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Barley food product development

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Front page: Participants at the Nofima Barley product development course in March 2016. From the left: Óli Þór Hilmarsson (Matis), Hilde Halland (NIBIO), Mattías Einarsson (Móðir Jörð), Tore Nordahl (Dyrøy mat), Marit Sandberg (Eldhusbakeriet), Pétur Smári Sigurgeirsson (Myllan), Jákup Sumberg (Barbara Fish House) and Almar Þór Þorgeirsson (Almar bakari).

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1. Summary

The work described in this report is a part of the project Northern Cereals – New Markets for a Changing Environment, and deals with the production of food products from barley (work package 5). The project is supported by the Northern Periphery and Arctic Program (NPA).

The report mainly contains knowledge shared at the three days Nofima barley food product development course in March 2016 where seven companies from Iceland, Norway and Faroe Islands participated. Many researchers from Nofima joined to give the participants the newest knowledge about barley as a food grain, quality and variation as well as knowledge on health compounds and processing possibilities. Theory about the product development methods were also given as well as practical work on product development. In addition one of the three days where spent in Nofimas bakery for practical trials with different products.

To sum up the knowledge gained from these three days we learned that: Barley has great potential as a food grain! Barley is a healthy grain and can meet customers need for healthy food. But, to be able to make good products it is important to understand the raw material. *Barley is not just barley*, meaning that there are large variation in the properties of barley between varieties, agronomical practices, location where it's grown and how it is processed. The chemical composition of barley can vary as can processed barley and this will influence the properties of the products. For example, how much water the barley flour can hold varies and needs to be adjusted in the recipes, even for each batch.

2. Introduction

Warmer growing conditions, improved varieties and technologies, and concerns about sustainability are creating new opportunities in northern areas for greater cereal production. In few areas, it has already been possible to produce higher value cereals for milling and malting which has allowed SMEs to develop new "local" products to meet a growing demand from tourists and residents. The challenge faced is to help all partners benefit from these opportunities while taking into account the different levels of development of cereal cultivation across the partner regions.

The Northern Cereals – New Markets for a Changing Environment, is a north Atlantic collaboration project with Matis, Iceland, as lead partner. The project is supported by the Northern Periphery and Arctic Program (NPA) and will run from June 2015 until May 2018.

The project is divided into six working packages (WP). This report deals with WP 5, Cereal food production.

The project objectives are to increase cereal growing in the partner areas and to increase the growing of higher value cereals for local food and drink products. The main outputs from the project will be increased numbers of farmers growing cereals for feed, malting or milling and the production of higher value cereal products like seed, malt, food and beverages. These changes will increase employment, income and consumer choice in rural areas. The main beneficiaries will be growers and their local communities, SMEs and consumers.

The objective of WP5 is to increase the market for locally grown cereals by developing their use for making high-value food products across the partner regions. This will have the added benefit of creating new opportunities for employment and product development and innovation.
The main goal and outcome of this WP are concrete new unique products where northern cereals are the raw material. Product innovation and development in both the production process and marketing strategies will be important to achieve this goal. Product development courses delivering new knowledge through individual sessions and joint courses will be held to help endusers to develop new products. Parallel to the new product development theoretical knowledge of the production process and necessary input will be conducted and serve as a necessary platform to ensure a common knowledge in the group.
Nofima (www.nofima.no), a Norwegian food research institute, which has some of the world leading researchers in barley product research, will provide external expertise in WP5. The expertise from Nofima will run the two product development courses for up to 12 companies from the participating countries. The companies participating will be food producing companies which produces or will produce food-products where northern cereals are the basic commodity. During the courses the companies will work and learn together and also from each other.

In the first course in March 2016 the main topic was barley as a food grain, product development and innovation as well as practical sessions. At the end of these three days the companies should have as much knowledge as needed for making a specified plan for their products development the following year.
The second product development course will be held in March 2017. Here the work with the product development will continue, but even more focus will be put on packing, durability, labelling and more.

3. Barley as a food grain

Barley as a food grain has large potential. Barley can meet expectations and preferences for healthy food. Large diversity in varieties gives variations in technological, nutritional and sensory properties providing possibilities for healthy, tasty products.

Barley is healthy

Barley is nutritious and healthy as it contains many potential useful components. Barley contains a high amount of fiber, a high content of antioxidants, important vitamins and minerals, and is low in fat. Barley can contribute to lower blood cholesterol, and thus reduce the risk of cardiovascular disease. Barley can also, control or reduce blood glucose levels and thereby reduce the risk of diabetes. Further, barley can have a positive effect on bowel and intestine function, microbial population (prebiotic), protection against some types of cancer, weight control, and the level of antioxidants (Tosh & Shea Miller, 2016; Wood, 2007).

There has been an increased interest in using barley in foods. One reason is renewed interest for tradition and traditional foods and barley has been an important food grain for centuries in the Northern countries. However, the primarily reason is due to barley being a rich source of dietary fiber (both soluble and insoluble fiber) (A. K. Holtekjølen, Uhlen, Bråthen, Sahlstrøm, & Knutsen, 2006; Knutsen & Holtekjølen, 2007).

There are two types of fiber in barley; water-soluble fiber (beta-glucan) and water-insoluble fiber (arabinoxylan, cellulose etc.) (A. K. Holtekjølen, Uhlen, et al., 2006; Knutsen & Holtekjølen, 2007). Both are important, as they have different physiological properties and thus will have different health effects. Optimal is therefore a good balance between both soluble and insoluble fiber. The amounts of dietary fiber will vary with type of barley, variety, climate, season and fractions (A. K. Holtekjølen, 2005; A. K. Holtekjølen, Uhlen, & Knutsen, 2008).

Compared to other grains or cereals, barley is (as oats) especially high in the soluble fiber beta-glucan. Barley also have high amounts of insoluble fiber (
Table 1).

The amount of beta-glucan in the barley grain will affect its technological and nutritional properties, and thus, end use preferences (A. K. Holtekjølen, 2005). Normal content of beta-glucan in Norwegian barley varieties (and other northern barley) is approximately 3-4 %.

Table 1 Amount of different dietary fiber in different cereals (measured in % of dry matter)

Cereal	Soluble fiber (beta-glucan)	Insoluble fiber (Arabinoxylan)
Barley	2-11	3-11
Rye	1-3	6-12
Wheat	<1	4-6
Oat	3-7	2-4

The content of soluble fiber (beta-glucan) is important, as it has been approved for health claims. A high content of this soluble fiber is therefore beneficial when using barley as a food grain.

Health claims

The European Food Safety Authority (EFSA) has approved three health claims associated with barley (Table 2).

Table 2 Approved EFSA health claims on beta-glucans (www.EFSA.eu, http://www.mattilsynet.no/mat_og_vann/merking_av_mat/ernarings_og_helsepastander/)

Fiber	Health claim	Article*	Dose
Beta-glucan from barley or oats	Reduction of parandial glycemic response. Maintenance of normal blood LDL-cholesterol concentrations	13 13	>4 g per 30 g available carbohydrate At least 1 g /meal : information about necessary daily dose of 3 g/day
Oat and barley grain fibre	Increased faecal bulk	13	At least “high in fiber” (6g/100g)
Barley and oat beta-glucan	Lowering blood cholesterol. High cholesterol is a risk factor in the development of coronary heart disease	14	>3 g/day; 1 g/portion

*Article 13: Describes a component significance to maintain the bodies functions. This includes weight control, increased satiety and reduced calorie content.
Article 14: Describe the reduction of a risk factor for disease development.

Not only the amount of beta-glucan, but also its size (molecular weight) and solubility/ extractability are important for its physiological properties (Brummer, Jones, Tosh, & Wood, 2008; Lazaridou & Biliaderis, 2007). However, at present, health claims relate to the total amount of beta-glucan. Thus, the total amount of beta-glucan in the finished products is important to know to be able to use these health claims in the marketing of a barley products. Duga AS is a Norwegian company producing different barley products. They use the approved health claims to market their products on their web page (http://duga.no/helse/).

Barley is not just barley!

Barley is a very diverse grain with many different types and cultivars/varieties (A. K. Holtekjølen, 2005; A. K. Holtekjølen, Kinitz, & Knutsen, 2006; A. K. Holtekjølen, Uhlen, et al., 2006; A. K. Holtekjølen, A. K. Uhlen, et al., 2008). These different varieties/cultivars will vary in grain quality, thus physical parameters and chemical composition, resulting in variation in functional properties. Different barley varieties will add variation to technological properties, and influence taste, thus bringing potential for different flavors to foods (A.K. Holtekjølen, Bævre, Rødbotten, Berg, & Knutsen, 2008). The diversity in barley can be beneficial, providing potential and possibilities, however it can also give challenges in food production (A. K. Holtekjølen, 2008). Thus, adjusting the process might be necessary to keep a stable product quality due to possible variation in the raw material (e.g. between batches).

Barley is produced all over the world in different climates and for different end uses. The breeding of barley cultivars have been concentrated around these factors. Thus, suitable agronomical properties and right grain quality for its end use have been the leading or governing parameters for developing new barley varieties. Feed is the main use of barley world-wide, followed by malt and seed. Only maximum 1.0% of the barley production at present is used for human consumption (food). Thus, the quality properties of barley have been focused on good quality for feed and high yields and good agronomical features instead of good quality for human consumption, health or good baking abilities.

In addition, different climates and growing conditions such as light and temperature will affect the maturing of the barley (K. Anker-Nilssen, Færgestad, Sahlstrøm, & Uhlen, 2006; Kirsti Anker-Nilssen, Sahlstrøm, Knutsen, Holtekjølen, & Uhlen, 2008). Thus, the long days, longer or higher light intensity, and lower temperatures in the north will influence the maturing of barley and affect anthesis different than seen in the south. Research made at Nofima in collaboration with NMBU and NIBIO showed that these climate factors also effected the grain quality - both physical parameters as well as chemical composition and thus functional properties (A. K. Holtekjølen, 2014). In addition to the genetical variation, differences in climate and growing conditions will also provide differences in grain quality and thus differences between barley varieties.

Also important to remember; grain quality is a diverse parameter. The meaning of the term "quality" varies depending on your place in the value chain and it will be different if you ask the farmer, the industry or the consumer. The farmer is mainly interested in a good yield and a cereal that is little susceptible to diseases, the industry is interested in a grain that is good to process, with good baking quality and the consumer is mainly interested in taste, history and health-components. In addition, chemical qualities such as nutritional value and processing properties including sensory properties are important and will also differ among different barley varieties. For example, the content of beta-glucans can vary from 2-11 % in different varieties.

Lack of quality criteria for barley as a food grain

There are no clear quality criteria for barley as a food grain, and there are no proper sorting or separation based on different barley grain qualities. Thus, all the barley usually end in one silo. Due to the large diversity in barley varieties, mentioned above, this could cause large variations in the barley batch used for human consumption. This again can result in variations in barley flour quality used in the bakeries and thus provide variations in product quality. It is important to perform controls of the raw material and adjust the process to possible variations to ensure a stable product quality.

Barley in the Northern countries

Barley has been grown since ancient times also in the Northern regions. Both naked barley and hulled barley have been grown. In cooler climates mainly six rowed hulled barley was grown and for example in Norway there where many early-maturing land-races. In 1900, a breeding program for different grain types started in Norway. The main breeding goals were earliness/adaptations, yield potential, disease resistance, resistance to lodging and quality for feed and the yield potential increased with breeding. In Northern-Norway the breeding program stopped in the early eighties, the last test fields were at Vågøynes in Bodø. Breeding for earliness was also not emphasized as much thereafter. In Iceland, in the same period, a breeding program emerged and over the last 25 years several new Icelandic early maturing varieties have reached the market. In Sweden there has been interesting work done on breeding barley varieties for food, however many of the varieties (Cindy, Magdalena, Karmose) are late maturing barley varieties and thus, not the best suited varieties for northern regions. One Norwegian variety has been identified as an interesting food variety (Olve) (A. K. Holtekjølen, 2005). It is uncertain how this variety will perform in the north of Norway or other northern regions and tests are needed to find out.

4. Processing

Processing of the barley is common before utilization as human food. Different processes include e.g. pearling, cracking, crushing, rolling/flaking, extruding and/or baking. Milling of barley grain, to produce barley flour, normally involves pearling or polishing before the grinding, which removes the outer hull (bran) from the kernel.

For the milling process, different parameters are important, both physical and chemical factors. A uniform size is beneficial, as are water content, grain hardness and chemical composition. These factors will influence the milling process and thus the milling yield.

There are many different mills available on the market; e.g. roller mill, hammer mill, stone mill, pin mill and ball mill. The mills come in all different sizes from small table mills to large industrial mills and choice of mill will depend on many different factors; e.g. economy, usage, throughput, and/or preferences of the resulting flour quality.

The barley kernel consists of different layers and the chemical compounds are distributed differently throughout the kernel. In the outer part of the kernel the minerals, antioxidants, vitamins and insoluble fiber are mainly located. However, for example starch and beta-glucan are located mainly towards the center of the kernel. Thus, the beta-glucan in barley is found throughout the kernel. This special feature is important, as it will reduce/minimize loss of these valuable compounds through the milling process. Thus, much of the health components (beta-glucan) stay in the processed flour, grains or flakes! Still, the process of pearling/polishing or dehulling (removing the hull and outer parts) before milling will affect the nutrients located in the outer part of the kernel. Thus, processing can have an impact on the amount of nutrients in the barley flour (A. K. Holtekjølen, 2007, 2010).

By fractionation of the whole grain barley flour, it is possible to add additional value to the grain by producing flours with different chemical composition. One example is bran fractions with high amounts of vitamins, minerals and rich in barley-taste. Another example is fractions especially rich in starch or in fiber (extra high in beta-glucans) ("BARLEYBOOST", 2013-2015).

Baking with barley is possible. However, barley is not wheat and the baking properties of barley will differ from wheat. The chemical content is important for the baking properties of barley, especially the fiber content (A. K. Holtekjølen, & Knutsen, S. H., 2011; A.K. Holtekjølen et al., 2008; Ann Katrin Holtekjølen & Knutsen, 2011;Rieder, Holtekjolen, Sahlstrom, & Moldestad, 2012). The amount of fiber in the barley flour increases the water absorption capacity and prevents the gluten from binding properly. When baking with barley or other grains with a high fiber (beta-glucan) content, an optimized water content is important for a good result (A. K. Holtekjølen, Olsen, Færgestad, Uhlen, & Knutsen, 2008).

Barley can further have especially large variation between varieties. This, together with little sorting on barley varieties before making the barley flour, can give the baker some challenges. Thus, optimization of the water addition can be necessary for each batch of barley flour.

Baking, or processing in general, might affect the physiological properties of barley. For example, during baking the beta-glucan is broken down and alter its physiological properties. This is related to a size reduction (reduction of the molecular weight) of the beta-glucan. This should also be considered when producing barley products. Research on this subject and how the size reduction of beta-glucan affects the health properties are ongoing at Nofima (A. K. Holtekjølen, et al., To be submitted; Rieder, Ballance, & Knutsen, 2015; Rieder, Ballance, Lovaas, & Knutsen, 2015; Rieder, Grimmer, Kolset, Michaelsen, & Knutsen, 2011).

To be able to make good products it is important to understand the raw material!

5. Product development – "Think out of the box"

Innovation and product development

Innovation and product development is important in every company. This can be solved in many ways but there are many different strategies on how to actively work on innovation and product development in companies so that it is more of a controlled process and less a result of coincidences. A huge percentage of new products on the markets is stopped after the first year and this means that companies can save a lot of money by doing the process "right" to ensure more successful new products or services (Dijksterhuis, 2016).

It is important to remember that there are many aspects of adding value, not only by producing a new product, but also a new hire, business model, collaboration, technology and so on. The new product/service must fulfil a need for the consumer, maybe even a need the consumers did not know they had! There are many pitfalls in the process. This can be to focus too fast on a solution, that the ideas remain in employees heads (create a culture for innovation), that the innovation is not consumer oriented, that development continues on wrong ideas, having too narrow focus or not to have enough long-term focus.

One type of innovation model is the Doblins ten types of Innovation presented by Keely in 2013 (fig. 3). It is shown that most innovations are of the type *New Products*, but of the ten types of innovations in the Doblin model, product development/product performance gives

the lowest value added for the company. The more of these ten types of innovation a product can fulfil the higher is the new added value to the company (Larry Keeley, 2013).

Figure 3 Doblins 10 types of innovation (source www.doblin.com)

In product development, there are also different models to follow. The most common is the classical linear approach where the idea is developed, tested and introduced in the market. Other approaches are designed thinking processes, where the consumers need is in focus and the innovation is tested on the consumer in every step of the process. Such an approach will lead to a higher success rate for the new product (Brown, 2008).

One very important step in product development is evaluation of the product after the product is introduced to the market. As mentioned, a large proportion of the new innovations flop in the market, but most of these products are just withdrawn with no evaluation. Often minor adjustments would be sufficient to ensure the success of the product in the market.

Barley product development

General food trends show that the consumers want foods that are healthy, responsible, have a meaning and express identity. For local food producers the first step to high volume sales is a locally accepted product. Local sales enable good feedback and are often more stable. Every year companies that carry out market analysis, make a list of the top ten market trends and now many of the trends are so called “good for you” products. For flour and grain it can be seen that convenient foods with a homemade feeling are popular, health is in focus with healthy carbohydrates and whole grain, old types of cereals have a renaissance, pre-fabricate or breads and cakes with long shelf life are popular as well as (for Norway) the category of knekkebrød is on a rise.

It is important to “think different” when producing new barley products. Think about products that can fit into different meal categories: breakfast, lunch, between meals, snack, dinner, desserts, evening meal and drinks. For a person to get a high amount of beta-glucan from the diet, one product high in beta-glucan does not have to be the only solution. Putting some barley in many products can also help the consumer to reach the recommended daily intake.

Be creative and generate new opportunities for product development. Remember, to be able to make good products it is important to understand the raw materials. The chemical

composition of barley can vary as can processed barley and this will influence the properties of the products. For example, how much water the barley can hold varies and needs to be adjusted in the recipes. Also, barley differs from wheat with a different baking performance (not as good), so great care must be taken in the production. As already mentioned, since there is usually little sorting on barley varieties, different barley flour can have different qualities. Thus, optimization of the water addition can be necessary for each batch.

Baking breads with a high amount of barley is possible (Rieder et al., 2012); (A.K. Holtekjølen et al., 2008; A. K. Holtekjølen, H. H. R. Olsen, et al., 2008; Rødbotten et al., 2015). As mentioned earlier, water addition is important for a good result, however different baking techniques can also improve the product quality. For example, using different types of pre-ferments can be beneficial. Add the pre-ferment into the main dough at the end of the kneading to ensure good gluten bindings in the wheat dough. Another possibility is to make barley bread with boiled barley grain. Sponge cakes are also possible to make only with barley flour. This gives a good taste to the cake.

Fermentation

Fermented cereal foods are used for their preservation effects and for their health effects. A famous typical cereal product is sour dough used to make breads. The function of sour dough is to help leavening the dough. In addition, it helps modify the flour components improving the baking properties (especially in rye dough), and it prolongs shelf life by inhibiting mold and bacterial growth. In other countries drinks, gruels and porridges are often made of fermented cereals. Fermenting cereals can influence the bioactive compounds (Hole et al., 2012). Fermented cereals containing live microorganisms from the lactic acid bacterial fermentation are so called probiotics. Products such as ProViva in Sweden, a fruit drink containing 5 % fermented oat gruel, is in the category of healthy foods that are increasing worldwide. These types of foods may have a huge potential on the market.

Brewers spent grain – a raw material for food?

Brewers spent grain is normally a waste product found in large amounts in every brewery, and is today used mostly as animal feed. There is a possible potential to use this as a raw material for human food products. The brewers spent grain contains a high amount of protein and dietary fiber (A. K. Holtekjølen, 2007). If not dried, the high water content in brewers spent grain can give challenges during transport and storing, as brewers spent grain will mold easily under unfavorable conditions. Some work has been done on this, but it is uncertain if brewers spent grain will be approved as a raw material for food products. This would have to be investigated by the producer.

Large diversity in barley varieties provides great potential for product variation!

The whole value chain from producer to consumer can benefit by increasing the utilization of barley in foods. Barley, as a food grain, will deliver nutritious and healthy products to the consumers as well as providing new opportunities and new markets for the Northern farmers.

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Appendix 1: Barley products on the market in Norway and Iceland in May 2016