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Test malting of Icelandic barley

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Table of Contents

1. Introduction

The notes and results reported in this document are a part of work package T4 of the Northern Periphery and Arctic Programme Cereal Project (Northern Cereals – New Markets for a Changing Environment). The task worked on was small-scale test malting.

Malt has been produced successfully from Icelandic barley.[1] Germination rates varied between 15 and 90% for different barley samples tested. Dormancy was found for barley and it was concluded that use of fresh (not dried) barley was not advisable. Barley variety Kría was used to produce about 700 kg malt which was used for beer production at the brewery Ölgerð Egils Skallagrímssonar.

Icelandic barley has been used unmalted in the brewing and distilling industries for production of beer and whiskey. In these cases enzyme technology has been applied to convert the starch in the grain into fermentable sugars.

The purpose of the work reported here was to find Icelandic barley suitable for malting and carry out small scale malting.

[1] Jón Guðmundsson, 2008. Möltun á heimaræktuðu byggi. Chapter 6 in: Ólafur Reykdal et al., Íslenskt bygg til matvælaframleiðslu. Matis Report 40-08. In Icelandic. (Malting of domestic barley / Icelandic barley for food production). Retrieved June 3rd 2016 from: http://www.matis.is/media/matis/utgafa/Skyrsla_40-08_Bygg_2008.pdf

2. Methods

Germination tests

Percent germination was carried out at the Agricultural University by placing 50 seeds on petri dishes with 4 or 8 ml of water. If germination rates are different between the two water volumes, it is indicative of presence of dormancy in the seeds. Two petri dishes were used for each test and water level and averages reported. Testing was carried out at about 15 °C for 8-10 days.

Tetrazolium tests were carried out at the SASA (Science and Advice for Scottish Agriculture) which is an Official Seed Testing Station for Scotland. The method was based on the Current International Rules for Seed Testing, ISTA on a reduced sample size of 100 seeds.

Malting tests

The malting potential of the Icelandic barley variety Kría (IsKría) was tested on certified seed barley imported from Sweden (SW Seeds). The reason for this selection was the low germination rates of the Kría grain grown in Iceland (see the results section). Several different malting approaches were conducted and the variables in the tests were: 1) How long time the barley seeds were immerged in water, 2) whether the water was drained and new water applied to the seeds and 3) whether the seeds were air dried overnight between water draining and reapplication in step 2. There were a total of six different malting regimes tested: 1) Seeds immerged in for 24 h (IsKría: 24); 2) seeds immerged for 8 h, then drained and immediately fresh water applied for 16 h (IsKría: 8+16); 3) seeds immerged for 8 h, air dried overnight and immerged again for 8 h (IsKría: 8+0+8); 4) seeds immerged for 16 h (IsKría: 16); 5) Seeds immerged for 8 h (IsKría: 8); 6) Seeds immerged for 4 h, then drained and immediately fresh water applied for 4 h (IsKría: 4+4). The water immerging was done in 20 L plastic buckets, with 400 g of seed and 5L of water. The air drying was done by laying the seed out on a cotton cloth overnight at about 15°C. After these treatments, the grain was left to germinate until the radicle (embryonic root) was about 3 mm in length. At that point the seeds were dried and the small roots brushed off.

The amount of fermentable sugars from the different malting methods was estimated by milling 200g of the malt and mashing it in 800 mL of 67°C water for 1 h. After the mash was complete, the liquid was cooled to 20°C before the specific gravity (SG) of the wort was measured using a floating hydrometer (alcoholmeter). The hydrometer measures the density of the wort, which relates to the amounts of dissolved fermentable sugars. Higher SG indicates higher amounts of dissolved sugars in the wort. Three commercial malts from Weyermann Malts (http://www.weyermann.de/) were used a references: Pilsner, pale ale and pale wheat. The idea behind the reference malts was to have

positive controls, i.e. malts that were known to work, for the milling and mashing steps. Dry matter of wort was determined by drying at 103 ± 2 °C for 4 hours. Correlation between dry matter and specific gravity was tested using R statistical program[2].

3. Results

Results for percent germination are reported in Table 1. Germination above 90% was only found for 3 samples: Kría and Saana from 2012 harvested at Korpa experimental station and Kría seed from 2014 grown in Sweden. The germination of the seed from Sweden was 100% after 3 days at 15°C, which was very different from the other samples. Germination tests were carried out four times 2016, each time with samples from Thorvaldseyri and Gunnarsholt farms. A few additional samples were included for comparison. Apparently germination of barley did not increase with time, indicating that low germination rates were not due to dormancy. Before the last test in May, barley had been stored for 3 weeks at 30-40 °C. The storage at 30-40 °C was not successful and it looks like germination has decreased.

Tetrazolium tests tell whether the grain is dead/pre-germinated or just dormant. Tests were carried out on three barley samples (Table 2). Viability is highest for Gunnarsholt barley, close to 90%, which might make malting possible. Heat damage was found for the Þorvaldseyri barley, the damage was considerably more for the 2015 harvest than for the 2014 harvest. This is also reflected in lower viability for the 2015 harvest.

Moisture contents of barley samples from Thorvaldseyri and Gunnarssholt were 8.5-13.7%.

Table 3 shows the results of the density measurements of the wort made from the commercial malts and the malted IsKría. Wort made from the commercial pale ale and pilsner malts had the highest gravity (1.059). The wort made from IsKria ranged from 1.034 to 1.044 in density. The treatment that yielded the highest gravity was IsKria: 8+0+8, where the seeds were immerged twice in water with an overnight air drying step in between before germination.

The dry matter reported in Table 3 is expected to be mostly sugars. Dry matter was highly correlated with the density measurements (R^2=0.98, $p < 0.001$).

[2] R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

These results indicate that IsKria is promising for brewing, since the density measurements of the wort indicate that even with relatively simple malting methods it is possible to extract considerable amounts of fermentable sugars from the grain. However, more extensive testing and measurements are required to test this further.

Table 1. Results from germination tests.

Test date	Farm	Variety	Harvest	Germination % 4 ml	Germination % 8 ml	Germination % Average
May 2016	Thorvaldseyri	Kría	2014	66	36	51
	Gunnarsholt		2014	52	18	35
	Gunnarsholt		2014	52	24	38
29.3-4.4.2016	Thorvaldseyri	Kría	2014	80	50	65
	Gunnarsholt		2014	80	20	50
	Sandhóll	Kría	2015	30	18	24
	Sandhóll	Kría	2015	36	12	24
9-16.2.2016	Thorvaldseyri	Kría	2014	76	46	61
	Gunnarsholt		2014	50	10	30
	Korpa	Kría	2012	98	100	99
	Korpa	Saana	2012	90	92	91
	Korpa	Saa-2	2015	84	80	82
	Korpa	06-65	2014	84	58	71
23-31.1.2016	Thorvaldseyri	Kría	2014	68	52	60
	Gunnarsholt		2014	38	6	22
	Gunnarsholt		2014	48	28	38
	Gunnarsholt		2014	42	8	25
	Sweden	Kría, seed	2014	100	100	100

Table 2. Results from tetrazolium tests.

Farm	Variety	Harvest	Viability %	Comments
Thorvaldseyri	Kría	2014	78	Evidence of heat damage present (2%).
Thorvaldseyri	Kría	2015	54	Evidence of heat damage present (16%).
Gunnarsholt		2014	88	

Table 3. Results for specific gravity (SG) and dry matter of wort made from malted Kría seed.

Malt*	Relative density of wort (SG)	Dry matter %
Pale ale**	1.059	14.4
Pilsner**	1.059	14.5
Hveiti**	1.045	11.6
IsKría: 8	1.034	8.6
IsKría: 4+4	1.037	9.3
IsKría: 24	1.041	10.1
IsKría: 16	1.042	10.6
IsKría: 8+16	1.044	NA***
IsKría: 8+0+8	1.048	11.3

* See Methods section regarding details on the malting of IsKría.
** Commercial malt from Weyermann Malts.
*** Not available.

4. Malting facilities

It is possible to carry out small scale-malting at the Korpa experimental station in Reykjavik. Malting has earlier been carried out in a building in the vicinity of the Agricultural University headquarters in Reykjavik.

The Thoran company has designed facilities for smoking malted barley for whiskey production. The company has now successfully carried out micro malting (500 g barley) with simple equipment. IsKria seed barley was used. The malt was dried to 8.4% water. See Figure 1a. Work is ongoing at the company to produce malt and whiskey.

Due to the problems that were encountered with Icelandic barley for malting, the malting experiments have been delayed until the problems have been solved.

Figure 1. Malted barley, (a) from Thoran company and (b) from the Agricultural University of Iceland.

5. Conclusions

Since some of the Icelandic barley samples gave satisfactory results for germination, it can be concluded that it is possible to use Icelandic barley for malting. Successful malting in the past supports this.

The low germination and viability of barley from the Þorvaldseyri, Gunnarsholt and Sandhóll farms might be explained by the following:[3]

1. The seed may have been dried at too high a temperature.
2. The seed had a very high moisture content at harvest, then heat may have built up while the sample was being stored.
3. Pre-germination in the field at wet conditions before harvest.
4. Dormancy due to inappropriate storage conditions, e.g. cold storage.

Immaturity, frost damages and broken grains are also possible explanations but not likely in these cases.

Heat damage has been confirmed for two Icelandic barley samples.

Moisture content was measured in the barley samples and found to be low. The second explanation does therefore not apply.

No information has been reported on pre-germination.

Dormancy might be the main problem with Icelandic barley for malting since heat damage can easily be prevented.

Grain in Iceland are stored in silos and storages at out-door temperature. Average temperature for the whole year in South-Iceland is only about 5.5 °C and for the coldest months December and January 0.8 °C. This low temperature might contribute to the dormancy of the grain.

Minimum germination percentage has to be decided for Icelandic barley to be considered for malting. It might be reasonable to set this reference a bit lower than in countries with more favourable barley cultivation conditions. In Scotland commercial maltsters would not malt samples with less than about 93-95% germination. Some malting companies set 95% germination as the absolute minimum. In Orkney, Bere from the 2015 harvest had a germination of about 98-99%. But there was a problem

[3] Peter Martin, 2015. Grain Quality Criteria for Malting Barley. NPA Report. December 2015.

with Bere from one particular field likely due to pre-germination in the field, harvest was very late and the weather leading up to this was wet. Germination was only between about 85% and 60% and this harvest was rejected for malting. Grain with only 60% germination is not recommended for malting.[4]

An inferior malt is expected for barley with germination < 90% compared to germination > 95%. The outcome would be a lower alcohol yield from the lower germination % in the grain. Taste implications are not certain.[5] However in some cases it might be justified to use barley with germination < 90%. A lower alcohol yield can be balanced by using more malt which of course will increase the price, but for small malting plants this might be satisfactory.[6]

The following measures are recommended for the next harvest season to ensure barley for malting:

1. Advice farmers on temperature control of grain during the drying process.
2. Advice farmers on moisture control of grain from the field, through the drying process and during storage.
3. Select barley for malting based on germination and tetrazolium data and information on storage.
4. Barley for malting should be stored at room temperature for one month before malting.

Guidelines should be written before the next harvest season to assist farmers and people purchasing barley for malting.

[4] Peter Martin, personal communication.
[5] Peter Martin, personal communication.
[6] Mette Thomsen, personal communication.