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The Beer Aroma Wheel

Updating beer flavour terminology according to sensory standards

Aroma wheels provide a terminology for the sensory description of products. They were developed to help people responsible for quality control and product development to communicate using unambiguous terminology.
30 years ago, *Meilgaard* [14] developed the beer flavour wheel. Its development was an important milestone in establishing an accepted terminology for the sensory science of beer. It still serves as the basis for the selection of terms in descriptive profiling tests today. Sensory science has since come a long way in terms of accumulating knowledge and developing sensory standards. In order to guarantee a consistent use of language, the existing beer terminology therefore needs to be reviewed. In Meilgaard's flavour wheel, olfactory, gustatory and haptic sensory perceptions overlap and several terms are not clearly matched with sensory perceptions.
Furthermore it is important for the communication with customers that they, too, understand the terminology. In some cases, it can be difficult to assign terms to the individual classes. This assumes that tasters come equipped with the knowledge of a beer connoisseur.
This article presents a beer aroma wheel that is structured according to sensory standards. Even people who have no knowledge of the way flavours in beer develop can use it to describe sensory perceptions. Alongside this, a beer aroma wheel is shown that supports assessors in the description of positive and desirable characteristics of beers. Initially an overview of the sensory language in accordance with European standards is provided.

Descriptors: sensory, aroma wheel, mouthfeel, trigeminal perceptions, flavour wheel, reference materials

1 Introduction

Sensory perceptions of beer are very complex. For the purposes of sensory evaluation, these perceptions are divided into optical, olfactory, gustatory and haptic sensations. The term "flavour" thereby includes all characteristics of the food item held in the mouth. There is no term that includes both odour and flavour [13]. The smell, the aroma, the taste and the trigeminal perceptions are therefore defined as the olfactory-gustatory overall impression. Odour is an organoleptic characteristic that the olfactory organ perceives when it smells certain volatile substances. Aroma is an organoleptic characteristic that is perceived by the olfactory organ over the hypopharynx. Taste is the sensation perceived by the gustatory organ and stimulated by certain soluble substances [1]. There are six distinct basic taste qualities: sweet, sour, salty, bitter, umami and fatty [2].

A fatty taste promises high calorific value as well as the presence of essential fatty acids and vitamins. Fats also influence texture and create a specific mouthfeel. Furthermore, fats are solvents for many odorous and certain gustatory substances [2]. Free fatty acids thereby impact directly on K^+ channels or similar proteins [8].

Apart from the olfactory-gustatory perceptions, the haptic sensation of foodstuffs plays a further role. The haptic perception is sensed via pressure and touch. The cutaneous sense can be divided into temperature sense, kinaesthetic sense, mechanical cutaneous sense and pain sense. The temperature sensation is connected to the perception of other sensory inputs. For example, more aroma is released at higher temperatures and the sensibility for bitter taste is at its maximum at 10 °C. Kinaesthetic impressions are caused as result of chewing movements. The mechanical cutaneous sense detects the tactile sensations such as rough or smooth, which are perceived with the mouth [3].

The sense of pain or the trigeminal perceptions are just as much part of the repertoire of sensations. These are feelings of irritation – irritating or aggressive perceptions in the oral cavity and in the throat [1]. The trigeminal nerve responds to thermal, tactile and painful stimuli. It transmits burning, astringent, tingly, stinging and cooling sensations. The reception of stimuli occurs in the distal parts of trigeminal nerve cells. The nerves end at the eye and in the mucous membranes of the oronasal cavity [13]. Sensations of pain can have positive connotations in connection with food. The sharp taste of alcohol and the sparkle of CO_2 for example are both appreciated [3]. The release of CO_2 causes a tingly sensation on the tongue and stimulates salivary production [16]. The carbon dioxide that continues to be released in the mouth also affects taste perception. The CO_2 content of beer, for instance, affects the sour taste and the astringent sensation. Beers with a high CO_2 content taste significantly more sour, but less astringent [18].

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The company Joh. Barth & Sohn supported the author's thesis "Methodology of Characterising Olfactory and Gustatory Perceptions in Beer" with the Barth-Haas Grant. The grant supports papers that are particularly concerned with hops and its manifold applications.

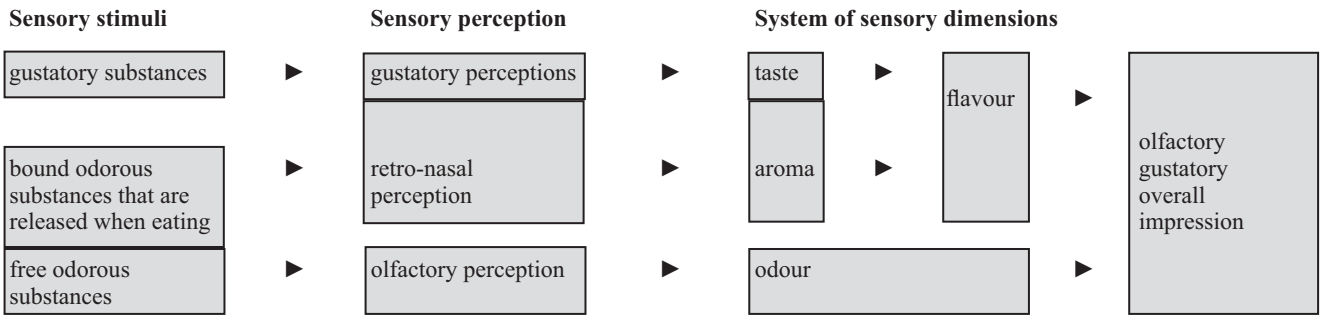

Fig. 1 Overview of the olfactory and gustatory overall impression

Ethanol itself, but also its high solubility for many substance classes, has a big impact on taste and odour. Ethanol content also affects perceptions. Thereby the intensity of bitterness increases with increasing alcohol content but with equal amounts of isomerised hop products [17].

Cauterisation of the mucous membranes at the back of the mouth also affects mouthfeel. This sensation can be described using the term "pungent". The sensation is also caused by smoke [1].

The terms "mouthfeel" and "body" describe the haptic impression of a food item. They are interpreted very differently within the beer sensory system.

The flavour wheel according to Meilgaard [14] describes mouthfeel with the terms alkaline, mouthcoating, metallic, astringent, powdery, carbonated and warming. Apart from mouthfeel, "body" is a further umbrella term. It stands for the fullness of flavour and mouthfeel.

Lawless et al. [11] showed that metallic sensations are retronasal perceptions of smell that may be caused by lipid oxidation within in the mouth.

Langstaff et al. [10] divide mouthfeel into carbonisation (total carbon dioxide, foam volume, bubble size and sting), fullness (density and viscosity) and aftertaste (astringent, stickiness, persistent mouthcoating). To describe the haptic sensation, they include foam volume and structure as well as aftertaste.

The aftertaste is an olfactory-gustatory stimulus, which is perceived after the product has been swallowed [1]. Aftertaste is not limited to the taste alone. It can contain aromas, taste components and trigeminal perceptions in the oral cavity. The lasting effect of the aftertaste can be described as persistence.

Persistence gives information about the chronological progress of the olfactory-gustatory perception. The perception that is to be determined chronologically appears when the food has been in the mouth and the stimulus remains for a measurable amount of time [1]. Once odour and taste substances have separated from a product and are bound by saliva, they become subject to attack by enzymes or are absorbed by the cell tissues of the mouth. This is determined by the chronological fate of the food in the mouth, but also by the structure of the odorous and gustatory substances [21].

2 Materials and Methods

A group of 20 tasters was trained and validated according to the DIN 10961 standard [5] to develop a terminology for the sensory perceptions in beer. To train the assessment of bitter taste qualities, iso-α-acid was used instead of caffeine.

Olfactory tests with standardised and non-standardised odours were carried out for training purposes. This exercise improves the memory and a larger number of aromatic substances can be recognised [3].

The flavourings were diluted and sealed inside glass containers. In addition, foodstuffs and other substances were used. These test samples were put in non-transparent and sealable containers and covered with cotton wool to avoid visual recognition. The samples

Table 1 Trigeminal perceptions

Trigeminal perception	Definition	Reference substance
Astringent	Puckering of the surface of mucous membranes in the mouth (1)	Tannin
Stinging	Tingling that can turn into a feeling of pain (1)	Capsaicin solution
Burning	Warming feeling in the mouth cavity. Not influenced by temperature (1)	Ethanol

were coded with three-digit numbers. Olfactory samples were tested by removing the container lids and sniffing the headspace.

The testers are unbiased with regards to beer. They do not look back on years of product experience or have knowledge of product recipes. What they do bring to the testing table is a positive attitude to the product beer and sufficient ability to articulate and describe their sensory impressions. Tasting sessions were held in the sensory lab of the Geisenheim Research Centre. The test room is designed in accordance with DIN 10962 [6] and has space for up to 30 assessors. For the sessions, tulip-shaped tasting glasses in T-form were used according to ISO 3591 [9]. The glasses are filled with 50 ml of beer for sensory assessments. The beer samples were brought to a drinking temperature of 13 °C.

Simple descriptive tests were carried out with different beer styles to work out a list of attributes. The panel testers tried different types of Pilsner, wheat beers, Alt beers, black beers and ales in order to determine the descriptive terms for the individual varieties. During testing, the smell and the aroma were described.

From the outset, testers were asked not to use hedonic terms or subjective adjectives like "elegant" or "traditional". In addition, they was asked to specify vague descriptions like "flowery" or "spicy".

The test results of the simple descriptive test were evaluated by determining the empirical distribution of individual attribute characteristics or groups of attribute characteristics [7]. Subsequently a terminology discussion took place where the number of terms was reduced. Similar terms were combined.

Table 2 References

Categories	Term	Used references	Further references
Citrus fruit	Lemon	Natural aroma lemon [A]	
	Grapefruit	Natural aroma grapefruit [A]	
	Orange	Orange aroma [B]	
Berry fruit	Cassis	Cassis aroma [C]	4-Methoxy-2-methyl-2-butanthiol (12)
	Raspberry	Raspberry aroma [B]	4-(4-Hydroxyphenyl)-2-butanon (3)
	Strawberry	Strawberry aroma [A]	Dodecalactone (4)
Pip fruit	Apple	Apple aroma [A]	Ethyl-Hexanoate (12)
	Pear	Pear aroma [D]	Ethyl-2,4-Decadienoat (20)
Tropical fruit	Banana	Banana aroma [C]	Methylamylketon (3)
	Pineapple	Pineapple aroma [A]	
	Mango	Mango aroma [A]	
	Melon	2,6-Dimethyl-5-heptan-1-al (15)	Cis-6-nonenal (4)
Artificial fruit	Pear drop	Isoamylacetat (4)	
Dried fruit	Prune	Prune [E]	
	Confiture	Strawberry jam [F]	Furaneol (4)
Sweet blossoms	Rose	Geraniol (15)	
	Jasmin	Jasmine oil	
	Acacia blossom	Acacia blossom oil	
Savory blossoms	Yarrow	Yarrow-extract [A]	
	Geranium	Chopped geranium	Myrcen (19)
	Lavender	Lavender blossom	Lavender oil
Fresh vegetal	Freshly-cut grass	Cis-3-Hexenol (3)	
	Green walnut shell	Chopped green walnut shell	Green walnut-extract
	Mint	Natural Mint [A]	Menthol (4)
	Onion	Chopped onions	
Cooked vegetal	Cabbage	Dimethyl sulphide (15)	
	Celery	Celery aroma [C]	3-Buthylphthalide (12)
	Tomato	Tomato aroma [C]	Methional (4)
Dried vegetal	Straw	Balsam-resin (4)	
	Cereal	2-Methyl-pyrazene (4)	
	Tabacco	Cigarette tobacco, do not ingest!	
Resinous	Resin	Resin	(E,Z)-1,3,5-Undecatrien and 1,3,5,8-Undecatetraen (2)
	Wood	Oil of cedarwood	
Savory spices	Liquorice	Liquorice candy [G]	
	Black Pepper	Ground black pepper	
	Nutmeg	Ground nutmeg	Oil of nutmeg

Table 2 continued ...

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Sweet spices	Vanilla	Vanilla Flavour natural [A]	Vanillin (15)
	Clove	Eugenol (15)	4-Vinylguajacol (19)
	Anise	Ground anise	Anethol (2)
Nutty	Hazelnut	Chopped hazelnuts	(E)-5-Methyl-2-hepten-4-one (12)
	Marzipan	Benzaldehyde (3)	
Herbage	Thyme	Thyme herb extract [A]	Tymol (3)
	Laurel	Laurel leaves	Laurel leaf oil
Caramelised	Caramel	Butterscotch [H]	3-hydroxy-2-methyl-4-pyrone (4)
	Malt	Pilsner malt [I]	2- and 3-Methylbutanal (12)
	Honey	Summer Flower Honey [J]	Phenylacetaldehyde (12)
	Cocoa	Cocoa [K]	Iso-amylphenyl acetate (4)
Smoky	Smoked bacon	2-Methoxyphenol (15)	
	Leather	6-Isobytylquinoline (15)	
Roasted	Toast	Chocolate roasted malt [I]	
	Coffee	Espresso [L]	
Backed goods	Bread	Breat Crust	
	Yeast	Yeast [M]	
	Gingerbread	Gingerbread spice [N]	
Papery	Cardboard	Trans-2-Nonenal (4)	
Animal	Cat	p-Menthane-8-thiol-3-one (4)	
	Horse sweat	p-cresol (4)	
Lactic	Butter	Diacetyl (15)	
	Lactic acid	D,L-Lactic acid [P]	
Alcoholic	Sherry	Sherry Medium [Q]	Ethanol (15)

[A] Symrise, [B] Omikron, [C] Haya, [D] Unipektin, [E] Seeberger, [F] Schwartau, [G] Haribo, [H] Lonka, [I] Weyermann, [J] Langnese, [K] Bensdrop, [L] Café Libertad, [M] Wieninger, [N] Ostmann, [P] Boehringer, [Q] Sandemann Jerez

To ensure that the terms mentioned were understood universally, references were used in accordance with Table 2.

The sense of smell can be trained using chemical standardised substances, flavourings or foodstuffs. The recognition of flavourings and foodstuffs is easier than that of chemically isolated compounds [3].

The mentioned terms were partly included in smell recognition tests. These helped panel testers to train their sensory memory and allowed testing for attributes that were not recognised and required further training.

3 Results and Discussion

Following the taster sessions, a list of terms was drawn up that was continuously refined. Early on similar terms were arranged into classes to ensure a clear structure. Due to the fact that fruity and flowery descriptions were often mentioned first, these were put on top of the list. The further order in which perceptions were listed differed according to beer style. For Pilsner beer, vegetative impressions came next. The descriptions of fruity notes in wheat beers were followed by biological terms (e.g. yeasty). For Alt beer, attributes relating to warmth were mentioned after the fruity and flowery descriptions. When describing black beer, warm attributes were mentioned first. Attribute characteristics with a relative frequency of less than 1 % were regarded as not relevant.

As a result of the panel's description of several kinds of beers, the panel developed a spectrum of terms for the characterization of odour and aroma of beer. The panellists used aromas of fruits, spices, everyday materials or other foodstuffs to describe their sensory impressions. The terms and their associated sensory perceptions were known as such. These characteristic and easily memorable sensory impressions were given preference to the pure substance, e.g. isoamyl acetate. The terms were categorized hierarchically into 3 classes. Related terms are found in the same class to simplify delineation of certain odours from similar terms. As the panel testers had access to a product range only containing beers without obvious faults, the terminology was amended with attributes from the flavour wheel according to Meilgaard [14]. To describe texture, terminology used by Langstaff et al. [10] for the description of mouthfeel was referred to.

Figure 2 shows the attribute collection for the description of sensory perceptions in beer. For better clarity, the spectrum of terms including its 96 attributes was organized in a wheel. The middle ring of the wheel is divided into 9 areas of different col-

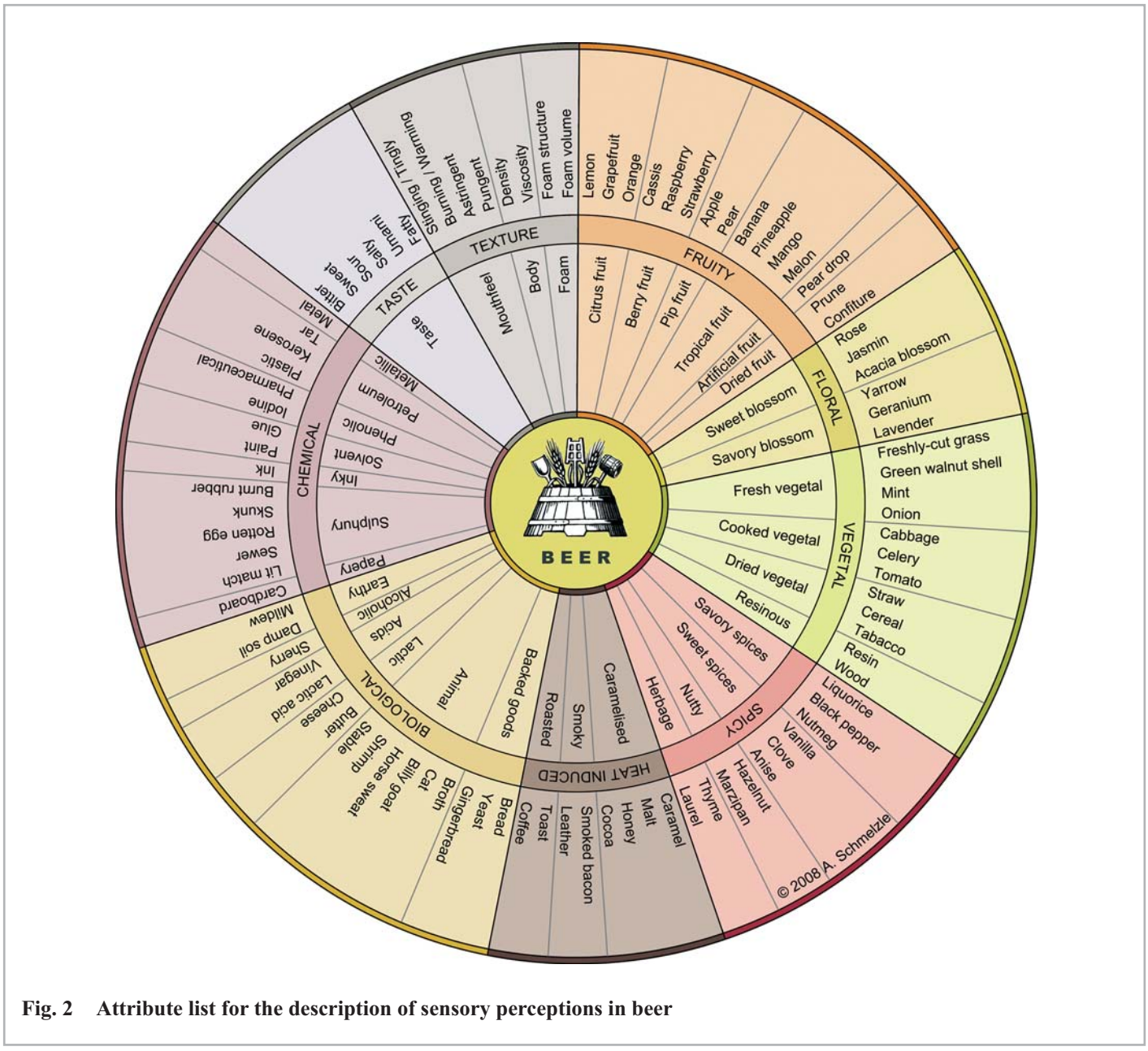

Fig. 2 Attribute list for the description of sensory perceptions in beer

ours and describes the 7 main odour and aroma classes as well as taste and texture. The innermost ring subdivides the 7 main odour and aroma classes into 32 sub-classes. The outer circle lists a detailed differentiation with a total of 96 attributes.

During the description of beers, attention was paid to the language employed. This means that the definition of terms was implemented according to European standards to ensure equal use of language.

Clear disambiguation and definition of attributes in the areas of odour, taste and texture mean that the sensory perception can also be communicated in other areas of beverage development. Aftertaste is clearly described using intensity and persistence.

In order to describe beer texture and in particular mouthfeel, several perceptions are included that stimulate the trigeminal nerve (tingly, warming and astringent). Density and viscosity are used to describe the body of the beer. Sensory impressions caused by foam are described using foam structure and volume.

The attribute wheel can be applied in the communication of sensory perceptions in beer. The user should not feel limited by the given terms. The terminology makes no claim to completeness. For the attribute “apple”, the separation into “green apple” and “ripe apple” can be helpful for descriptive purposes. Clear reference samples are needed to describe any additional terms used.

The terminology of the panellists is based on the assessment of beers that were devoid of obvious faults in odour and aroma. The descriptive test is value-free and no distinction is made between negative and positive attributes. For this reason, the terminology was amended with additional attributes from Meilgaard’s flavour wheel. Nevertheless, where communication with the consumer is concerned, the use of a beer aroma wheel (Fig. 3) without obvious

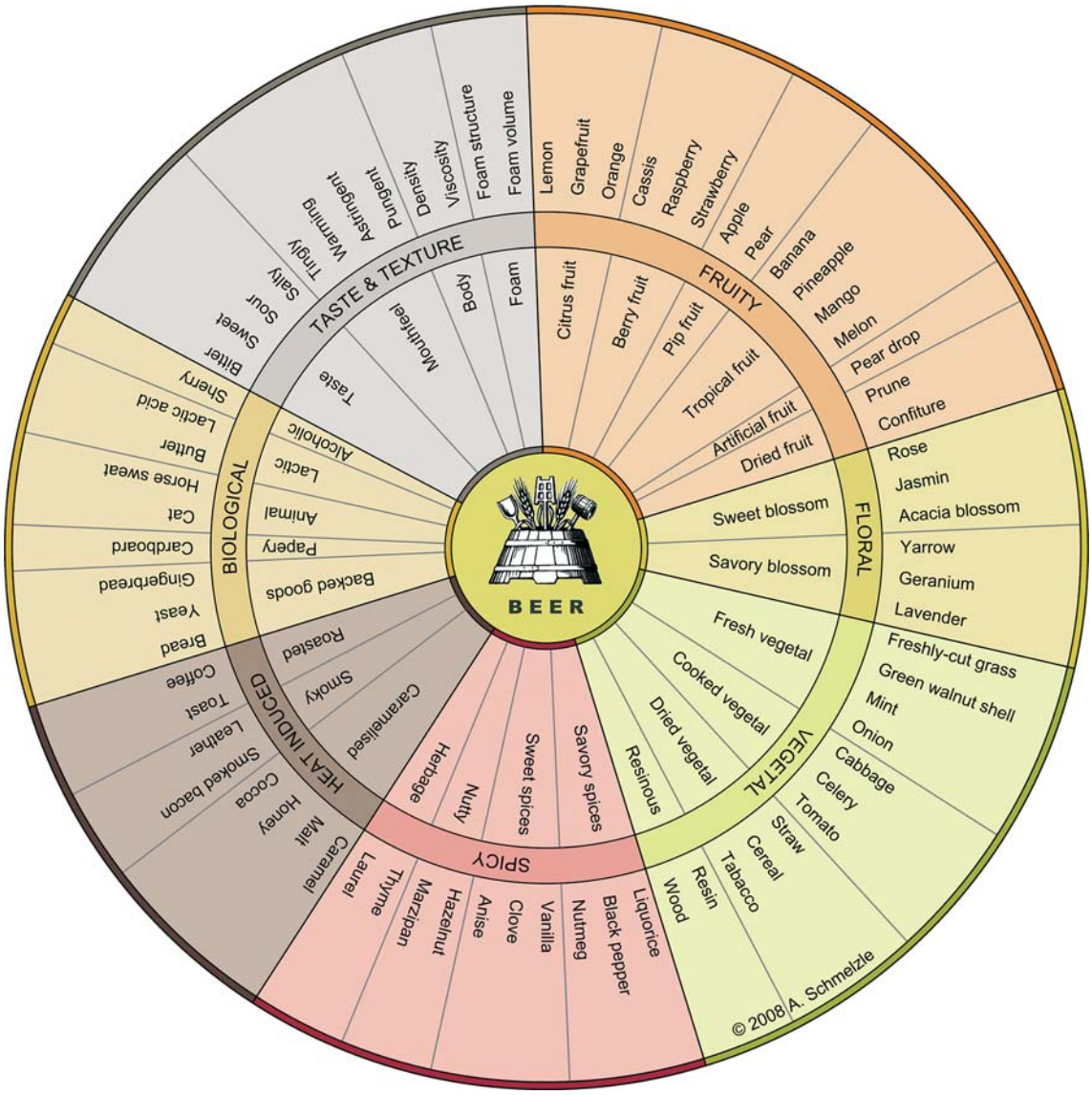

Fig. 3 Beer aroma wheel for communication with the consumer

faults in odour and aroma is more appropriate. Due to the reduced number of attributes, this is clearer to understand and simplifies the description of faultless beers.

4 Conclusion

The aroma wheel offers a sensory language that allows expression of the diversity of beers. In addition, it is at the same time understandable for laymen but also provides experts with a sufficiently large vocabulary. Using comprehensible attributes familiar from daily life allows experts as well as laymen to communicate among and with each other in the same language.

Through clear separation and definition of attributes into the areas smell, taste and texture, the sensory perception can also be communicated in other areas of beverage development.

With this repertoire of precise terms for the characterisation of odour, aroma, taste and trigeminal perceptions, beers can be described in a more differentiated way. The occurrence of a spicy character, for example, can be described via 10 distinct attributes.

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Received 05 January, 2009, accepted 07 February, 2009