

Flavour science: Repositioning to achieve perfect beer

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The aim of this poster is to challenge the commonly used approaches to the design of sensory experiments and their interpretation. An example, given here, is the development simple transformation of sensory data and the subsequent graphical approaches to understanding the multivariate (good) flavour quality of beer.

Current situation

Many brewers use flavour profiling methods, which have their origins from the 1950's.

- Most flavour profiles are heavily biased towards flavour negatives (typically > 70% of descriptors are negative)
- Developed from 1950's onwards....knowledge of off-flavours less well developed then
- With one or two exceptions, negatives are well-known and can be determined analytically

Today, we ask more from profiling than just pass/fail judgments. We want to know, for instance:

- The degree of quality (acceptable vs excellent vs perfect)
- Inter-brewery consistency and excellence, increasingly at a global level
- How what is tasted relates to analytical measurement
- How analysis relates to consumer behaviour.

I contend that as is profiling is too blunt a tool to do the job. It needs to be reviewed. A start is outlined here

Good quality has many dimensions!

Sensory profiling attempts to match the reductionist capability of analysis. Works with off-flavours ("diacetyl", "chlorophenolic", "cardboard" better than positive qualities ("drinkability", "refreshing", "balanced"). Need to find a different approach to tackle today's quality requirements.

Temptation is to apply multivariate techniques. However, the application of the usual multivariate techniques to most sensory data is at best misguided, at worst erroneous!

Two big problems

1. There is a well-known, non-linear relationship between concentration and perceived intensity of flavour compounds, whilst many of the most common data analysis techniques rely on assumptions of normality and linearity
2. Generally, little or no compensation for known sensory scale biases. Green *et al.* are a notable exception here, with their concept of the Linear Magnitude Scale (LMS):



Usual assumption: Equally spaced descriptors assigned arbitrarily

b) Psychophysical equalisation of length and descriptive terminology (LMS approach):



LMS derivation shows that a priori assignment of descriptors forces additional scale bias.

Scientific background

There are two strands of research that are pertinent here.

- 1) The analytical concentration of a component is of little value unless there is some understanding of its flavour intensity. Meilgaard developed the concept of the Flavour Unit (FU):

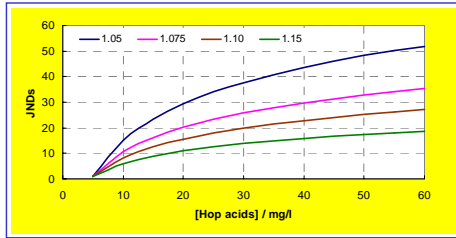
$$\text{Flavour Units (FU)} = \frac{[\text{Analyte}]}{\text{Flavour threshold}} \quad (\text{eq.1})$$

He showed that many beer components are at levels below their threshold (ie FU < 1). This is the basis of the analytical flavour specification of beer brands

- 2) Weber and Fechner contended that human sensitivity to different levels of stimuli (eg flavour components) obeyed a logarithmic law, an empirical observation that has been partly confirmed by physiologists:

$$\frac{\Delta I}{I} = K \quad (\text{eq.2})$$

The Just Noticeable Difference (JND) represents the smallest "sensory unit" (SU) or sensory step. Each curve represents different values of 1 + K.



Implication is that the analytically-based FU is not a linear scale.

- A deviation from, say 1.1 to 1.2 FU is more significant than that from 2.1 to 2.2 FU
- What happens on moving from, say, 0.9 to 1.1 FU?

Combining these two concepts in visual context provides an approach to better understand multivariate flavour and quality issues

How are these combined?

The general relationship between SU and FU is:

$$SU = a \ln(FU) + b \quad (\text{eq.3})$$

In the following example, the constant K = 0.075 (see eq. 2) and so the resulting expression used in the example below is:

$$SU = 13.83 \ln(FU) + 1 \quad (\text{eq.4})$$

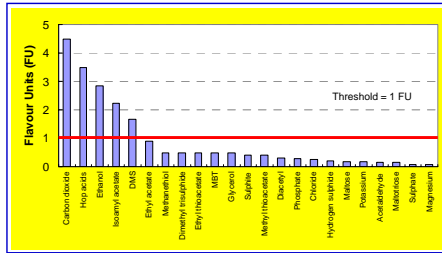
With a value of K = 0.075, there are around 24 SU's from 1 – 5 flavour units (the highest intensity of a single compound in most beers is < 5 FU's), so that, for a given flavour, we effectively quantise flavour intensity into 24 discrete boxes. Lower values of K result in more SU's.

Brand Flavour Maps

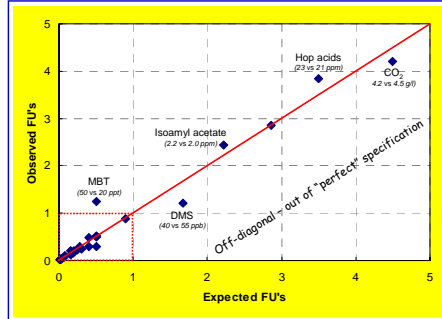
Bringing together existing knowledge can logically move us to a better understanding of good quality.

Step 1 – The Flavour Unit (FU) graph

A simple bar chart tells which are the apparently dominant flavour characteristics of your beer. An incomplete example is given below:



Better to compare specifications (expected) with actual (observed):

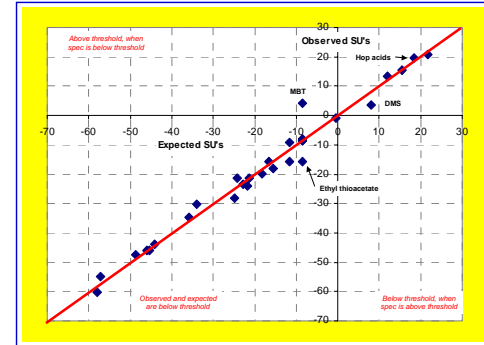


Immediate observations include:

- Large FU deviation for a within specification deviation in bitterness
- DMS and MBT are the furthest from the diagonal...a sulphur flavour problem here?
- Crowded subthreshold region (dotted red box), hiding potentially additive phenomena

This representation though does not take into account the non-linear relationship between JND and FU's. Enter the Brand Flavour Map.

Step 2 – The Sensory Unit (SU) graph or the Brand Flavour Map



Comparing the FU and SU graphs, the emphasis shifts from CO₂ and bitterness to two of the sulphur volatiles. MBT still registers strongly, an indication of the phenomenon of off-flavours...developing at abnormally high, sensorially significant concentrations. The plot gives a highly visual and sensorially-relevant overview before the application of complicated data analysis techniques.

Moving forward

There are several questions that this poster highlights:

- Can more linear, unbiased sensory experiments be performed? Approaches such as the linear magnitude scale (LMS) will provide data of higher quality that will facilitate any subsequent data analysis and contribute to better decision-making
- What happens at or near threshold? This is an important question, as it might be expected that panelist data is most noisy around threshold. This should be amenable to a probabilistic consideration of the thresholds of a population.
- Are we missing any analytes? Almost certainly. Probably more significant for multivariate flavour problems, especially if coupled to other flavour-active analytes that are diagnostic of production, raw material or stability issues

Summary

The contention here is that commonly used sensory methodologies and data analysis techniques are inadequate for fine discernment of products at a group (panel) level. Several of these deficiencies can be readily addressed by application of existing knowledge.

It is proposed here that this existing knowledge be effectively used by our industry to allow us to derive more valuable information from routine and research activities that rely on sensory evaluation and interpretation. One example, presented here, is the Brand Flavour Map, which provides an essentially non-statistical image of beer flavour performance and, with educated interpretation, lends itself to diagnosis of good vs perfect beer.

There are knowledge gaps though, which include perception at or close to threshold, both in terms of individual sensitivity and product-specific synergies and antagonisms between flavour components. These represent pertinent areas of future research.