Paper 13
MALTING QUALITY — WHAT IS IT?

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INTRODUCTION

Barley malting quality equals malt quality; a good malting barley can make good malt, but a poor barley cannot make good malt. The question is, "What is good quality malt?" To a brewer, and as the end user he is the important person, it is a malt from which he can get the maximum amount of fermentable extract, as easily as possible and without any problems. Sometimes he has other requirements, such as the amount of amino acids and soluble protein, or the levels of certain enzymes in the malt. Occasionally, what appears to be a good malt may turn out to be inferior because it is deficient in an essential mineral or vitamin, thus upsetting yeast function during fermentation.

GRAIN STRUCTURE

To understand what is meant by malting quality, it is necessary to understand the anatomy of a barley grain (Fig. 1), and the malting process as described below.

The largest and most important part of a barley grain is the endosperm. This is made up of starch granules surrounded by a protein matrix and enclosed in hemicellulose cell walls. The ratios of these three substances, one to another, can vary from grain to grain and cultivar to cultivar. To a large extent this controls malting quality, particularly extract.

The endosperm is surrounded by an important single layer of cells called the aleurone layer. These cells synthesise and secrete enzymes during germination. Both the aleurone layer and the endosperm are enclosed in a waxy layer called the pericarp and testa. Outside this is the husk. At one end of the grain is the embryo. When the grain germinates the embryo develops into the young barley plant. At the embryo end of the grain the pericarp has a small gap called the micropyle. Through this the majority of solutes and water enter the grain, as the pericarp tends to be impermeable or at the best semi-permeable. Between the embryo and the endosperm is the scutellum. This is another area which synthesises and secretes enzymes.

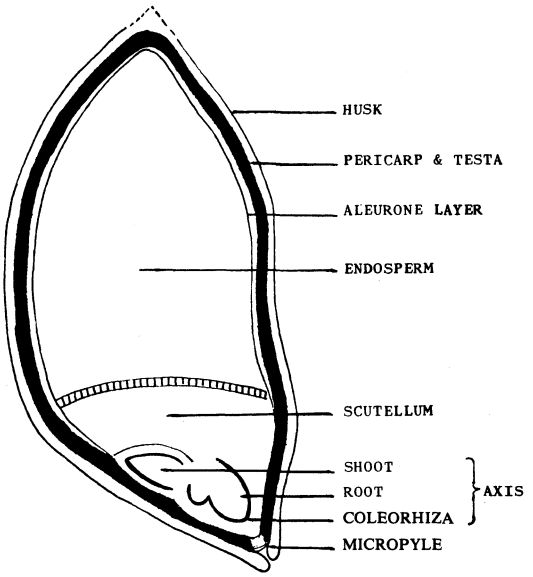

Figure 1: Barley grain anatomy

MALTING PROCESS

To make malt, the grain is given enough moisture to start germination. This is known as steeping. When the grain starts to germinate, the embryo releases gibberellins, which activate the scutellum and aleurone layer into synthesising enzymes. These enzymes carry out specific functions. They move into the endosperm and some break down the cell walls to soluble carbohydrates. Others reduce much of the protein to a soluble form, which may be either protein, peptide or amino acid. This exposes the starch granules to attack by the starch-degrading enzymes. The end products of this degradation are simple fermentable sugars and other soluble carbohydrates. This latter reaction should take place in the brewer's mash tun.

If germination proceeds too far during malting much of the starch is degraded to sugars, which the growing embryo either converts into insoluble material in the rootlets and shoot (acrospire) or uses during respiration — this is known as malting loss.

If germination does not go far enough, the cell walls are not broken down enough to expose the starch granules, thus stopping them being degraded and extracted during mashing. As well, the cell-wall material and protein may only be degraded into semisoluble or high-molecular-weight material which causes problems during brewing, being hard to filter and forming hazes in the final product (unstable beer). This type of malt is known as under-modified.

At the end of the normal germination period the malt is stabilised by kiln drying. This reduces the moisture and allows it to be stored and transported.

There are a number of factors which affect a barley's ability to make an acceptable malt.

QUALITY FACTORS

Germination Capacity

This is the most important factor in malting quality. If a grain doesn't germinate it won't malt. For ideal malting a sample of barley should have 100% germination, and anything below 95% is unacceptable. There are a number of factors which affect or reduce germination.

Post-Harvest Dormancy

Immediately after harvesting barley sometimes shows very poor germination. This is a natural phenomenon called post-harvest dormancy, and disappears during storage. The degree of post-harvest dormancy is both varietal and environmental. Although this dormancy can be broken artificially, it is a nuisance to the maltster, and barley which has low post-harvest dormancy is preferred.

Physical Damage

Any physical damage up to the time the grain is malted can impair germination. If the embryo is damaged it will not germinate, or will do so in an abnormal manner. If the pericarp is broken the grain will take up water faster than sound grain does, therefore it may be drowned during steeping. Physical damage is commonly known as skinning.

Heat Damage

Barley which has been harvested with a high moisture content and then dried can have its germination damaged if the drying temperature has been too high (above 45 °C).

Sprouting

Barley which has been subjected to warm, damp weather in the field at harvest time, and has sprouted, tends either not to re-germinate, or to be very weak if it does. Weather-affected barley which has been dried and stored correctly and had initially germinated tends to have a short storage life. Within a few months the number of grains which will germinate starts to decrease.

Water Sensitivity

It is common for barley which has been weather-affected to require very little water to germinate, and also to drown easily if it receives too much water too quickly during steeping. This characteristic is known as water sensitivity, and affected lines are classified as problem barleys.

Poor Storage

Barley not stored under the correct conditions can loose its germinative capacity through damage by fungi, bacteria, or insects. The most important storage condition is the moisture content. The ideal storage moisture is below 12%. Above 14%, barley can not be stored for any length of time with safety.

Grain Size

Grain size is an important malting characteristic, as the ratio of the endosperm to other grain organs, and therefore the potential available extract, is directly proportional to the size of the grain (Fig. 2). Most maltsters specify a minimum size when purchasing barley. This is usually defined by width. In New Zealand, the standard allowable percentage of grains smaller than 2.38 mm is 5%. Grain over this percentage will be purchased with a corresponding price reduction, up to a maximum of 12-15%. Only grain over 2.38 mm is malted. Barleys which have been harvested with a high percentage of screenings, and subsequently dressed to meet the malting specification, usually remain poor in malting quality because the average grain size remains small. Many European maltsters only accept barley for malting if it contains at least 90% of grain over 2.5 mm, and 50% over 2.8 mm.

Husk Content

Some husk is essential for lautering in the brewery, but thick-husked barleys tend to give low extracts and show poor malting quality. Maltsters speak of husk fineness — a character found in all good malting quality barleys.

Crude Protein

The total protein in a barley is often expressed as total nitrogen, and by convention total protein equals total nitrogen x 6.25. Within any single cultivar the total barley protein is inversely proportional to the potential malt extract — this is a highly significant relationship. Between cultivars, there is no relationship between total protein and potential malt extract. This means that protein analysis can be a good tool of the maltster in judging the quality of a parcel of barley. Conversely, it is not a good tool of the plant breeder in selecting malting barleys, particularly at an early generation stage — grain size and shape are better. The environmental conditions which increase the grain protein within one variety are many. These include anything that increases the nitrogen status of the soil or limits grain size, such as previous crop, the use of nitrogenous fertiliser, and lack of soil moisture. There is a highly significant negative correlation between grain size and grain protein.

Cell Wall Material

Barley endosperm cell walls are made up of hemi-celluloses. The main bulk of material is a beta-linked

glucose polymer called beta-glucan or more commonly, because of its characteristics in the soluble form, barley gums.

Barleys high in this material are both difficult to malt and difficult to brew with. The amount of this material in the grain is determined by genetic and environmental influences. The environmental conditions which cause an increase in gums are those which put the barley grains under moisture stress during development — the more the stress the higher the gum content of the grain.

Sugars

There is some evidence to suggest that the more free sugar there is in the barley grain, the poorer its malting quality.

QUALITY TESTING

Notwithstanding all the quality factors discussed above, the most reliable means of assessing the malting quality of barley is to malt it and assess the quality of the malt. The type of malting used for this will depend on the size of each sample, the number of samples, and what the results are to be used for. Experimental or trial maltings can be divided into three very general classifications: laboratory scale or micro maltings, pilot scale maltings, and full scale or commercial maltings.

Laboratory Scale Maltings

These may vary in size from a few grams up to several kilograms. The number of samples able to be malted at a time will vary from several dozen down to one or two. The size of the sample is usually inversely proportional to the number that can be malted per batch. For plant breeding work large numbers of small samples are malted per batch, using strictly uniform parameters from batch to batch.

For quality assessment of commercial batches of barley or quality control of commercial maltings, the size of the sample is usually larger than for plant breeding work. The malting parameters are also quite often adjusted from sample to sample or batch to batch.

Within each trial a standard of known malting quality is usually included, against which the other samples are compared. The main parameters looked at in the malt analyses of laboratory maltings are:—

Extract

This is normally the main character assessed. It is the amount of potentially soluble material formed during malting. It is determined by using a standard mashing technique and measuring the amount of malt dissolved. Extract is commonly expressed as a percentage of the malt, usually on a dry basis.

Enzymes

The barley's ability to develop certain enzymes during malting can also be measured. The main enzyme systems are:—

1. The starch-degrading enzymes, which are measured as total diastase or alpha-amylase, or both.
2. Beta-glucanases — these are the most important of the cell-wall degrading enzymes.
3. The protein-degrading enzymes, which are measured very occasionally.

Carbohydrate Modification

This is the ability of the barley cell walls to be degraded during malting. It is measured in the following ways:—

1. Fine-coarse extract difference; when determining the extract, the finer the malt is milled the higher the extract. But the better a malt has modified, the smaller the difference between the extract of a finely milled malt and the extract of the same malt coarsely milled.
2. Wort viscosity; the lower the wort viscosity the lower the molecular weight of soluble beta-glucans, also the more even the germination during malting.
3. The percentage of fermentable sugars in the extract; the higher this figure is the better the malt. Most brewers like to see as much of the total extract fermentable as possible.

Protein Modification

This is measured in two ways:—

1. As the total soluble protein formed during a standard mash; it is expressed as both a percentage of the malt and as a percentage of the total protein. The latter is known as the kolbach index.
2. As the total free amino nitrogen in the wort.

Pilot Malting

This is a more advanced stage of trialling than micromalting and is the stage before commercial-scale malting trials. Batches usually vary in size from 0.5 to 10 tonnes. Here the barley is malted using a general standard procedure, with allowance made for the known characteristics of the barley. The aim of this malting will be to get the best out of the barley. The main difference between a micromalt and a full-scale malt is that in a micromalting a barley's performance is measured using a standard method, whereas in a commercial malting the maltster's aim is to make the best possible malt out of the barley, bearing in mind the specifications being malted to. In a pilot malting the maltster's aim is to make the best general malt from the barley under test. Not only is the barley being tested to find out how good a malt it will make, it is also being assessed to find out what types of malt can be made from it.

For a pilot malting the following characters may be assessed:—

Malting performance: Speed of water uptake, evenness of germination, extent of acrospire development, amount of rootlet growth, respiration loss, evenness and degree of endosperm modification, and the ability of the malt to dry during kilning.

Extract: total, coarse-fine difference, fermentable, Hartong, and filtration rate.

Wort: Colour including boiled wort colour, clarity, aroma, viscosity, and pH.

Protein: Total, total soluble, permanently soluble, kolbach index, amino nitrogen, and Lundin fractions.

Enzymes: Total diastase, alpha-amylase, and beta-glucanase.

These will not all be determined on every sample, and from time to time other parameters may be used.

Commercial Malting and Brewing Trials

The final evaluation of a malt (or barley) is its acceptability to the brewer. In the final stage of testing a barley, enough malt is made for the brewer to do as many trials as he desires, to satisfy himself of its quality.

The main items looked for by the brewer are the brewhouse performance of the malt, the fermentability of its wort, and the assessment of the final beer. The assessment of the brewhouse performance of the malt includes ease of milling, speed of lautering or mash filtration, clarity and colour of the wort both before and after boiling, and the availability and recovery of extract. The characters looked for during fermentation are the speed and degree of fermentation, the sustained health of the yeast, and the filterability at the end of fermentation. The final beer is assessed for clarity, colour, stability and flavour.

CONCLUSIONS

The above remarks on malting quality refer to New Zealand barleys. At present these are all two-row spring-sown barleys. The other main type of barley in the world is six-row, from which the malts tend to have lower extracts because of their smaller grain size, but higher enzyme activity; consequently they are used by the brewer as a source of enzymes to degrade raw grain such as wheat, barley, rice, and corn. This then provides the major part of the extract.

In the Northern Hemisphere there has been a move towards winter-sown barleys because of their higher potential grain yields; but because of their lower extracts, their difficulty to malt, and their brewing performance they have not found favour with either the maltster or the brewer. Few cultivars of winter barley show good malting performance, and it is common for a brewer, when furnishing a malt specification, to specify that the malt must be made from spring-sown barley.

The opening paragraph of this paper sums up the requirements for quality in barley and its malt — high extract, easily obtainable and causing no problems to the brewer. In the competitive world of international brewing, a brewer does not change a recipe unless economics or a drop in sales forces him to do so. Each brewer knows the requirement of his own brew and he makes the malt specifications accordingly. But he always requires a high extract — 80-81% plus. The maltster knows the characteristics of the barley he needs to make this malt and this is what he must have. Sales malting is a very competitive business and the maltster will strive to keep the malt within the tolerances specified. Regardless of how good his plant is or how knowledgeable his technique, he cannot do this if the barley is not up to standard. The higher the standards set by the brewer the better the barley required — hence malting quality.

DISCUSSION

Gallagher: About Western European winter barleys, I know that in England Maris Otter, which was bred by the Plant Breeding Institute, for about 12 successive years won first prize from maltsters for producing top quality malt. If you have a good crop of Maris Otter, the maltsters are queueing up to take it.

Smart: Yes, I thought the question of winter barley quality would come up. With the exception of Maris Otter, the maltsters from Western Europe I have spoken to do not like malting winter barley.

Q: Undoubtedly, growers in certain environments in New Zealand will be able to produce the high quality barleys you require. Is there an economic method of testing for quality?

Smart: A quick way is to test for protein. A method using infra-red reflectance can be done in two minutes. The Wheat Research Institute use this method for testing. I would think that in the future we will test for quality before storage. At the moment, we only look for damage, including sprouting, and grain size. Moisture is slightly different, that's a storage quality factor. All other factors — crude protein, gum content, dormancy, water sensitivity, and free sugar content, we have to accept, under the terms of our present contract.