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Sensory profiles of cooked grains from wheat species and varieties

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To assess differentiation in the flavour and odour properties of cooked wheat grain by sensory evaluation, 24 wheat samples representing different species, landraces and cultivars of wheat were served to a trained sensory panel. Descriptors were established by trained panellists to describe odour, flavour, appearance and texture attributes. Analysis of variance revealed significant differences in 7 out of 11 odour descriptors, in 7 out of 10 flavour descriptors, in 3 out of 3 appearance descriptors and in 4 out of 4 texture descriptors. A *post-hoc*, Bonferroni *t*-test revealed that many wheat varieties are significantly different from each other in odour and flavour profiles. Using Principal Component analysis, a distribution trend of the wheat samples was observed with ancient wheat species, landraces and older cultivars of bread wheat where dominated by descriptors of oat porridge and bulgur, while more recent cultivars were described by descriptors of wild rice, cooked malt, bitter, cocoa, vanilla, sweet and the Danish speciality "øllebrød". Correlations between sensory descriptors showed that grain darkness and hardness were positively correlated with descriptors for cocoa, cooked malt and øllebrød; meanwhile, bulgur correlated negatively. Bitter flavour positively correlated to dark appearance. These results may be useful to future plant breeding efforts.

1. Introduction

In recent years, flavour parameters of wheat (*Triticum* spp.) have become more important as criteria in consumer selection, as the quality of locally grown cereals have received more attention through modern culinary developments such as in the "New Nordic Cuisine" but also the "New Nordic Diet" (Mithril et al., 2011), in which wheat, in the form of cooked grains, is often used as the staple component of a meal. Cooked durum is widely used for bulgur as a staple food in the Mediterranean area. Up to now, wheat sensory properties have not been systematically included as quality parameters in the selection of new wheat varieties. Wheat is a temperate staple crop of global importance with 684.6 million metric tons produced in 2008–9 (FAO, 2011). As one of the founder crops of the agricultural revolution, wheat has evolved from its wild origins in the Middle East, to domestication over the last 11,000 years (Diamond, 1997). Wheat has evolved during its cultivation history (Reif et al., 2005), undergoing two significant hybridisation events, which ultimately led to the emergence of modern bread wheat (Haudry et al., 2007). Wheat domestication led to a diversity bottleneck (Haudry et al., 2007) which resulted in the evolution of landrace cultivars which were adapted to specific local conditions (Reif et al., 2005). Until the late nineteenth century, most cultivated wheat varieties in northern Europe were landraces (Belderok, 2000). From these landraces the first early selections were made, often by crossing local landraces with a landrace from another area (Lupton, 1987). After the rediscovery of Mendelian laws, in the early 20th century, an increased understanding of genetics resulted in modernized breeding programs across Europe. Wheat breeding focussed on improving yield capacity, disease resistance, stress tolerance and also milling and baking qualities (Belderok, 2000).

Concerns have been expressed that modern selection programs have exasperated the narrowing of the genetic base of newer wheat varieties, as the tendency in wheat breeding has been to propagate further on successful varieties which are genetically related (Tanksley, and McCouch, 1997). Reif et al. (2005) confirmed that this had indeed been the case between the years 1950 and 1989. However, they also reported that there had been a reversal of this tendency, at least for spring wheat, between 1990 and 1997, though only after deliberate intervention by breeders at the International Maize and Wheat Improvement Centre CIMMYT to introduce novel wheat material. The introduction of aroma/flavour quality as a new breeding criterion could possibly contribute towards broadening

Abbreviations: ANOVA, analysis of variance; PCA, Principal Components Analysis.

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genetic diversity of modern bread wheat, by causing future plant breeders to re-evaluate and incorporate novel genetic material. Although little attention has been paid to the importance of wheat flavour, the following steps have already been taken which have laid the foundation of this current work. Czerny and Schieberle (2002) showed significantly higher concentrations of some aroma compounds in whole-meal flour when compared to milled white flour. They isolated several odour-active compounds from the two flour types, and compared them. They then cross-referenced this data with published results of aroma compounds which had previously been isolated in bread crumb. They found that compounds which they had isolated in the wheat flour had also previously been identified as important contributors to the aroma of wheat bread crumb (Grosch and Schieberle, 1997; Schieberle, 1996). This led to their conclusion that wheat flour was an important source of bread odorants and that the type of flour used to make bread should be an influencing factor in the aroma quality of wheat bread. Løje et al. (2003) carried out a sensory test of cooked wheat grains from cultivars of the ancient wheats Einkorn, Emmer, and Spelt wheat as well as a bread wheat cultivar. A difference was reported between the Einkorn samples for the assigned descriptors of maize aroma and maize taste, which characterized these samples. The descriptor "hot oatmeal porridge" was found to be more intense in the Einkorn samples than in the bread wheat variety. The Einkorn samples were also reported as being generally sweeter than the other samples. The results of these previous studies (Czerny and Schieberle, 2002; Løje et al., 2003) suggest that there is a potential for aroma and flavour diversity in wheat. If this is the case, then it could be worth re-evaluating the qualities of older and obsolete varieties and landraces which are currently stored in gene-banks, and compare their flavour characteristics with bread wheat varieties. Up to now, no work has been conducted on the flavour differences among wheat varieties. It would therefore be of great value to systematically investigate wheat species as well as cultivars for their flavour attributes, as a tool to establish any differentiation between varieties, but also in order to understand the potential for production of aromatic, high quality bread wheat in both modern wheat varieties and older landraces. This could provide future breeding programs with the knowledge needed to improve or specialise new varieties or to select or deselect for specific aroma traits.

The objective of this work was to make an assessment of the sensory properties of different wheat varieties with an emphasis on flavour and aroma and to establish methodologies for future work in this area. The results of this study are intended to supplement future instrumental analysis of wheat and bread flavour. Cooked grains were used for the sensory evaluation as they provide the panellists with a wheat sample which has not received any other additions or undergone any other process than cooking.

2. Materials and methods

Cooked whole wheat grains from 24 different wheat samples were served to a trained panel of assessors for sensory evaluation. The samples that were tested were from the ancient wheat species: Einkorn, Emmer, Khorasan and Spelt wheats, as well as from landraces and modern bread wheat varieties.

2.1. Wheat samples

The wheat samples were all cultivated in the same harvest year (2009). The samples were obtained from different sources in northern Europe and were cultivated at different locations in Denmark, Sweden, Germany and the UK. Two of the Danish locations provided multiple samples: 7 samples were grown in the same field from one source in northern Zealand and 4 samples were grown in the same field from the source in northern Jutland. The Swedish source provided 4 samples but it was not possible to confirm that they had been grown in the same field.

The following wheat samples were used for sensory profiling: spelt wheat (Oberkulmer Rotkorn); Emmer, Einkorn and Kamut (Aurion milling and baking company, Denmark); Solstice (Ian Foot – Limagrain UK Ltd); Dragon (Per Kølster, Fuglebjerggård, Denmark); Complet (Saarzucht Firlbeck GmbH & Co., Germany); Extra Squarehead, Goldblume, Halland, Kolben, Purple Justin, Konini and Øland Wheat (Per Grupe, Mørdrupgård A/S, Denmark); Kossack, Kuban, Magnifik and Stava (Tina Henriksson, SW Seeds, Sweden); Kraka (Erik Tybirk, Nordic Seeds, Denmark); Ure (Peer Hummeluhr and descendants, Denmark); Heroldo, Hereward, Tuareg and Vinjett (Lars B. Eriksen, Sejet Plant Breeding, Denmark). Upon receipt, all grain samples were measured for moisture content on an HOH-Express HE90 (Pfeuffer GmbH, Kitzinger, Germany) to ensure that moisture content was less than 14%. This was done to minimise the risk of samples developing mould. The wheat grains were then stored at 5 °C. Information on taxonomy, pedigree and release dates of the tested wheat varieties are presented in Table 1.

2.2. Sample preparation

The grain samples were visually assessed against a white paper background and all visible impurities were removed, 80 g grains were then rinsed three times in cold water to remove any residual impurities before being placed in a 600 ml glass beaker. To the 80 g grain samples, 320 ml ordinary tap water was then added, a ratio of 4:1 for all samples except for Emmer, Spelt and Einkorn wheat to which only 240 ml water was added to 80 g grains, a ratio of 3:1, in accordance with the protocol established by Løje et al. (2003). A Combi-steamer (manufacturer: Conmatic line, Houno, Brønnum) was set to full steam and the temperature was selected to 135 °C. When the selected temperature was reached, the glass beakers containing the samples were placed in the oven.

Optimal cooking times for de-hulled whole wheat kernels were established by Løje et al. (2003). Einkorn and Emmer were cooked for 45 min, whereas Spelt wheat was cooked for 55 min and the remaining bread wheat samples were cooked for one hour and 10 min. The variance in cooking times is due to the variance in grain sizes between varieties. Larger grains needed more cooking than smaller grains to reach an acceptable sensory consistency (*al dente*) at which the cooked grains were firm yet with no hard particles present. These cooking times ensured that the samples all reached this basic texture. After cooking, the excess water was drained from the cooked grain sample and the samples were then placed on ice prior to sensory evaluation.

2.3. Sensory analysis

The cooked whole wheat grain samples were delivered for sensory evaluation in foil-covered 600 ml glass beakers. The cooked grains were portioned out into approx. 35 g samples in FIX PACK, clear round, plastic beakers of 11 cL volume, with lids made from a plastic material which was approved for foodstuffs. The plastic beakers were labelled with a three-digit code. The sample beakers were tempered in a cooled incubator cabinet series KB8000 (Termaks a/s, Bergen, Norway) at 20 °C for 1½ h before serving. All evaluations took place in a sensory evaluation laboratory, which was equipped after ISO guidelines (ISO 8589:2007). One booth was assigned to each assessor, there was air extraction in each booth, each booth had an independent light source and the ambient temperature in each booth was 22 °C. The panel consisted of 10 experienced assessors (three men and seven women between the ages of 21 and 39 years). The assessors were subjected to a screening