



## Review

## Sensory characteristics of wholegrain and bran-rich cereal foods – A review



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## ABSTRACT

**Background:** Wholegrain foods are known to be health-beneficial but their sensory characteristics may be a limiting factor for consumption. The scientific literature of factors influencing sensory quality of wholegrain foods is rather scarce.

**Scope and approach:** Many cereals like rye, oats, barley and sorghum are actually used mainly as wholegrain, whereas for wheat the situation is the opposite. This review deals with factors that differentiate the sensory properties of wholegrain and bran-rich foods from those of refined cereal foods.

**Key findings and conclusions:** Wholegrain and bran contain flavour-active compounds, flavour precursors and resistant cell wall structures causing changes in flavour and texture during processing. In wholegrain foods, different chemical constituents contribute to bitterness. Increased knowledge on flavour formation has led to the possibility to not only measure but actually also design the flavour. Structure and texture are also important determinants underlying eating quality and stability of cereal foods. Hitherto established means of modulating sensory quality and thus improving acceptability of wholegrain foods are presented.

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## 1. Introduction

Cereal grains are a major energy source globally. In Europe, wheat is the most commonly used of all grains. While bread and pasta are elementary parts of the daily diet, the consumption of biscuits, breakfast cereals and snacks is increasing. In the past, cereal foods were based on wholegrain flour. In the 1900s', industrialization brought along development of the milling industry, which led to increased production of refined white flour and separation of the outer bran layers of the kernel mainly to be used as animal feed or biofuel. This refining, driven by facilitated

processing, food safety and consumer preferences for white flour, was accompanied by a decrease in intake of dietary fibre (DF) and nutrients present in the wholegrain (Slavin, 2000). In the Western world, due to growing prosperity and abundant availability of food, white wheat flour became the standard raw material for the wheat based cereal industry, leading to product and process development of refined wheat products. In addition to improving public health, utilisation of wholegrains for human food would also contribute to food security and sustainable food production.

Since the 1970s' there has been a growing understanding of the importance of sufficient DF in the human diet. This led to the current wide recognition of the nutritional significance and health benefits of using wholegrain vs. refined grain. Consumption of foods containing wholegrain and especially cereal DF has in numerous epidemiological studies been shown to reduce the risk of

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chronic diseases (Ye, Chacko, Chou, Kugizaki, & Liu, 2012), and dietary recommendations in different parts of the world urge to eat more of this kind of foods. However, even though the offering of wholegrain foods is increasing, there is a huge gap between recommendations and intake. This can mainly be attributed to the sensory characteristics vs. consumer expectations. Less than 10% of the US population was reported to consume the recommended three servings per day in 2000 (Cleveland, Moshfegh, Albertson, & Goldman, 2000). In UK, only 3% of adult respondents met the US recommendations of 3–5 servings/day (Lang & Jebb, 2003), and 27% of them were consuming no wholegrain at all (Thane, Jones, Stephen, Seal, & Jebb, 2005).

Identification of factors underlying flavour and texture formation helps to improve the sensory attributes of cereal products containing wholegrain or bran, and thus contributes to healthier and more sustainable diets. This paper reviews progress in this area, as well as processing techniques which can be utilised to enhance the sensory characteristics and acceptability of wholegrain cereal products.

## 2. Consumer perception of wholesome cereal products

Foods with health benefits need to have high sensory acceptance in order to be chosen and eaten, and it is of great importance to identify causes of sensory concerns in wholegrain foods. In addition to sensory product properties, extrinsic properties such as packaging, product information, claims etc. influence the acceptance of a product. Preferences for the sensory attributes found in refined bread are often stated as the reason for the relatively low consumption of whole wheat bread and other wholegrain cereal foods. Hersleth, Berggren, Westad, and Martens (2005) showed that texture attributes in bread are important for consumers' sensory perception, and Heenan, Dufour, Hamid, Harvey, and Delahunty (2008) demonstrated that odour and flavour attributes are positive drivers of bread freshness. Bakke and Vickers (2007) conducted an acceptance test including nine different breads chosen to represent comparisons between equivalent refined and whole wheat breads, and concluded that sensory preferences may be a barrier to whole wheat bread consumption, but ingredient or processing modifications can improve liking of such products. Arvola et al. (2007) suggested that making more wholegrain foods available with sensory characteristics comparable to refined grain foods would be a good strategy to promote wholegrain food consumption. Moreover, traditional bread consumption is changing among young consumers from home use towards fast food bread and bread consumed outside home (Sandvik, Kihlberg, Lindroos, Marklinder, & Nydahl, 2014). Thus, there is a current need to develop new appealing product concepts as well as tailored communication strategies focused towards younger consumers. Nudging has recently been studied as a tool to influence healthy food choice by affecting unconscious behavioural processes. Van Kleef, Vrijhof, Polet, Vingerhoeds, and de Wijk (2014) provided school children with bread in regular or funny shapes. Their intervention study showed that whole wheat bread consumption doubled when presented as fun-shaped products, demonstrating that visual appeal can stimulate wholegrain consumption.

Health information of cereal products induces sensory and hedonic expectations, and it is important that these expectations are fulfilled during consumption (Di Monaco, Cavella, Di Marzo, & Masi, 2004). Consumers' beliefs and expectations of healthy cereal products have been widely studied lately (Arvola et al., 2007; Dean et al., 2007; Saba et al., 2010; Shepherd et al., 2012), as well as the motivational factors underpinning consumers' understanding of health claims (Dean et al., 2012). Dean et al. (2007) showed that nutritional improvements of staple foods were perceived as more

beneficial for health than those of fun foods, e.g. pizza, biscuits. Arvola et al. (2007) concluded that consumers generally seem to regard cereal products as good for their health. However, the awareness of wholegrain products being healthier for you than refined grain products varied between consumer groups. Country-wise differences in perception of health-related messages in cereal based food products were demonstrated in Saba et al. (2010) and Shepherd et al. (2012).

Schaffer-Lequart et al. (2015) reviewed the current use and challenges of wholegrain in manufactured foods, as well as possibilities to increase the intake. However, their paper did not discuss sensory characteristics of wholegrain products. Consumers' acceptance of wholegrain foods was also recently reported by Kuznesof et al. (2012), who identified that barriers for sufficient intake included taste preferences of the family, cooking skills, price and availability of wholegrain foods. Participants' self-reported benefits of eating wholegrain foods included perceived naturalness, high fibre content, superior taste, improved satiety and increased energy levels. There is clearly a need to take the variation between different cultures, traditions and eating habits into account when introducing healthy cereal based products to the market. In any case sensory appeal remains a key food choice factor.

## 3. Flavour-active compounds in wholegrains

Cereal grains each have their characteristic flavour profiles and precursors, even though the flavour of native, untreated grains is mild and bland (Heiniö, 2014). The flavour and texture of cereal foods are mostly formed during processing due to process-induced changes in the grain biopolymers and flavour-active compounds (Fig. 1). White wheat flour furnishes a small amount of volatile compounds and aroma precursors, and their contribution to bread flavour is estimated to be small (Drapron and Molard, 1979). In wholegrain wheat flour, the amount of volatile compounds as well as amino acids is considerably higher (Czerny & Schieberle, 2002). Fermentation and baking are the main sources of flavour of wheat bread, and both steps are essential (Hansen & Schieberle, 2005). Volatile compounds are generated from previous precursors

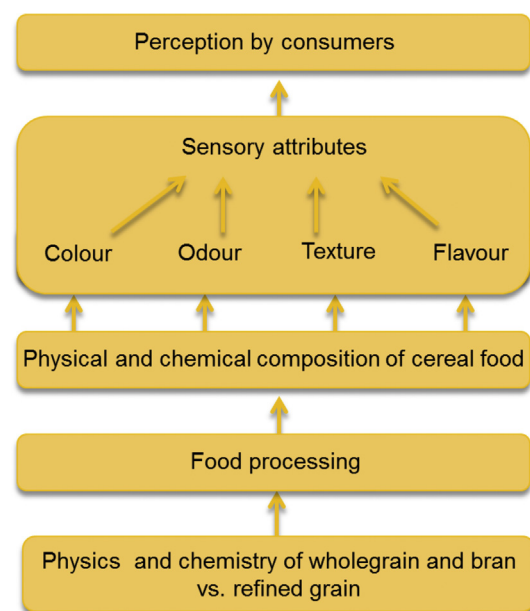


Fig. 1. Formation of sensory attributes as interplay of raw materials and processing conditions.

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