one of our project proposals, which for the next two years will be able to continue the work that Henriette in particular has begun in 2024.

The new project means that over the next two years, professional kitchens and sourdough bakers will get to know our more than 50 grain varieties and be able to use the grain in both green dishes and good sourdough bread. This will benefit chefs, bakers and those who grow the grain.

As part of the project, Landsorten will organise an international grain festival in 2026, where all the good people and organisations will join forces in a joint event dedicated to grain. Emilie Berning from Vild Hvede will be the coordinator of the grain festival, but the event is part of a series of recurring grain events organised by a Nordic network and the European network Let's Liberate Diversity. You can expect a cornucopia of exciting workshops, field demonstrations, tasting and baking sessions, talks from home and abroad and much more.

We will be reaching out to you at a later date regarding special varieties not only from Landsorten but from all over Europe and the world, to be sown in a demonstration field in continuation of the grain festival. We need to receive the varieties already in the summer of 2025, so if you already know of any unique grain varieties or know of any projects that might be interested in sending their grain on a journey, please send them our way.

The mailbox for ideas is also open if you have an exciting idea for presentations or speakers that revolve around the communication of grain, cultivation practices or processing.

Enjoy - and thank you to the Plant Foundation for willingly support

Status of cultivation and seed

The area of landrace cereals continues to increase. In 2024, an area of around 500ha has been cultivated with varieties from Landsorten, and we expect that around 900ha has already been sown (or planned to be sown) during the autumn of this year, of which Mariagertoba accounts for just over half. The total area of organic baking wheat in Denmark is estimated to be 10,000ha, so we expect that varieties from Landsorten in 2025 will cover an areal equivalent in size to around 10% of organic bread grain production in Denmark.

Mariagertoba in particular has been a great success in the market. All the mills in Landsorten report that stocks of Mariagertoba are either already empty or expected to run out in the spring. Therefore, we expect production to increase in the coming years. However, there are limits as to how quickly production can be expanded. If all the grain is used as seed in anticipation of increasing demand, there will be no grain for the mill and the market could stall. Conversely, if too much is milled, there will be no grain left to sow and nothing to harvest for the coming years. Therefore, there must always be a balance between keeping the market going and at the same time securing seed for an increasing demand. This also requires coordination between companies and is one of Landsorten's major tasks.

Borris Rye, which was described in The Landrace in May 2022 has also become one of the year's great successes. When Landsorten put Borris rye into production with farmer Christian Hjorth in Himmerland, there has been great demand not only for bread grain, but also for whisky, where, among other things, a major production has been established in England.

In Danish spelt production, Oberkulmer Rotkorn has so far been the dominant variety, but in Landsorten we have now found and multiplied the only spelt variety originating in Denmark. The market has responded to this, and we expect Danish Spelt to become the dominant spelt variety in Denmark in the future, as it has roughly the same quality, but it performs better in terms of yield than Oberkulmer Rotkorn, and it has a better story to tell in a Danish context.

A night with einkorn at Lille Bakery

Anders Borgen and Emilie Berning represented Landsorten at a packed and atmospheric evening in the sign of the einkorn at Lille Bakery in Copenhagen on 19th November. Here, bakers and chefs had gone to great lengths to interpret the einkorn through different breads and a delicious risotto with cooked polished einkorn kernels. There were presentations and stories focusing on the entire journey of the grain from farm to fork. One of the things we learnt about through Anders Borgen's presentation was the pedigree of einkorn, and to the surprise of many, it turns out that einkorn is not really the mother of all wheat, as is claimed in certain circles. Rather, einkorn has its very own lineage, which is not directly related to the modern wheat we grow today. There you have it.

News from the Board

For all of you who are not already informed, we can report that this year the following new people were elected to the board; Jonas Astrup, Development and Innovation Manager at Meyers and Gitte Hesselbæk Breum, Director of Food for Every Day and owner of the consulting company Økokonsulenten. With these experienced profiles, we strengthen the development of Landsorten towards the market.

On the board, we have a broad representation of disciplines and competences, which is of great importance for the association's work in these years, where we must keep up with developments and sharpen Landsorten's strategy both internally and externally.

The Landsorten board. From left: Anders Borgen, Jonas Astrup, Lars Sørensen, Karsten Kjærgaard, Bitte Breum, Bjarne Hansen and Emilie Hansted Berning.

The strategy that Landsorten is now working on is based on two pillars. Firstly, we must promote demand from the food companies so that the market continues to increase. This part of the strategy is ensured, among other things, through the Plant Foundation project described above.

The second part of the strategy is to ensure that there is a production to market. Quality assurance is the main bottleneck here. Even varieties such as Mariagertoba and Borris rye, which are grown on large areas, do not keep themselves alive. Time and time again, we see that the grain either becomes infected with seed-borne diseases or gets mixed up with other grain, and then the grain cannot be used as seed. Therefore, there is a lot of work involved in ensuring that there is enough seed of all varieties for next year's production of a satisfactory quality. This is done partly by inspecting the fields and partly by cultivating smaller areas under controlled conditions that require special equipment for harvesting, cleaning and analyses. We currently have no funding for this part of Landsorten's work, but we have submitted several project applications for it and naturally hope that it will succeed. It would be a shame if we have a grant for a grain marketing project if there is no grain to sell.

General assemply on 25 February 2025

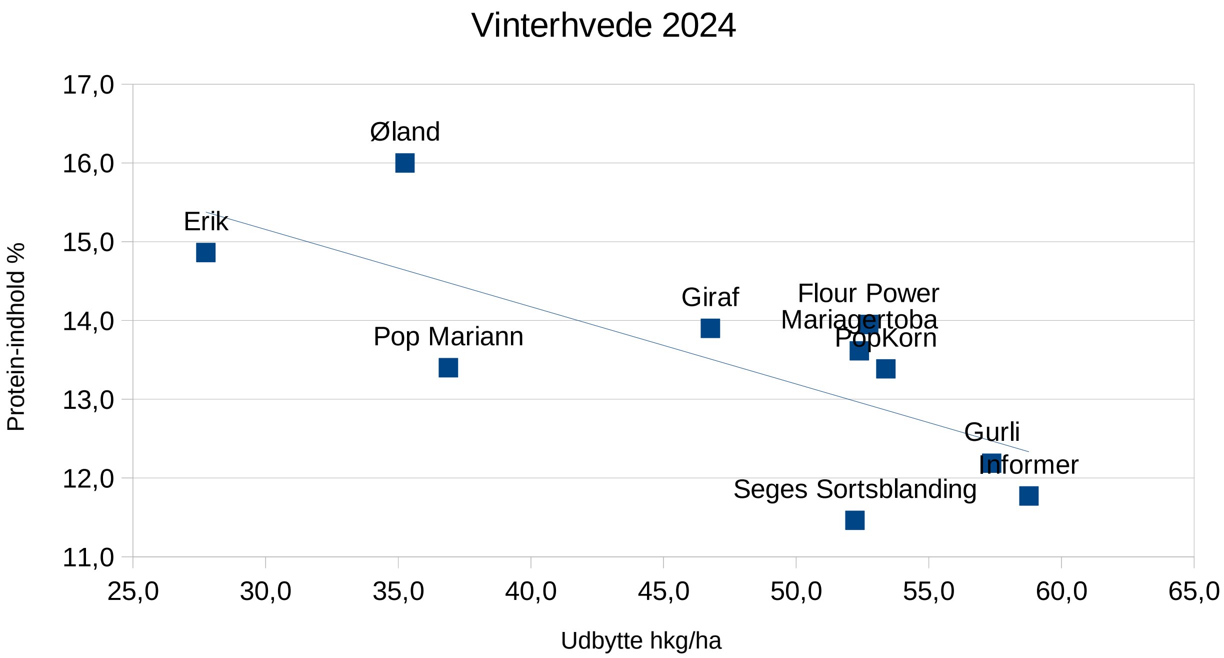
Next year, Mejnerts Mill will host our general assemply. Mejnert's kitchen will provide a delicious meal, and of course we'll take a tour of the mill and its production. We promise it will be a great afternoon in good company, with room for debate and talk about current issues that affect the development of the association, and certainly also the association's members.

Landsorten is still a new and rapidly developing organisation. For some companies, membership of Landsorten is of great importance on both the revenue and expense side. That's why it's important that we can discuss how Landsorten should develop in the coming years at the general meeting. Which and how many varieties are needed? How should we finance the work?

So put an X in your calendar for 25 February. More details will follow as we get closer to the day.

Yields of Landorten varieties

Landsorten conducted a winter wheat yield trial in 2024 at Christian Hjort in Himmerland on good soil with a good preceding crop of red clover. The grain was sown late in 2023, and these conditions have together ensured a very satisfactory yield for organic conditions and at the same time a satisfactory protein content in all varieties. Under these conditions it makes sense to go for the high-yielding varieties, while under more difficult growing conditions it would be better to choose varieties with lower yields to ensure protein content.



Field trials with organic winter wheat with 8 replicates in 7,5m2 plots on fertile soil with low weed pressure. The cultivars 'Erik' and 'Øland' are winter sown spring types and subject to lodging.

There is a close correlation between yield and protein content, so high yields are not necessarily good if the resulting protein content is so low that it cannot be used for baking, for example.

The trial shows that the populations from Landsorten are competitive with conventional varieties in terms of yields. The conventionally bred variety 'Informer' and the population 'Gurli' from Landsorten were the highest yielding, and have given 13% higher yields than the variety mix of high-yielding feed wheat used as a reference in the official National trials and value testing. The populations 'Popkorn', 'Mariagertoba' and 'Flour Power' have given the same yield as the variety mix, but with a higher protein content.

You should never judge varieties based on a single year's trials in a single location, but the ranking in protein content is similar to previous years' trials, although 'Popcorn' is usually 10% higher in yield and 10% lower in protein content than 'Mariagertoba' and 'Flour Power'. With this in mind, the results of this year's trials come as no surprise.

The 'Popkorn', 'Mariagertoba' and 'Flour Power' populations are part of new independent trials by the Innovation Centre for Organic Agriculture in 2024-25, and are now also being tested in Germany and France. We are eagerly awaiting these results.

Is baking quality determined by cultivation or cultivar?

Grain quality is a broad concept. Some would argue that the most important thing is the absence of pesticide residues, while others believe it should be vegan and grown without animal manure. If we pretend for a moment that this is BBC's The Great British Bake Off, where all focus is on baking technique and where environmental ethics, health and food waste are totally ignored in the quality assessment of the result, bread baking in this narrow technical context is very much about getting a bread to rise well and contain air bubbles and juiciness, and about keeping its shape both before, during and after baking.

Anyone who has tried baking with different flours knows that there are differences in the baking properties of spelt, einkorn and wheat. This is primarily due to differences in the gluten properties of the species, which are primarily genetically determined. We also know that some grain is discarded because the individual grain variety can differ from year to year and from field to field. This is primarily due to the falling number and thus the starch, which is primarily determined by environmental factors, especially just before harvest. In other words, gluten properties are primarily genetically determined, while starch is primarily environmentally determined.

Gluten structure

Gluten is a complex mixture of two main groups of proteins, gliadin and glutenin. Gliadin are small round proteins that are particularly important for making dough viscous. Glutenins are generally larger and are important for the extensibility, tightness and elasticity of the dough. Therefore, it is differences in the composition of the glutenins in particular that affect how the dough behaves in the dough dish.

When work began on developing wheat varieties in the 1800s, it was almost exclusively about finding types that grew well in the field. This focus continued in Denmark until well into the 20th century, but in Canada, interest in gluten and baking quality began already at the turn of the century. Charles Saunders discovered that if you chew on some wheat kernels and swallow the spit, the gluten forms a small lump of gum, and from that lump you can actually assess the baking properties of the wheat variety. Even an untrained gum chewer can clearly tell the difference between a traditional spelt and a modern baking wheat. The size of the gum lump indicates the amount of wet gluten in the grain, and whether it is hard or soft to chew expresses the gluten index.

Instead of chewing through all the varieties, you can do a lab test where you basically do the same thing: knead some dough from flour and rinse it with water. This produces a small lump of gluten that you can spin through a sieve. If the gluten is weak, the gluten will be ejected through the sieve, while a strong gluten will be retained by the sieve. The relative amount of gluten retained by the sieve is called the gluten index of the wheat, which varies between 0% and 100%. 'Mariagertoba' is around 90-95, while 'Ølandshvede' is around 60. Spelt is often below 50 and einkorn as low as 10. Especially when the gluten index is low, it can fluctuate somewhat, while varieties with strong gluten are more stable in different analyses.

Until a few decades ago, measuring gluten and dough properties alone determined the selection of good baking wheats, and this is also the method we have used in the development of 'Mariagertoba', 'Popkorn' and other wheats from Agrologica. In recent decades, researchers have also started to look at which specific proteins affect dough quality. Proteins don't just appear out of nowhere, and it's mainly the genetic characteristics of the variety that determine whether the gluten is composed by one or another protein. It has been found that it is the large glutenin molecules in particular that affect the baking properties of wheat, and these high molecular weight glutenins are not very abundant. Some varieties make some proteins, while others contain other proteins. So improving the baking properties of wheat varieties is simply a matter of crossing different varieties that each have their own glutenins and then selecting the plants that have inherited something good from both parents.

Wheat has three genomes A, B and D. Each genome contains genes that determine the production of proteins, but they are grouped into sub-units that in practice always follow each other. On the A genome, there is only one site that determines glutenin, and that site can code for three different glutenins: '1' or '2*' or 'null'. In general, '1' is considered to be the best, while 'null' does not contribute quite as much.

On the B genome, there are 7 different options for subunits, namely '17+18', '7+8', '13+16', '7+9', '7', '6+8' or '20', with '17+18' being the best and '20' being the worst.

On the D genome, there are only two options, '5+10' or '2+12', with '5+2' being far better than '2+12'.

If a wheat variety has none of these subunits, it's really rubbish for baking French style free standing loafs. It may be fine for baking biscuits, for animal feed or for many other purposes, but it won't win any awards for raising a baguette.

Depending on which subunits a wheat variety has on the three genomes, you can calculate how strong gluten it will make. This calculation was developed by Peter I. Payne, and is called the variety’s payne index. The highest payne index is found in varieties that have the combination of '1', '17+18' and '5+10', which together give a payne index of 10, which should result in a gluten index close to 00. However, the world is rarely that simple in reality.

A high gluten index and a high payne index are not always good. If the gluten is too tight, it actually inhibits the dough's ability to rise. Many people actually prefer a gluten index of around 80, but it depends on which recipe you use for baking. If the gluten is soft, the bread should be put in the oven as soon as it comes out of the rising basket to prevent it from flowing out and looking like a thick pizza crust, but if it's tight, it's an advantage to post rise to avoid serving golf balls to family and guests.

By mixing wheat with different gluten indexes, you can achieve the tightness you want. In Landsorten we focus on developing populations rather than genetically uniform varieties. Although you can make good baking wheat by having a certain desired combination of subunits in the variety, we believe that diversity is also important in this context. Therefore, we would rather create populations that are mixtures of many different lines that all have good combinations of traits, but where they have different genetic setup to achieve the desired goal.

Recently, Dennis Christensen has been working on developing genetic markers for the different subunits of glutenins. In the coming years, we hope to use this tool to help identify the best selections for the populations. Not necessarily to set a new European record in gluten index, but on the contrary to ensure that we achieve the desired result while ensuring that we utilise and maintain a wide range of genetic backgorunds to achieve the result.

Many ancient cereals have long straw and a rather soft gluten structure, while all modern short-straw baking wheats have a stong gluten structure. However, it is important to understand that it is not the age of a variety per se that matters in this context, and there is no correlation between the baking properties of a variety and its plant height, spike morphology or other properties. All the gluten quality subunits mentioned above have been found in ancient cereals, and through crossbreeding they are combined in modern varieties to contain up to three different subunits, one on each genome. There are ancient cereals that have a high gluten index because they contain several of the good subunits, and there are plenty of short straw modern wheat varieties that do not contain any of the relevant subunits and are therefore used for purposes other than baking bread.

Kernel hardiness

A grain is made up of cells, and both the cell walls and the inside of the cells contain protein. The majority of gluten proteins are located in the cell walls. Cell wall thickness varies depending on how much nitrogen the plants have had available during cultivation, but also depending on the genetic characteristics of the variety. All things being equal, grains with thick cell walls have more gluten compared to other proteins. A kernel with thick cell walls is hard to cut and has an almost crystal-like structure and resembles amber inside, while a kernel with thin cell walls is softer and more flour-like inside. With a little experience, it's easy to tell the difference between hard and soft grain kernels, especially wheat kernels. This not only affects the gluten properties and thus baking, but also the milling properties in the mill.

There are two genes in wheat that genetically determine whether the cell walls in the kernels are thick or thin, and these two genes are located on the A and B genomes respectively. There are no genes of equal importance on the D genome. Since durum, Kamut and emmer only have A and B genomes but no D genome, durum and the other tetraploid wheats can become more hardy than bread wheat, which will always carry around a D genome that can't really contribute to the party. Still, bread wheat can be quite hard in the kernel if it has both hardness genes.

In addition to the two hardness genes, kernel hardness is also determined by protein content, so the same wheat grown as spring wheat with 14% protein will be significantly harder in the kernel than if it is sown in autumn and ends up with only 9% protein. If you want a very hard kernel for your mill, you should go for a wheat variety with both hardness genes and grow it in a way that ensures a high protein content.

When the cell walls are very thick, what happens during milling is that the kernel splits. This breaks the starch granules and makes the dough stickier. This is especially a problem in stone mills, which (excuse me for saying so) is a rather primitive way of breaking a kernel. On a roller mill, the kernel is crushed between two rollers, which is more gentle on the starch grains. In the grain-producing regions of the Americas, summers are dry, which results in a higher protein content, and they have traditionally used varieties with both hardness genes. This is why the Americans switched to roller mills early on, while in Northern Europe in particular, they stuck to stone mills for a long time, as our wheat is softer due to both climate and varieties and therefore does not cause as many problems with sticky dough.

When the kernel is hard, it becomes difficult to separate the bran from the aleurone layer and to produce white flour by sieving. When you grind a hard wheat on a stone mill and want to sift it into white flour, you end up with a large amount of bran and a low flour yield. Either there is too much bran in the flour or you lose a large part of the aleurone, which contains both flavour and many important nutrients. Stone grinders are therefore best suited to either wholemeal flour or softer wheat types where it is easier to separate bran from flour.

'Mariagertoba' is a relatively hard type of wheat that is often sold as sifted flour. Some stone mills therefore have problems processing the 'Mariagertoba' because there is too much litter. Roller mills, on the other hand, would probably like an even harder type of wheat from Landsorten, precisely to utilise the quality potential inherent in hard wheat, if you have the right equipment to control it in production. Fortunately, in Landsorten we have the opportunity to design wheat varieties according to the individual mill's preferences, and hopefully in the coming years, in dialogue with the mills, we can offer a wider range of varieties with different properties. For example, we are currently multiplyiing the variety 'Cadenza', which was found to be the hardest wheat variety in Europe in a major UK study.

I The Landrace no. 11 there is a little more written about kernel hardness in wheat.

Protein content

The baking properties of a cereal variety are largely determined by its genetic characteristics, and it is estimated that around 60% are determined by the Payne index alone. But then there are still 40% that are not.

It doesn't help that a variety has a great composition of gluten proteins if there isn't enough of it. That's why the overall protein content of the grain is also interesting.

Whether the grain is high or low in protein is again determined by both genetics and environment, but especially by environment. A fertile soil or a soil that has received a lot of nitrogen will result in high protein content in the grain because protein contains a lot of nitrogen and the availability of nitrogen is usually limiting for plant growth, especially in organic farming. So it's primarily the cultivation that determines how much protein is in the grain, but it's the genetics that determine whether the protein is suitable for baking or not. As usual, this is not the whole story, as cultivation can also affect the qualitative properties of the protein.

When large amounts of nitrogen are applied to the grain, especially if it is applied late in the growing season, more protein will be produced. However, the fertiliser will also affect the composition of the protein, and it is mainly the gliadin content that increases and not so much glutenin, which is more important for baking properties. Therefore, the gluten index will often be lower in grains with very high protein content than in grains with low protein content. This can also be seen in late-sown spring wheat, which can have a very high protein content. This is also due to the fact that sulphur compounds are very important for the properties of gluten proteins, and when a lot of nitrogen fertiliser is applied, relatively less sulphur is available to the plants, which means that gluten does not stick together as well.

The effect of storage on the gluten index of two wheat varieties. Graphic from: A. Miś 2003: Influence of the storage of wheat flour on the physical properties of gluten. Int. Agrophysics, 2003, 17, 71-75

During storage, the grain will oxidise and this strengthens the sulphur bonds that bind gliadin and glutenin together during gluten formation. Stored grain therefore normally bakes better than freshly harvested grain. Instead of storing the grain, you can add oxidising additives as a quick fix. In Denmark, only ascorbic acid is used, but it is added to almost all industrial flour to ensure stable quality throughout the season, while most smaller organic bakeries do not add additives to the flour and therefore experience greater variation in the flour quality during storage. Potassium bromide $KBrO_3$ (E number E924) is the most effective agent for improving the leavening properties of wheat flour, but brominated agents were banned in Denmark and the EU in the 1980s, but are still used in the US and some other countries.

Hagbergs Falling number

Bread dough is not just gluten, but a mixture of both gluten and starch as the main ingredients. Grain is a seed, and when seeds are given water, they will begin to germinate. The most important thing that happens during germination is that the starch is broken down into sugar, which the grain needs as energy source for germination. Therefore, the starch in germinated grain will be fully or partially broken down into sugar. This is what is utilised to brew beer from grain, because malting is simply the germination of grain to produce sugar that can be fermented into alcohol.

Handbag bread made from flour with a low falling number. Photo: Mariann Jensen

To thicken a sauce, you add a spoonful of flour to the water and when it is heated to around 80°C, the sauce becomes viscous. This is because the starch gelatinises, which is a process where the starch begins to bind together. You can't achieve this with sugar water. That's why it's important that the flour for the gravy thickener is not made from sprouted grain, because then the starch is converted to sugar and the gravy will not thicken.

Bread baking also utilises the ability of starch to gelatinise during heating. When the bread rises because the yeast develops air that is retained by the gluten network, the starch will gelatinise during baking when the bread reaches around 80°C. This prevents the bread from implosion when it's finished baking and is cooled down again. If the flour is milled from sprouted grain, the bread will not hold its shape after baking. The crust is so hard that it stays standing, but the crumb inside the bread will be a lump of dough at the bottom of the loaf.

When the grain in the field is ripening, it can start to germinate when it gets water during rainy weather. In 2023, the summer rained away and a lot of grain started to germinate in the field. Not necessarily because green sprouts came out of the ear, but chemical processes inside the grain started to prepare the grain for germination. The amylase enzymes that develop during germination are enough for the starch breakdown to continue even after harvest and during leavening. As a result, much grain was discarded as bread grain in 2023.

To measure whether the grain has been damaged by incipient germination, you can measure the falling number of the grain. The falling number is simply an expression of how thick a sauce you can make from the flour, and it is measured by dropping an iron weight through a porridge of flour and water. The more seconds it takes to drop to the bottom, the more viscous the flour has been to make the porridge. If it takes 400 seconds, then the falling number is 400 and it's really thick, but if it takes less than 150 seconds, it starts to become difficult to bake a proper loaf from the flour.

If the starch is converted into sugar, it cannot be re-converted into starch later. But in some cases, the starch is not converted into sugar, but the falling number is still low because a lot of enzymes have formed in the kernel, which then break down the starch when you start working with the grain, either in the bakery or in the falling number meter. In this case, the falling number can rise again if you succeed in breaking down some of the enzymes. This can happen, for example, when stored for a long time at high temperatures. In this case, you may find that discarded grain in the spring has a higher falling number than when it was stored just after harvest.

Falling number decreases when ripe grain is left in the field for a long time in rainy weather, but even if it doesn't rain, the falling number can still go down. This happens especially in high-pressure weather where there is a big difference between day and night temperatures. Then you get what is called LMA (late-maturity alpha-amylase). In this case, the starch will not be broken down, but the grain will develop a lot of enzymes that can potentially break down the starch. In the humid climate in North-Western Europe, periods of rain are the dominant problem for rainfall and what everyone talks about, but in countries with dry climates like the US and Australia, LMA is just as big a problem. However, we also experience it occasionally in Denmark, where it always comes as a surprise that falling number can be low when the weather has been "good".

The drop is primarily determined by enzyme activity, and not so much by the conversion of starch to sugar that has already taken place. And enzymes are not just a chemical substance that you should avoid having too much of. An enzyme is a catalyst, so even a little bit can do a lot of damage. It's a bit like a flame with fire. Even a small flame can light a very big fire. If there is lodging in a small part of the field where the grain has started germinating in the ear, it can ruin the fall number of the whole field if it gets mixed in with the grain that is standing up nicely. And if you have a batch with a low falling number, don't ever start mixing it with a batch with a high falling number in the hope of raising the average. You can do that to get a satisfactory gluten index, but it doesn't work with falling numbers. The falling number of a mix will always be closest to the component with the low falling number.

In the BOOST project, Gl.Buurholt Hovedgård has acquired a machine called InSight™, which sorts individual kernels based on the reflection of ultraviolet light (NIR). Although it is not calibrated specifically for falling number, the BOOST project has shown that in some cases it can actually increase the falling number. However, this is not possible in all cases. It depends on the individual batch whether it makes sense to sort it. If the drop rate is low because a small part of the batch is damaged, it may be possible to increase the drop rate, but if it's the entire batch where all kernels are equally affected, you can't.

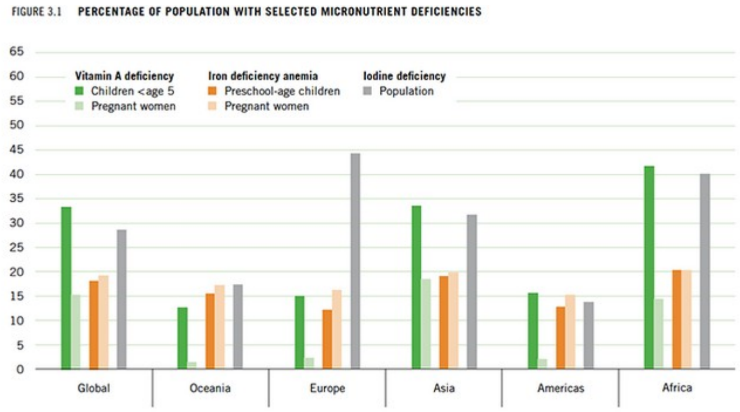
In nature, grains and seeds should only germinate when the season and conditions are right to ensure the survival of the plant. It's not smart to germinate in the ear just because it rains a little bit. That's why grains and other plants have different mechanisms that prevent germination of their seed. There are different chemical substances that prevent germination. There is a difference in how many germination inhibitors are developed in different varieties. The germination inhibitors prevent all or part of the starches from being broken down into sugars and proteins from being broken down into amino acids. There are also substances such as tannins and phytic acid that bind minerals and micronutrients so that they don't leach out (see also article on mineral content).

The substances that prevent germination even if the grain is given water will also inhibit the digestion of the grain when we eat it. During digestion, we also have to break down carbohydrates and proteins. Therefore, grains with a high falling number are more difficult to digest. With modern technology and good wheat varieties, the falling number is almost always high in the grain we use for baking, which is why it is nowadays extra important to break down the germination and digestion-inhibiting substances in grain during the processing of the grain and flour. This is primarily done with long-term fermentation of dough and pre-soaking of cooked grains. Unfortunately, developments in the food industry are going in the opposite direction, reducing rising times in bread industry to save time. This is one of the main explanations for the increasing food intolerance experienced in almost all countries with industrialised food production.

You can read more about falling numer here (Danish only).

Is it the variety or the soil that determines the mineral content of grain?

Most readers of The Landrace probably don't go to bed hungry and as such we get enough food. Increasing obesity in the population also shows that food contains enough energy to nourish us, and more. However, there is some evidence to suggest that many of us are lacking minerals that we used to get more of through food. This mineral deficiency is also known as "The hidden hunger" because it does not result in weight loss, on the contrary, but manifests itself in other deficiency symptoms depending on the minerals involved. It is estimated that around 2 billion people worldwide suffer from mineral deficiency, which is more than twice as many as the 800 million people who are malnourished due to hunger and lack of energy. As the figure shows, mineral deficiency is slightly more prevalent in the Global South, but it is also pronounced in Europe and North America. A Swedish study from 2016 showed that 80% of Swedish high school girls were getting less iron from food than recommended by health authorities and that 26% had such low iron depotes in their bodies that they were at risk of iron deficiency. So we don't lack food in our part of the world, but it doesn't contain everything we need. This is partly because we eat differently than we used to, but it's also because the raw materials in our food contain less minerals.



Source: Black et al. (2013).

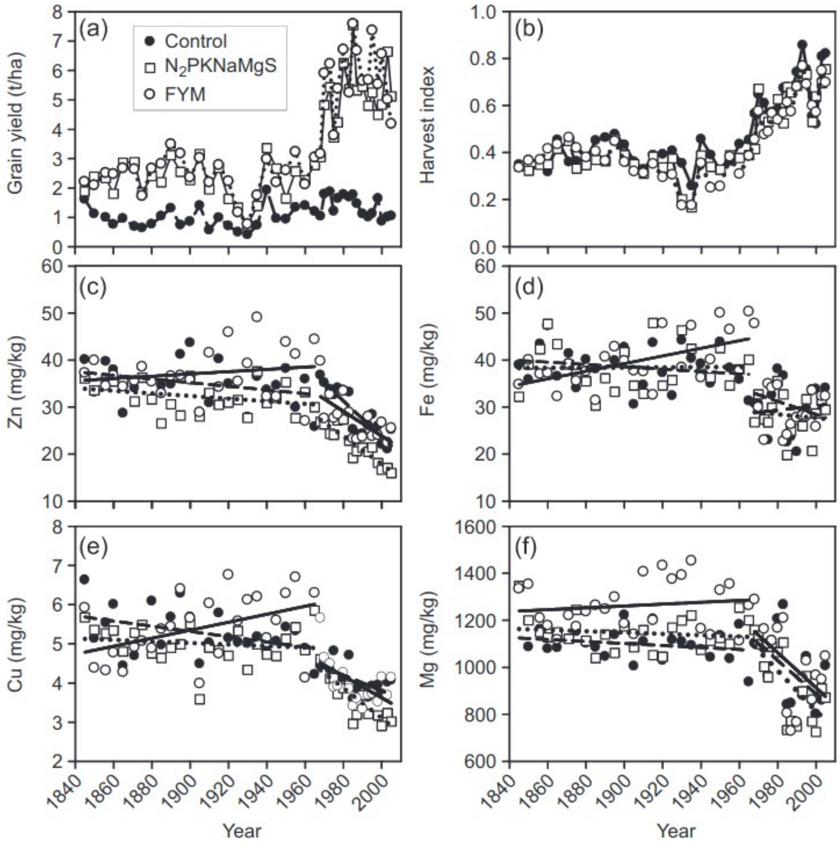
The big question is, why does the food contain fewer nutrients in the form of minerals? Is it the fertiliser, the fertility of the soil or the cultivated varieties that have changed?

Before we start looking at cultivation and grain varieties, there are two things that cannot be said clearly or often enough: The mineral content of the grain in the field and when it is harvested can be completely irrelevant if the flour is sieved during processing to remove almost all the minerals, or if the minerals are not digestible.

As described in the article above, food preparation is a crucial factor in our mineral digestion. Minerals in grains and other seeds are in-digestible by humans because they are chemically bound in phytin and tannins. Whether the mineral content of the food is high or low doesn't matter if the phytin is not broken down before we consume the food, because we can't digest the food at all and access the minerals if they are bound in phytin.

Degradation of phytin requires soaking for a minimum of 6-8 hours. If grains are heated like in cooked rice or baked into bread before the phytin is broken down, the minerals are completely indigestible and it doesn't matter if the initial content is high or low. Grain and other seed products should not be sold to consumers without a warning that they are not suitable for human consumption unless soaked in water before any heat treatment. All industrial animal feed has phytase added to it to help break down the phytin so that our livestock do not suffer from mineral deficiencies, but in human food there are no requirements, including labelling.

Almost all micronutrients and minerals in grains are found in the bran, aleurone layer and germ, while the endosperm contains only small amounts. Wholemeal products contain an average of 28.2mg/kg of iron, while sifted flour only contains only 6.7mg/kg. Whether the grain contains a little more or less minerals before sifting makes little difference if the flour is sifted afterwards and the bran with all its minerals is simply used as biofuel, fertiliser or animal feed. The significance of the mineral content of grain is only relevant for true wholemeal products.



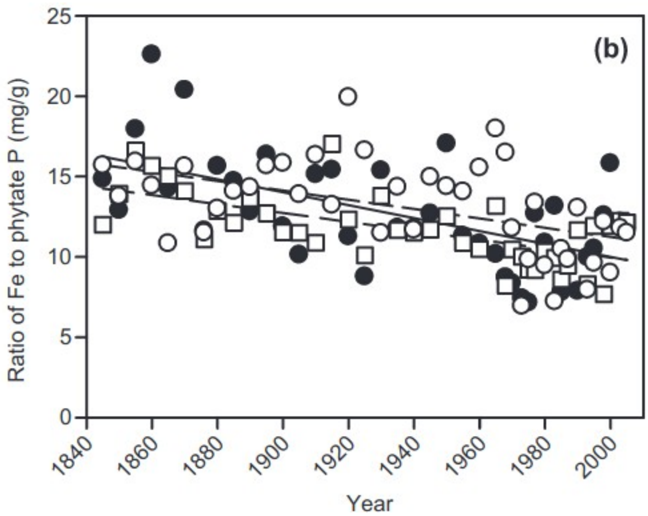
Once this is said and understood, it's time to start taking an interest in what the grain actually contains of the minerals that most of us lack one or more of.

In a well-known experiment from England, three adjacent soils have been cultivated since 1843 with either artificial fertiliser, animal manure or no fertiliser at all. Both the total mineral content and the plant-available mineral content of the soil have increased slightly over the period up to the present day in the fertilised soils, while it has remained stable at a lower level in the unfertilised soil. There was no difference whether it was fertilised with artificial fertiliser or farm yard manure. This suggests that it is not modern farming with artificial fertilisers that depletes the soil of minerals that explains the decreasing mineral content in modern food. If looking at the crop grain instead of the soil itself, the trend is the same. Studies comparing organic grain with conventional grain show that organic grain typically contains more zinc because phosphorus fertilisers and perhaps also pesticides inhibit mycorrhizal fungi in the soil, thereby inhibiting access to certain minerals in the soil. The zinc content in the UK trial was also 15% lower in grain from artificial fertiliser compared to farm yard manure, so this may explain a little, but the amount of manure is not lower in modern agriculture compared to the past, so this is probably not the whole explanation for the general mineral deficiency in the population. The difference in iron content in conventional and organic grain or in the British experiment with grain from land cultivated with artificial fertiliser for 150 years is not statistically different from grain that has been cultivated with animal manure, so the explanation about the importance of artificial fertiliser for zinc cannot be transferred to iron.

The soil does not appear to be depleted of minerals as a result of modern agricultural practices, and CIMMYT trials also show that cereals generally have higher levels of iron and zinc in crops with high nitrogen fertilisation compared to crops with nitrogen deficiency. So organic farmers should not skimp on fertiliser to ensure a high mineral content in the grain, as the opposite is actually true in some compounds.

We eat other things besides cereals, but cereals are an interesting food in the context of mineral deficiency because iron and zinc are minerals that we are often under-supplied with, and cereals are the main source of these minerals in daily nutrition. It has also been investigated whether there is a difference in the mineral content of ancient cereals compared to modern cereals. And it turns out that the chronological trend in the mineral content of cereals is far more important than the type of fertiliser used.

The figure shows that yields on fertilised soil are much higher in cereal varieties developed after the Green Revolution in the 1960s compared to old varieties, but the mineral content is significantly lower.

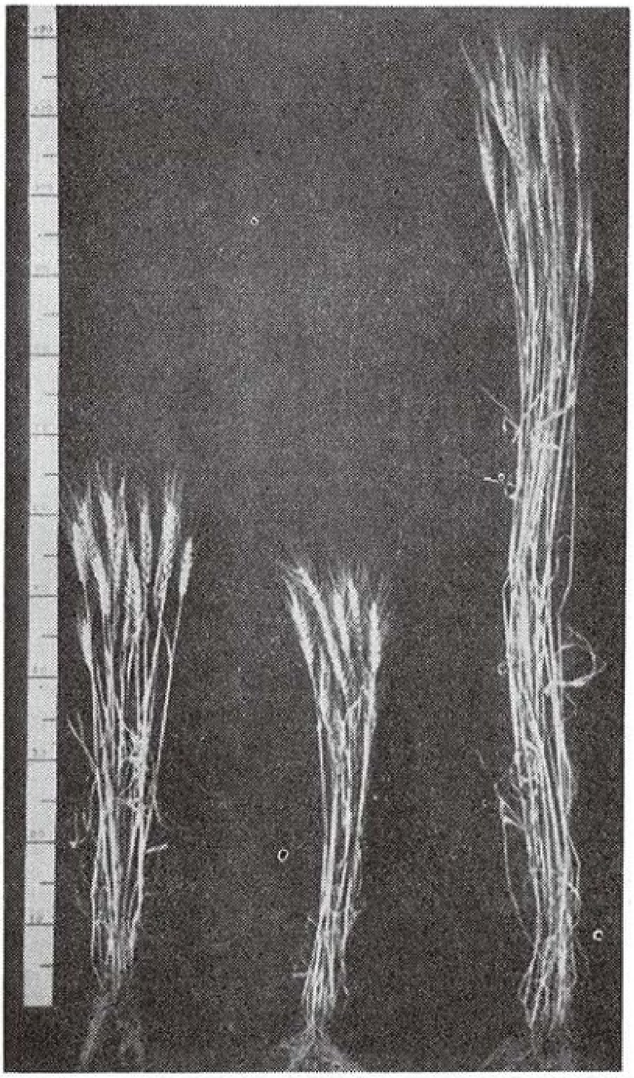


It's not the year of breeding that determines the mineral content of a variety, so what is different in modern varieties compared to the old varieties? They have also studied this in England.

From the figure, it might look like the high yield is the reason, because the increase in yields in modern varieties occurs at the same time as the decrease in mineral content. The minerals are, so to speak, diluted away in the high yield, but that doesn't seem to be the whole explanation.

The mineral content of grains is actually not as important as it sounds, because as mentioned above, what matters for human nutrition is not how much of the minerals are in the grain, but how much we absorb through digestion. This is because the minerals in grains are chemically bound in the substance phytin. Therefore, it's not just the mineral content of the grain that matters, but also the phytin content. Unfortunately, the arrow is also pointing in the wrong direction here, with phytin content increasing in relation to both iron and zinc content. This is probably due to the fact that phytin is one of the substances that inhibits germination in grain and therefore ensures a high falling number. In the breeding of wheat varieties with high falling number, which is good for baking quality, it has a negative effect on nutrition by making the minerals indigestible.

The crucial difference between ancient cereals and modern cereals is new traits introduced into cereals through plant breeding. This started in Japan in the 1920s and 30s and later spread to the rest of the world during the Green Revolution in the 1960s and 70s. The key difference was plant height, where the two dwarf genes Rht1 and Rht2 were crossed into most modern varieties to counteract blight. Unfortunately, these two genes have an unfortunate side effect on plant growth, reducing not only the length of the stem but also the length of the roots, and actually have a negative effect on yield, protein content and susceptibility to several plant diseases. However, the negative effects of these dwarfing genes were more than offset by the benefits of the lower plant height, because low plants can be applied more fertiliser without resulting in lodging, and more fertiliser results in higher yields. In yield trials with high fertiliser levels, varieties with dwarfing genes will always have higher yields because they are not bothered by lodging, and in 1990 it was estimated that over 70% of all wheat varieties in the world had dwarfing genes.



The wheat variety 'Norin 10' with the dwarfing genes Rht1 and Rht2 was bred in Japan from a cross between 'Fultz-Daruma' and 'Red Turkey' and registered as a variety already in 1935. By the 1940s, this variety covered over 30% of the wheat area in central Japan, but it wasn't until the late 1960s that dwarfing genes were spread to the rest of the world in what is known as the Green Revolution. After World War II, the story that the Japanese were 40 years ahead of the Western world in plant breeding was not a good one to tell, so posterity has given all the credit for the breeding to Norman Borlaug, who was later awarded the Nobel Prize for it.

The dramatic decrease in mineral content in wheat varieties developed in our part of the world after 1960 is probably mainly due to reduced root development in varieties with Rht1 and Rht2 dwarf genes, and it is documented that varieties with these genes have lower mineral content and that it is the gene itself and not the plant height that affects the mineral content.

Since these first dwarfing genes were introduced to wheat varieties worldwide in the 1960s, several genes have been found that have similar effects on plant height but do not have the same negative effects on root growth and protein content, including Rht8, Rht12, and Rht18.

The old landraces were both very tall and had weak straw. In modern organic farming, we need varieties that are not quite as tall as the oldest landraces, but have stronger straw without being quite as short as conventional varieties, as this results in poor competition against weeds.

In the development of Landsorten varieties in the future, we will be aware of the negative effects of the old dwarfing genes and use other genes to achieve the height and straw strength appropriate for the fertilisation levels of modern organic farming.

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