Towards the use of green malt in breweries for more ecological beer

A GREEN APPROACH | At a time when climate and ecology are at the center of political and citizen debates, it is also the duty of industries to reduce their ecological footprint. For breweries, the use of green malt is one way to achieve this. Castle Malting has been thinking and searching for many years for the best way to value green malt.

FIRST, LET'S BRIEFLY RECALL the malting process, as traditionally performed at Castle Malting. For base malts, this process consists of 3 main stages: 1. steeping initiates germination; 2. germination is used to produce the enzymes that will transform starch and proteins; 3. finally, kilning is used to "stabilize" the product and give it its color, flavors, and friability.

What is the principle?

"Green malt" refers to sprouted cereal grains at the end of the germination stage (fig. 1). It is interesting to note that, at this point, the enzymatic power of grains is at its maximum. In other words, producing fermentable sugars from a cereal is already possible at the "green malt" stage. Producing fermentable sugars from a cereal at the green malt stage is even more effective than producing fermentable sugars from kilned malts. The research carried out at Castle Malting shows that it is possible to produce quality beers by replacing a portion of the base malt (e.g. Pilsen) with green malt. But what are the advantages for the brewer? And what are the challenges?

The advantages

Ecological footprint and marketing

Kilning is an energy-intensive activity. This step alone represents approximately 70 % of the energy required for the entire malting process. And yet, this expenditure of energy is theoretically useless because moisture that is removed during the kilning step is then added back in for brewing (fig. 2).

To quantify the impact of kilning on the environment, let's do a simple calculation. For each ton of malting barley, kilning requires 550 to 650 kWh (in the form of gas, fuel oil, electricity, etc.). Let's translate this in terms of CO_2 emissions and assume here the emission of 0.198 kg of CO_2 per kWh of natural gas, as is the case in Belgium [1]. Based on this assumption, kilning emits 109 to 129 kg of CO_2 per ton of barley entering the process. When one considers all Belgian malting plants (including Castle Malting) approximately 1140k tons of malting barley are transformed each year. This represents an emission of 124 260 to 147 060 tons of CO_2 per year. By way of comparison, this equates to the amount of CO_2 emitted annually by 14 971 to 17 718 households in Belgium (habitat and transport combined).

Obviously, kilning remains essential. It is necessary to continue to produce malts that bring color and flavor to beer. Specialty malts are needed to compensate for the use of green malt. But CO_2 emissions could be reduced easily by replacing only a portion of the Pilsen (30 % for example) with green malt in certain beers.

Why should brewers care about this? Because if you look at the entire beer produc-

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Fig. 1
Green malt in a germination box

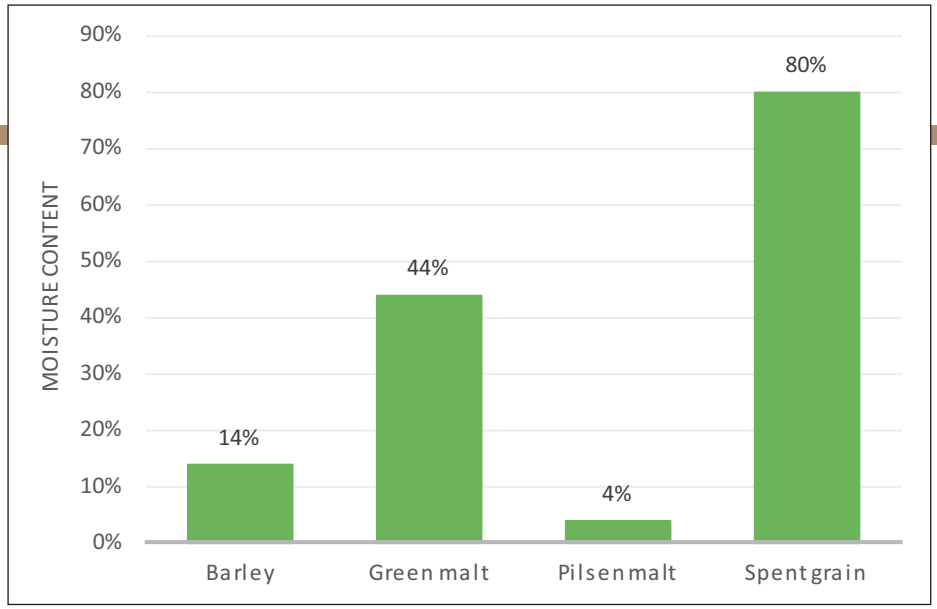

Fig. 2 Wasting energy to lower the moisture content: is it necessary?

tion process (from barley to beer), there are two steps that make this drink relatively unecological. There is the "packaging" made by the brewers and the kilning performed by the maltsters. The use of green malt in breweries gives brewers the opportunity to reduce CO_2 emissions in the beer production process, and thus to produce more environmentally conscious beers. Consumers are more and more attentive to this aspect of product design. If you are in doubt, take a look at the development of organic beers during the last decade. Beyond environmental considerations, there can obviously be a marketing interest for brewers focusing their sales on environmentally conscious consumers.

Impact on production costs

Due to the energy and time consumed, the kilning step represents a relatively high cost in the malting process. The energy cost of kilning can be estimated at around EUR 45 per ton of malt. It is then necessary to add the labor cost for this stage, which can last 1 or 2 days, depending on whether the kiln is single or double deck. For a brewer who produces 10 000 hl/year, using 22 kg/hl, this represents EUR 9900 in savings per year (without considering labor cost).

Enzymatic booster

The use of green malt in breweries is not limited to energy savings and economic gains. The absence of a rise in temperature, normally achieved during the kilning step, makes it possible to more effectively preserve all the enzymatic potential of the product. By way of example, β-amylase is especially sensitive to heat, and levels can be reduced by 60 % during kilning [2]. In some cases, the use of green malt can be particularly useful for breweries:

- Combined use with base malts (e.g. Pilsner, Pale ale, Vienna type malts): For brewers, the extraction yield of sugars is particularly important. This yield depends on the enzymatic power (or diastatic power) of the base malts. The addition of green malt makes it possible to raise yields in a natural way, as already performed with the addition of enzymes derived from fungi.

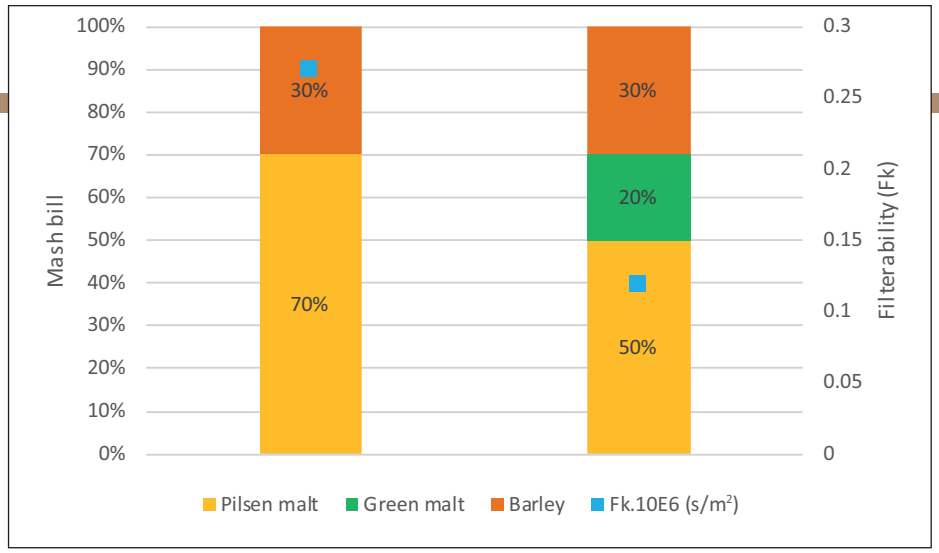

Fig. 3 Green malt improves filterability (Fk is inversely correlated with filterability)

- Combined use with poorly modified malts: It may happen, for example, that some batches of malts generate a relatively high level of β-glucans (> 250 mg/l) in the mash, for reasons related to the quality of the barley and the parameters used during malting. The use of these malts can lead to serious filtration problems. In this case, adding green malt rich in β-glucanases would reduce the β-glucan content in the mash and thus avoid filtration problems.
- Combined use with raw cereals: The addition of raw cereals (unmalted) in a brew is always done in a very limited quantity because the diastatic power of the base malts have to compensate for the absence of enzymes in the raw cereals; otherwise, the level of extract would be very low. By using green malt, the fraction of raw cereal can be increased while maintaining excellent filterability. In a research project led by Castle Malting, mash filterability tests were twice as efficient when 20 % of Pilsen malt in the mash bill was replaced with green malt (fig. 3). Surprisingly, this prospect does not seem to have been much investigated by industrial breweries, while they generally seek to reduce their production costs by replacing some of the malt with raw cereals. Brewers interested in using local cereals (potentially unmalted) may also be interested in this approach.

The challenges

Milling

One of the advantages of kilning is that the process gives malt its friability (generally greater than 80 %), which allows brewers to mill it easily. For green malt, because of its high moisture content (± 42 %), it cannot be milled with most of the mills commonly used. This would form a thick paste, that would be difficult to use and likely to obstruct the mills. A "wet milling" device helps to overcome this problem. About two decades ago, during a research project in partnership with Castle Malting, the Hydromill from Meura [3] was developed to allow the wet milling of green malt.

Conservation

Green malt is a living and rather unstable product. Due to its high moisture content, it cannot be stored in the open air and at room temperature. It is an ideal medium for the development of many bacteria and molds. There are four main approaches to overcome this problem:

- The conditions of storage and packaging can be adapted. Cold and dry storage help to slow down germination and "stabilize" its enzymatic activity. At Castle malting, multiple assays were conducted to evaluate different types of packaging that could solve this problem.
- Green malt can be transformed into another product with longer shelf life. This was the subject of a previous research project led by Castle Malting. In this project, high-gravity mashes (± 25 °P) based on green malt were concentrated by vacuum evaporation to make syrup (at 70-80 °P), or spray-dried to make a powder extract.
- Green malt can be mixed within a range of 10 to 20 % with kilned malts or with raw cereals. The moisture content of the mixture allows longer storage than does green malt alone.
- Finally, green malt could also be used "immediately" to avoid the need for conservation. This concerns the bulk use of green malt at breweries located near malting plants, where production cycles could be synchronized.

Off-flavors, appearance, and staling of beers

Some undesirable compounds may be present in larger amounts in green malt, compared to kilned malt. These compounds can have an impact on beers, in terms of off-flavors, appearance, and staling. Multiple examples can be cited:

- Precursors of dimethyl sulfide (DMS), normally decreased during kilning, will require a longer boiling time when brewed with green malt; otherwise the result will be a strong odor of cooked corn or black olives.
- Phenols from rootlets can precipitate with certain soluble proteins to form a permanent haze [4].
- Lipoxygenases (LOX), levels of which decrease during kilning, may prematurely alter the flavors of beers. That said, the brewing process can be adapted, and LOX-less barley varieties [5] can be used to reduce this risk.

The use of green malt in breweries is not without consequences. However, the process can be adapted, by the maltster and the brewer, to prevent these undesirable impacts on beers.

Conclusion

Should we stop drinking beers because these drinks are not "green" enough? No! Let's not go that far. However, the time has come to do everything possible to reduce the associated ecological footprint. The use of green malt in breweries is one of the ways to go. For brewers, green malt could be a relatively cheap raw material, whose enormous enzymatic potential offers many prospects, especially for use in combination with raw cereal.

There are certainly many challenges to be met before green malt can be commonly used in breweries. However, none of these challenges seems insurmountable. The biggest challenge is probably the conservation of green malt.

Castle Malting makes every effort to be a "green" malthouse. Therefore, the use of green malt in breweries is of paramount importance. Castle Malting will continue to contribute to research in this area. Many trials, currently underway, have been designed to respond to the multiple challenges mentioned in this article. ■

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