Northern Periphery and Arctic Programme

Northern Cereals – New Markets for a Changing Environment

Malting process and malt quality - Brewing from local grain

Activity T4.1 Small scale local malting of grain

Authors: Mette Goul Thomsen[1], Trude Wicklund[2], Rune Lennart Andreassen[3], Peter Martin[4], Hilde Halland[1], Magnus Göransson[5] & Morten Rasmussen[1]

Institutes: **[1]**Norwegian Institute of Bioeconomy Research; [2]Norwegian University of Life Sciences; [3]Mack Brewhouse; [4]Agronomy Institute, Orkney College UHI; [5]Agricultural University of Iceland

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Northern Cereals Partners:
Matis – Icelandic Food and Biotech R&D
Agricultural University of Iceland
Norwegian Institute of Bioeconomy Research
Agronomy Institute, Orkney College UHI
Agricultural Centre, Faroe Islands
Forestry and Agrifoods Agency; Newfoundland and Labrador, Canada

Innhold

Introduction

In parts of the Northern Periphery Region like Orkney, Iceland, Newfoundland, Faeroe Islands and Northern Norway it can be challenging to grow malting barley to conventional specifications.

On the international market, defined standards are set for the quality of malting barley (e.g. Bramfort 2006, Briggs et al. 2004) and these were summarised in Martin (2015). To obtain these standards and a high grain yield, it is necessary to use varieties developed for malting together with appropriate growing conditions. This includes length of growing season, appropriate growing temperature, and amount of and periods of rainfall. In order to obtain a long growing season a number of the malting varieties are furthermore developed as 2-row winter barley. However, due to the short growing season in the Northern region and poor winter survival of winter varieties, spring barley varieties are normally used. In Northern Norway, 6-row barley is commonly grown, having more irregular/smaller kernels than 2-row barley. In the Northern region, summer temperature may either fluctuate or remain low, combined with unstable or mostly long rainy periods resulting in very variable grain quality. We know that the grain quality is affected by the seasonal weather conditions and this is also a very important factor affecting malt quality (e.g. content of protein, kernel size and germination rate). For malting, grain is harvested as dry grain with a low moisture content (around ≤ 22%) which is then dried down to about 13% for storage. As the barley growing region in the North is largely located in high-rainfall coastal areas the moisture content at harvest will often be higher than 22%, thus increasing the risk of damage to the kernels at harvesting. During malting there are a number of different steps where the aim is to transform starch to sugar for fermentation in the brewing process. The drivers in this are enzymatic processes which vary with factors like variety and temperature. In grain of variable quality, an important initial step to achieve more even germination in malting is thorough size/weight sorting before malting. Then, the steeping and germination process should also be adapted to this. In the steeping process factors like length and stirring of the grain, water temperature, length of wet and dry periods and content of oxygen in the water are also important.

The standard criteria for malt are aimed at achieving an optimal yield in brewing, but they do not necessarily exclude the use of barley/malt which do not meet these criteria. So the background for increased malting barley production in the Northern Periphery Region is more based on a wish for local malt, greater self-sufficiency, shorter supply chains and last but not least the special qualities obtained in these areas. We could possibly denominate this ‘Nobel malt’.

The aim of the present study is to increase the usage/yield of grain for malting and brewing by adapting the malting process to suit the more variable quality of the grain produced in northern areas.

Background information

Weather in the respective growing seasons

As the weather during the growing season strongly influences grain and therefore malting quality, information on temperature and rainfall during the relevant growing season is provided for the different varieties used (Table 1).

Table 1. Data on temperature and precipitation during the relevant growing seasons, when the barley samples were grown.

	Northern Norway, 2015		Orkney, 2017		Iceland, 2016		Southeast Norway, 2016	
Variety	Tiril		Bere		Iskria		Salome	
	Monthly precipitation, mm	Avg. temp °C	Monthly precipitation, mm	Avg. temp °C	Monthly precipitation, mm	Avg. temp °C	Monthly precipitation, mm	Avg. temp °C
March	84.5	1.8	96.3	6.8	84.5	2.7	42.2	1.3
April	85.5	2.7	73.9	7.6	30.4	4.3	74.7	3.9
May	29.2	6.2	46.0	9.0	28.0	6.6	66.1	10.7
June	94.8	8.0	92.4	12.2	50.7	10.9	29.5	15.1
July	31.0	11.6	68.1	13.2	40.0	12.5	59.4	15.8
August	50.2	13.3	74.9	13.7	33.4	11.8	109.1	14.3
September	39.6	9.6	93.2	12.4	59.3	8.7	21.4	13.6
October	186.9	4.9	147.1	10.8	206.9	7.8	39.2	4.2

When delivering barley to commercial maltsters a number of quality criteria are important for determining acceptance and also the price (The Malter Association of Great Britain, http://www.ukmalt.com/home; Canada Malting http://www.canadamalting.com/canada_malting) these include:

- Germination: > 95%
- Crude protein: 10.0 - 10.9% (UK); 11 - 12.5% (Canada)
- Moisture content: 12 - 19% depending on the time of purchasing by Maltsters
- Kernels: Even shape, plump. Kernel size > 90% retained over a 2.5 mm screen
- Damaged kernels: < 5% peeled or broken kernels
- No chemical residues
- Variety purity

Preceding malting the malt quality is assessed, where different criteria applies for different malt types as e.g. described by Castle Malting www.castlemalting.com. We have used the standards from Scandinavian Brewery-Laboratory, Valby, Denmark (Table 2).

Table 2. Specification for malt quality assessment

Water in malt, %	<4.5
Extract m/m %	>80
Saccharification	<15
Filtration	Normal
Clarity of wort	Clear
Wort colour, EBC	<4.5
Wort pH	<5.8
Friability	80-85%
Total protein, %	9.7 – 11

Material and methods

Grain quality

In this experiment, four varieties of barley were used representing four different qualities. Iskria from Iceland (2-row; released in 2005), Tiril from Northern Norway (6-row; released in 2006), Bere from Orkney (6-row; an ancient Scottish landrace which is still grown in Scotland's Northern and Western Isles) and finally Salome (a German 2-row variety which was grown in South-Eastern Norway). Salome is a recognised malting barley variety and was included as a control. The varieties were grown in different seasons: Iskria 2016, Tiril 2015, Bere 2017, and Salome 2016.

The initial quality of the grain was determined by measuring protein content, HL weight (hector litre weight), starch (determined using near infrared transmittance, NIT), Foss Infratec^{TM} 1241 Grain Analyser was used (FOSS Tecator AB, Höganäs, Sweden), thousand kernel weight (TKW) was calculated using the Opto-Agri12 Seed Counter (Opto Machines, Riom, France). Water % was calculated from weight after harvest, weight after air drying and also using the Infrared transmission machinery.

Germination was tested by placing 100 kernels in soil at 20ºC for 10-12 days.

Prior to malting the barley samples were sorted on a 'Sortimat' (Falling Number, Sweden). For the experiment, only kernels > 2.5 mm were used.

For analysing quality of the barley, malt and wort we used methods described in 'European Brewery Convention' (EBC) Standards.

Malt

Equipment

Malting was performed on a micro malting plant from “Custom Laboratory Products” (Figure 1) at the Norwegian University of Life Sciences.

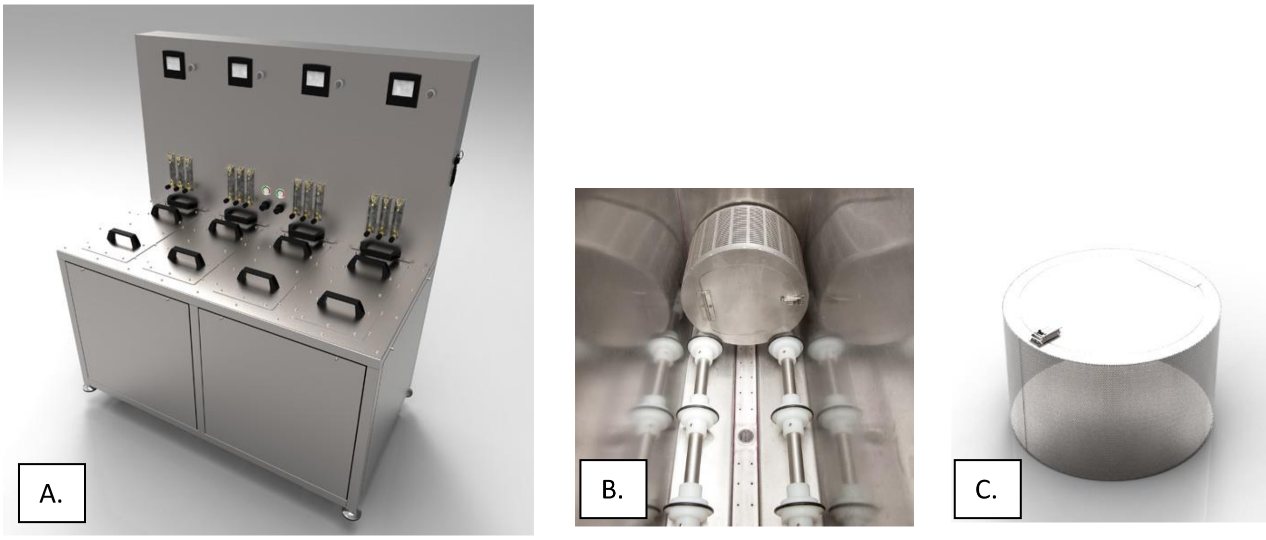

Figure 1. Micromalting plant from Custom lab. (A) Malting machine with four chambers for malting. (B) Malting chamber and (C) each chamber contains four malting vessels that take up to 0.5 kg each.

Malting process

For appropriate malting of the grain, steeping is a critical step and the process may to some degree be adapted to the quality of the kernels. In the steeping process, the kernels take up water necessary for the metabolic process and promotion of germination. The quality of malting barley has been connected to the rate of water uptake (water sensitivity) (Brooks et al 1976; Bamfort, 2003), and the optimum water percentage has been set at 42-45%. Temperature is variable and low temperature will prolong the germination, possibly giving a more even germination in otherwise uneven lots. Normally this is around 12-16°C, but everything from 4°C to 20°C is used.

To assess how variation in the steeping procedure may affect malting quality we applied three different steeping regimes (Table 3)

Table 3. Showing the three malting procedures applied in the experiment.

Steeping	Hours			Temp °C
Malting process	**A**	**B**	**C**	**All**
Wet	4	8	5	16°C
Dry	8	16	16	
Wet	4	8	3	
Dry	8	16	8	
Wet	4	2	+ wetting 3 x a day in 2 days	
Dry	8			
Wet	4			
Germination	Ca. 50 hours at 16°C			
Kilning	55°C for 16 hours, 72°C for 4 hours			

Germination was assessed as optimal when the hypocotyl reached 2/3 of the kernel length. Evaluation was done by assessing seven kernels x three times for each treatment and the average relative length of hypocotyl calculated.

Results

Grain quality

Initial quality of the grains varied in a number of the measured characters. TKW was especially low in Bere but high in Salome. Bere was also found to have the highest content of protein and Tiril the lowest (Table 4). All samples had a good germination.

Table 4. Initial grain quality for four varieties of barley grown in the Northern Region.

Variety	Water %	Hl-w, kg	TKW, g	Protein, %	Starch % of DM	Germination, %
Salome	12.3	67.2	47.9	10.1	56.6	97
Tiril	9.7	71.6	40.6	9.0	58.8	97
Bere	11.8	68.6	34.4	11.6	53.4	94
Iskria	-	69.6	42.0	9.5	-	96

Malt

By the end of the malting process, we found variation in the relative length of the hypocotyl both between the varieties/qualities and the malting methods (Table 5). Iskria had developed least of the four varieties and on average, the C method resulted in the fastest germination of the kernels.

Table 5. Relative length of hypocotyl in four varieties (qualities) of barley, following three different malting procedures.

Malting method	A	B	C	Average on variety (quality)
Bere	0.69	0.79	0.94	0.81
Iskria	0.59	0.65	0.72	0.65
Salome	0.75	0.84	0.84	0.81
Tiril	0.68	0.73	0.80	0.74
Average on method	0.68	0.75	0.82	

Water sensitivity in varieties/qualities did not vary within each of the procedures. The malting process C gave the overall highest water percentage in the malted kernels (49.6%), followed by B (41.8 %) and A (40.5%). Amongst the varieties, Bere had highest water content (45.5%), followed by Tiril (44.9%), Salome (43%) and Iskria (42.7%).

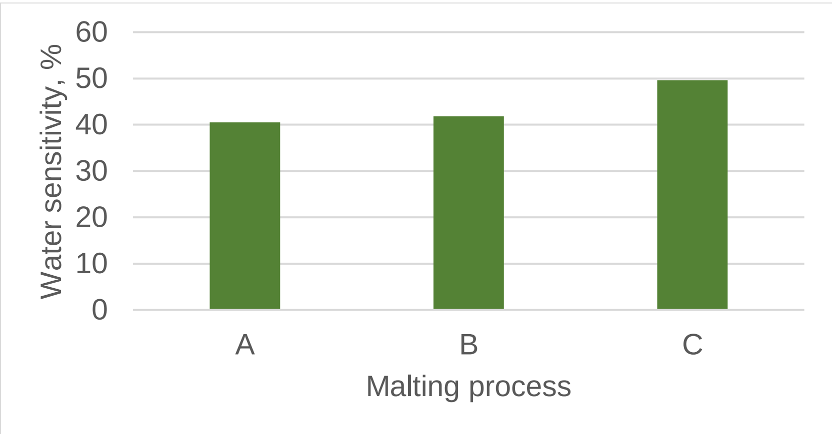

Figure 2. Water sensitivity in four varieties/qualities of barley after using three different malting processes.

Friability varied both between varieties as well as between malting procedure, but the two did not seem to interact. Salome had the highest friability (71%), followed by Bere, Iskria and Tiril (61.7%; 58 % and 52.6 %, respectively). The malting processes A and B gave a higher friability (69.8% and 68.0%, respectively) than C (45.6%).

Also in percentage water in the malt, we found a clear difference between the three malting methods. The content in B was approximately 0.5% lower than in A and C (Figure 3)

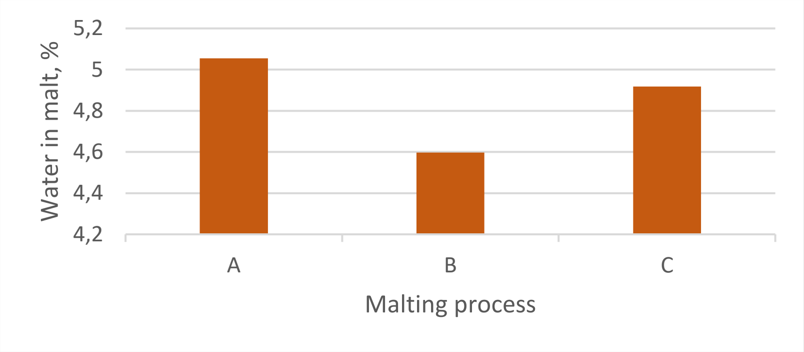

Figure 3. Water percentage in malt for four qualities of barley malted by three different processes.

There was a similar pattern in the extract yield of the malt, with no differences between varieties but between the malting processes. C gave overall the lowest extract yield (70.3 %), followed by A (74.8 %) and B (77.9 %).

Refractometer measurement (°Plato) varied with malting method and largest difference was found between procedure B and C (8.5 and 7.7 respectively).

The colour was measured in the wort using the EBC colour measurement. We found that Bere had the highest EBC followed by Tiril, Salome and Iskria (Figure 4).

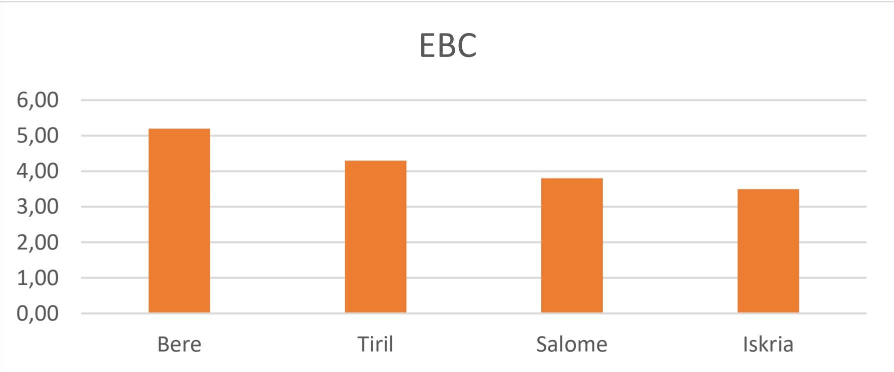

Figure 4. EBC colour measurement in wort in four varieties/qualities of barley. Average for three malting processes.

Discussion

A number of factors have contributed to the differences in the initial quality of the cereal samples used here. First, the variety itself, than climatic conditions, soil type, machinery used for harvesting etc. but also storage time and storage conditions will influence the kernel quality. In the present study, it has been the aim to see how the chosen malting processes affect the malt yield and quality given the initial kernel quality. The reasons for the initial kernel quality has not been an issue in the present study.

The initial grain quality varied between the varieties, especially in protein and TKW. Bere had the highest content of protein and lowest TKW. The high content of protein in Bere may partly explain the higher colour measurement, EBC, for Bere since one of the most significant factors affecting colour is the interaction between proteins and polyphenols (Briggs et al. 2004). Colour in Tiril was near the upper limit for the processes A and B but under the limit using the C method. Tiril also had a better clarity of the wort with the C method but a slower filtration rate.

Germination rate in Bere was significantly affected by the malting method and relative length of hypocotyl was longest following process C. In C the kernels were soaked in water for a shorter time then in the other two processes (C: 8 hours, B: 18 hours and A: 16 hours). The wetting of the kernels 3 x a day for two days in C seems to have increased the germination in all four varieties but most strongly in Bere.

In general the friability was below the optimal >80% for all treatments but significantly lowest in process C. E-malt (http://e-malt.com/) report that 80% is very good, 71-80% is good, 65-70% average and <65% unsatisfying. Based on this information, we see that C generally gave unsatisfactory results for friability percentage. For example, Salome gave the highest friability with the B and A processes but this fell almost 30% using the C process. As both friability and extract yield were low there is reason to assume that the process of germination went on for too long. However, the relative length of hypocotyl was between 0.68-0.94 and should therefore not support this.

We can conclude that the malting method applied has a strong influence on the malting process and extract yield. For some of the measured characters we found more optimal characters in the otherwise less optimal malting process, here C.

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