Perception of Color and Flavor in Malt

Nigel Davies
Muntons plc., Cedars Maltings, Stowmarket, Suffolk, UK.

ABSTRACT
The description of malt color is often a source of confusion that creates difficulties in control of hue in foods and beverages. Quite often confusion is simply due to a misunderstanding of the various methods used for malt color description. Even when these differences are taken into account, there is much more information available on malt color that is perceptible to the eye and has an impact on final product color quality but that is simply not adequately described by conventional methods of analysis. Using a tristimulus method to describe color quality has been shown to better represent the differences in color quality of a number of specialty malts when, in baked goods in particular, relatively small differences in hue have a significant impact on the acceptability of the final product. Combining this type of color information with detailed sensory analysis allows more targeted selection of malts and improved troubleshooting of issues associated with malt color and flavor.

Keywords: color, flavor, malt, malt extract, tristimulus, troubleshooting

INTRODUCTION

MALT COLOR ANALYSIS ISSUES

When you place an order for colored or specialty malt, just how certain are you that it will match your requirements? Perhaps you think this is a simple question, and if you only ever buy colored malt from one supplier, you might never enter the somewhat bewildering world of malt color description that is generated by the analytical methods used in different countries. There are many methods of describing and analyzing malt color, and their use varies among suppliers, whether local or international. This paper explores some of the pitfalls that generate much heated discussion between suppliers and brewers and opportunities that are oftentimes missed to exploit malt color selection more fully.

Increasingly, where malt is used in beverages, flavor profile and color quality are important for brand differentiation. Flavor profiling of malt is an amazingly simple test that can open up a world of options for product development.

SÍNTESIS
La descripción del color de malta, o productos de malta, es frecuentemente una fuente de confusión, creando dificultades en el control del tono en bebidas y alimentos. Esta confusión es a menudo sencillamente debido a un mal entendido en cuanto a los diferentes métodos de medir el color debido a la malta. Aun cuando se toman estas diferencias en consideración, existe mucha más información disponible sobre el color de la malta perceptible al ojo y que tiene un impacto sobre la calidad del color final del producto, pero que no es adecuadamente descrito por los métodos convencionales de análisis. Se ha demostrado que el uso de un método "tristimulo" para describir la calidad del color resulta en una mejor representación de diferencias en la calidad del color de malta especializadas cuando, especialmente en productos de pastelería/pañadería, relativamente pequeñas diferencias en tono tienen un impacto significante sobre la aceptabilidad del producto final. Combinando este tipo de información sobre el color junto con un análisis sensorial detallado, permite mejorar la selección de la malta más indicada y mejora el análisis de problemas asociadas con el color y sabor de la malta.

PALABRAS CLAVES: análisis de problemas, color, extracto de malta, malt, sabor, tristimulo

TRADITIONAL DESCRIPTORS FOR SPECIALTY MALT

A system for malt and malt product flavor profiling has been developed that uses the grain directly rather than the wort, which can be overpoweringly sweet. Using a ground malt "porridge" made by adding a little water has made it possible to identify the best malts in a series of samples that are all analytically acceptable. Using this method, malts made in plants with poor hygiene can be identified, and the nature of contamination in production, storage, or transit of malt can be determined.

Currently, full malt profile tasting is not part of any formal malt specification, but it offers the ability to differentiate both positive and negative flavors. A conventional chemical analysis can indicate that malts are identical, yet processing parameters can differ depending on the method of production; the flavor profile can also differ (1). Thus, it is important to have a sufficiently discriminative method to profile malt flavor that reflects the range of malt flavors available.

DISCUSSION

Malt descriptions in the literature are often brief, one-word terms that do not fully describe all the attributes of a malt and cannot easily differentiate between malt types. There is so much more detail about malt flavor that is available, and an impressive set of descriptors could be created by flavor profilers and grouped into classes to enable profiles to be constructed (2–4).

Using a wet porridge avoids the problem (for the taster) of drying out the palate when tasting whole malt or dry ground samples. When given free rein to describe malt flavors, tasters tend to use food products as descriptors. It is then possible to group these into a smaller number of sensory terms to create unique profiles for the entire range of malts (4).
Examples of the clear differences in profiles achieved using this method are provided for lager and ale malts (Fig. 1) and lager and chocolate malts (Fig. 2). These two graphs show the great degree of discrimination that is possible when describing malt sensory attributes. It is immediately obvious that the main difference between lager and ale malts is in the degree of kilning: the lager malt is kilned to a lower final temperature and, therefore, tastes less cooked or greener (uncooked), whereas ale malt is kilned at higher temperatures that generate more cereal, nutty, and sweet toffee notes (Fig. 1). When roasting a lager malt to make chocolate malt, such as is used in production of stouts, there is a dramatic increase in flavor notes associated with roasting and browning (Fig. 2).

**Use of Sensory Analysis to Improve Selection and Specification of Specialty (Roasted) Malt**

Sensory profiling has also proved a useful tool in determining which specialty malt is most appropriate rather than relying on conventional color analysis. This is particularly important when working with the rather broad description of crystal malts. These malts are made primarily by stewing green malt, but the final temperature used creates color and very different flavor profiles that markedly affect the final product. The crystal malt category has a color range of 145 to 400 EBC color units (10% dilution), but the flavor characteristics vary widely (Fig. 3). At low color (145 EBC units), the flavor notes are predominantly sweet, fruity, and toffee, whereas at higher colors (350 EBC units) they are characterized by bitter, burnt fruit, and treacle notes.

It is very important to specify what color is required, with an accurate knowledge of the associated flavor impact, rather than just adding these malts to adjust color, because it is possible to detect the blending range of malts that have been used to create a crystal malt. For conventional color analysis it is acceptable to blend colors from either end of the crystal specification to achieve an intermediate. If, however, a specific flavor is required, then there is a very marked difference between higher and lower color crystal malts, and the flavor difference is simple to detect if the colors, and hence flavors, blended differ too widely.

**Troubleshooting Flavor Defects or Taints Using Malt Sensory Analysis**

Malt sensory analysis can also assist in detecting flavor problems, as described in the following brief case studies in which I was involved as an external witness.

**Case Study 1.** A brewery purchased malt from four malsters; the malts were all in specification based on conventional analysis. Sensory profiling of the beer, however, indicated an off-flavor note in beer brewed with one of the malts. A very different profile, particularly an increased solvent/wet note, was identified in this malt (Fig. 4). Subsequent investigation of the malt in-
dicated poor attention to hygiene and a tendency to underkiln or undermodify even though the malt was produced to the customer's specification.

Case Study 2. An unusual oily note was detected in beer produced using a malt that met specification. Tasting the malt used, it was immediately apparent that there was a note variously described as goaty, oily, or diesel. How could diesel notes have gotten into the malt? After an investigation, the malter found that on the day the malt was produced there was a queue of trucks onsite outside the kiln air intake. It was determined that these fumes had tainted the husk of the malt. The solution was to ban trucks from queuing in this area.

Neither case history could have been resolved by conventional analysis. Malt sensory analysis, however, was shown to be a useful tool for pinpointing problems not easily resolved by conventional analytical methods.

There is clearly much to be gained by understanding malt flavor in more detail. This relatively low-tech solution allows the more obvious differences in flavors to be appreciated by almost anyone with a reasonable ability in sensory analysis. With improved levels of training and description, some very elegant profiling and troubleshooting are possible.

What Color Is My Malt?

Have I gone mad—isn't this the simplest analytical parameter on the specification sheet? The answer is that it is only a simple parameter when it is the parameter for which you think you are asking.

At first glance, there are some simple mathematical differences in methods of color measurement among the American Society of Brewing Chemists (ASBC), the European Brewery Convention (EBC), and the Institute of Brewing (IoB) (Fig. 5A). However, in the United Kingdom two distinct additional IoB methodologies are still widely used, even though one is superseded that differ in the way the malt is mashed either on a weight basis (450 g) or volume basis (515 mL). It is important, therefore, to recognize the additional calculation that is necessary to convert between these two methods and to note that the factor changes for malts above about color 20 using IoB 450-g mash (Fig. 5B). IoB mashes are also processed at one temperature (isothermal), whereas EBC and ASBC mashes use ramped temperatures that are able to extract more of the available color. To cloud the issue further, to remove the very high colors of roasted products you can either mash using 50% normal white malt, which has enzymes to extract the color, or simply boil out the color using a 100% grist of the colored roasted product.

The results of these rather tortuous conversions are shown in Figure 6. If you order a malt with color 350 based on IoB 450-g mash and then from a different supplier ask for a color 350 malt that the supplier bases on a 515-mL mash, the resultant ASBC color will be 16% darker. This, of course, can generate a complaint that could easily have been avoided.

Isn't It Easier to Determine Color by Eye?

The idea that it is easier to determine color by eye is a view held more widely by those using specialty malts for bread making, and if the first bag of a new batch doesn't by eye match the last bag of the previous batch, then it is assumed to be the wrong color. This might be true, but the eye can also play tricks on you.

Figure 6 shows a series of samples (courtesy of Chris Boer, Campden-BR) from a roaster with their mashed color values. Most people would rank the bottom right sample as the darkest, whereas the bottom middle sample is analytically darker. Perhaps even more surprisingly, the top right sample is much darker than it seems visually, because the inner crystallized part holds most of the color.

This introduces the importance of being able to extract all of the colored components from the malt and not being misled by the outer color, which may or may not be the same as the roasted or crystallized product inside. It is possible when roasting to achieve the same color at two different points in the roasting process. However, at the later point the extract is lower, which means that in the mash less color will be extracted than at the earlier roasting time (Fig. 7). It is clearly more efficient in terms of energy and color extraction to terminate roasting earlier.

Roasting to Achieve a Red Hue

It is probably intuitive to assume that as a crystal malt is roasted it will become redder. A misconception, however, is that redness increases in a linear fashion with roasting or stewing time. This misconception leads those setting specifications to ask for higher colors to achieve more redness, which leads to problems. In fact, the relationship between redness and EBC color is non-linear and has a steep fall-off on either side of maximum redness (Fig. 8).

![Figure 6. Color development in roasting. Samples taken during roasting were analyzed for color. By eye the darkest sample is on the bottom right. Analytically the sample second from the left at the bottom is the darkest, because internal color is not perceived by visual assessment and in this type of malt that is where most of the color is concentrated.](image-url)
When roasting a crystal malt to a specification in the region of 350 I°B (EBC color units), there can be appreciable variation in the red hue, which impacts beers light enough to allow redness to be perceived. If red hue is an issue, traditional color measurements may be insufficient to guarantee that product color remains true to type.

If it is assumed that red color is related to the EBC specification, then that specification needs to be quite specific. For example, redness for this product in the range of 340 to 360 is at a maximum, and there is little variation across this color range. Moving to a range of 290 to 310 or 410 to 430 would result in much less redness and a more widely variable amount of redness between batches that are otherwise in specification. If the requirement is simply for a degree of darkness, then it might be more suitable to specify a lighter colored chocolate malt rather than risk differences in color hue by asking the supplier to make a high-color crystal malt.

It has become, therefore, more important in some circumstances to use a tristimulus method to assess malt color. Using this method, a specialized but relatively low-cost analytical measure is made of the color quality (red, green, and blue), which is expressed as the degree of lightness (L*), the amount of red-green (a*), and the amount of blue-yellow (b*). This technique is also widely used in other industries where color quality is of prime importance.

Samples can be compared for their color quality using a very simple method. It is not necessary to compare all three L*, a*, b* values because programs are available to combine all these values into one and compare the difference between two color points as one value. A small difference in this single value (ΔE*) shows the sample to be very close in quality and vice versa. Thus, it is a very straightforward process to compare batches of roasted material being made or taken in by a customer and to determine the color quality range of batches blended together in that delivery batch if this is important to the application.

Of course even the tristimulus method has pitfalls of which users must beware. There can be very good correlation for lightness compared with conventional color data (Figs. 9 and 10) for a colored crystal malt rated at approx. 200 I°B color. The best correlation (90%) is for lightness (L*) with conventional color (Fig. 9). This type of crystal malt increases in redness but has a poor correlation (24%) with conventional color (Fig. 10A), while correlation (13%) of blueness with conventional color is very poor (Fig. 10B). For this type of malt, there are many differences in color that develop during roasting and interact. These differences result in a low correlation for specific color but generate overall darker colors with time.

It is essential that the manner of preparation of the grist for analysis of the dried ground malt (e.g., flour) is consistent. As shown earlier for external visual appearance (Fig. 6), the internal parts of the malt contribute greatly to the color extracted and must be fully ground, otherwise the correlation can be reversed and result in utter nonsense (Fig. 11). Figure 11 shows a noncorrelated scatter of results for the unground (nonmilled) version of the sample that produced the high correlation shown in Figure 9. This indicates the importance of obtaining a sample that truly reflects all of the color-contributing parts of the malt, and this is only possible using a ground sample.

**Use of Malt Extracts to Develop New Beer Flavors**

In the same way that color and flavor can be profiled and described for malt, an identical description can be created for the malt extract made from these malts. Muntons makes a range of malt extracts based on specialty roast malts using the first (mashing) part of the brewing process. The difference is that the wort is evaporated to 80% solids rather than fermented. It is easy then to take relatively small amounts of the concentrated extract and add them into the late stages of another wort boil to control color in the same precise way that is currently practiced for hops and bitterness, for example. The malt extract needs to be warmer than

![Figure 8. Nonlinear development of red hue in the crystal malt.](image8)

![Figure 9. Correlation of lightness (L*) with I°B color. Using ground (milled) malt samples, there is an excellent correlation between the two analyses at 90%, allowing this parameter to be easily used in a color specification.](image9)
40–50°C (104–122°F) to dissolve well; at wort boiling temperatures, it dissolves very quickly.

For the first stages of a new product development assessment, it is possible to dissolve small amounts of malt extracts directly into the beer to see what impact they have. The effects can be dramatic. For example, one customer was able to transform a lager line to make sweet porter by adding only small amounts (1–2%) of a malt extract rich in chocolate malt and one rich in crystal malt to effect the change. The addition of chocolate malt extract had the added advantage of allowing the hopping rate to drop a little, since chocolate malt imparts some bitterness as well. This new product development work was completed in just one afternoon in the sensory suite and went straight into production at the brewery!

**Conclusions**

These observations show that a clear understanding of the impact of the analytical method used to measure color should be highlighted to prevent product color mismatch. An appreciable difference in color can be achieved by sourcing from different suppliers unless the exact analytical method is stipulated on the specification.

When specifying color it is now possible to enhance product value by utilizing variation in hue. At the same time, the extractability of the color needs to be discussed with the supplier to ensure that you are able to effectively extract all the color in the process. Indeed, there may be opportunities to produce the same color target in a less energy-intensive manner. Malt hue analysis can also improve quality control of incoming material by detecting the ranges of malts blended together to achieve the specification.

Novel opportunities are becoming available with the use of the tristimulus method to specify malt color and hue and more accurately match malt type to the desired market. This may be of particular value when developing new products. The aim of this paper is to encourage a wider discussion of these opportunities and engender a desire to experiment and fully exploit the potential locked up in a wholesome product and develop and differentiate beer brands.

**REFERENCES**