



## Review

## Wheat bread aroma compounds in crumb and crust: A review

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## ABSTRACT

Bread is one of the most widely consumed foods in the world. Among the different properties that define its quality, the aroma of bread is considered essential to its approval by consumers. Knowing what the compounds found in bread are, as well as the most important ones in crumb and crust, and understanding their biological sources and how they affect the final aroma of bread, could make it possible to modify the steps of bread manufacturing in order to enhance those with a positive impact and reduce those with a negative impact. The aim of this review is to provide a guideline correlating a great deal of the information now available regarding wheat bread aroma. For this purpose, a total of 326 volatile compounds reported in the literature have been included. The sensorial correlation of these compounds with the final aroma of wheat bread has also been explained, as well as the biological sources that generate them. Finally, it is shown how modifying the production stages of wheat bread could also affect the odour quality.

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Abbreviations: FD, flavour dilution factor; LABs, lactic acid bacteria; OAV, odour activity value; WHO, World Health Organisation; WWF, whole wheat flour; RWF, refined wheat flour.

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## 1. Introduction

Baking of bread is one of the oldest of human activities. It is not possible to talk about human history without making reference to bread and wheat (Edwards, 2007). Bread is, simply, a mix of flour, water, yeast and sodium chloride, with or without butter, in the right proportions, kneaded, fermented and baked in an oven. The WHO recommends consumption of 250 g of bread per person per day. Consumption, however, depends on the country. Baked products are, therefore, one of the most widely consumed foods in the world, with an annual worldwide consumption of bread of over 9 billion kg (20 billion lb) (Cho & Peterson, 2010). The quality of bread is normally defined according to its volume, texture, colour and flavour (the sum of the gustative and olfactory impressions experienced during eating (Guinet & Godon, 1996)). Among these fundamental properties, the aroma of bread plays a key role in its acceptance by consumers (Paraskevopoulou, Chrysanthou, & Koutidou, 2012). Aroma is one of the first characteristics

perceived by customers by their olfactory sense when bread is bought. Olfactory perception is divided into two groups of stimulations: everything that can be perceived directly with the nose when the food is near and everything experienced retronasally during chewing. In both cases, volatile compounds must, without the help of a liquid phase, reach the recipient cells of the olfactory mucous located deep in the nasal cavity, where these olfactory cells are connected with the brain to discriminate the perceived aroma (Guinet & Godon, 1996).

There is a large list of volatile compounds reported in wheat bread, including alcohols, aldehydes, esters, ethers, ketones, acids, hydrocarbons, pyrazines, pyrrolines, furans, lactones or sulphur compounds (Paraskevopoulou et al., 2012; Poinot et al., 2007). These volatile compounds may originate from the crumb, crust or both. In the crumb, the volatile fraction is engendered by enzymatic reactions during dough kneading (Guinet & Godon, 1996) and, principally, during the fermentation of dough sugars by yeasts and lactic acid bacteria (LABs) (Bianchi, Careri, Chiavaro, Musci, & Vittadini, 2008; Birch, Petersen, Arneborg, &

**Table 1**

Volatile alcohols found in wheat bread (crumb and/or crust) reported in literature their typical odours. Volatile compounds are in descending order by times cited.

Alcohols	Crumb/crust	Odour	References
3-Methyl-1-butanol (isoamyl alcohol)	Crumb, crust	Balsamic, alcoholic, malty	a, b, d, e, f, g, j, k, m, n, o, p, q, r, t, u, v, w, x, y, z, aa, a c, af, ag, aj, ak, al
Ethanol	Crumb, crust	Alcoholic	b, e, f, g, j, k, m, n, o, p, r, t, u, v, w, x, y, z, af, ah, ak
2-Methyl-1-propanol (isobutyl alcohol)	Crumb, crust	Glue, alcoholic, wine-like, malty	a, b, d, e, f, g, j, k, m, n, o, p, t, v, w, x, y, z, ac, af
1-Hexanol	Crumb, crust	Green grass, flowery, woody, mild, sweet	a, b, d, e, g, j, k, m, n, r, t, v, w, x, y, z, af, aj, ak
1-Pentanol	Crumb	Balsamic, fruity, fusel-like sweet	a, b, d, e, f, j, k, n, o, t, v, x, z, af, ak
1-Propanol	Crumb	Fruity, alcoholic, plastic, pungent	a, b, d, e, f, g, j, n, o, p, w, x, z, af, ak
2-Phenylethanol	Crumb, crust	Flowery, yeast-like, honey	a, d, h, k, n, v, x, y, aa, ae, af, ag, al
2-Methyl-1-butanol	Crumb, crust	Malty	b, e, f, j, n, t, w, x, z, af, ag, al
1-Butanol	Crumb	Fruity, solvent	a, b, d, e, k, n, o, x, af
1-Octanol	Crumb, crust	Earthy, mouldy vegetable	a, b, d, e, k, m, t, v, z
1-Heptanol	Crumb	Green	a, b, d, e, k, t, v, z, al
Benzyl alcohol	Crumb	Pleasant aromatic	k, m, n, s, t, v, y, af, ah
1-Octen-3-ol	Crumb, crust	Mushroom-like	d, f, j, k, t, v, x
3-Nonen-1-ol	Crumb	Waxy	d, m, s, t, v
2-Methoxy-4 vinylphenol (4-Vinylguaiaicol)	Crumb	Spicy	i, s, t, ae, ai
Phenylethyl alcohol	Crumb, crust	Rose-honey-like, wilted rose	f, g, s, t
Phenylethanol	Crumb, crust	Flowery	m, t, ah
2-Ethyl-1-hexanol	Crumb, crust	Green, vegetable	a, d, t
2,3-Butanediol	<sup>b</sup> Bread	Neutral smelling	f, n, x
1-Nonanol	Crumb, crust	Citrus	t, v, av
Phenol	Crumb, crust	Sweet and tarry	t, v, ac
1-Penten-3-ol	Crumb	Burnt, butter, grass, green, slightly meaty	d, x, al
2-Octen-1-ol	Crumb	Green, vegetable-like	a, t
2-Penten-1-ol	Crumb	Green type	a, d
3-Methyl-3-buten-1-ol	Crumb	Fruity, green	a, d
2-Butanol	Crumb	Alcoholic	b, e
2-Hexanol	Crumb	Winey type	b, e
2-Hexenol	Crumb	Green type	b, e
Decanol	Crumb, crust	Fatty type	s, ac
3-Hexenol	Crumb	Grassy-green	d, u
3-Pentanol	Crumb	Herbal type	n
2-Ethyl-1-decanol	<sup>b</sup> Bread	Citrus type	m, ah
3-(Methylthio)-1-propanol	Crumb (traces)	Potato	ag
2-Ethyl-1-ethanol	Crumb, crust	Green, vegetable	v
Guaiacol	Crumb, crust	Soapy, sweet, burnt	ai
3-Ethoxy-1-propanol	Crumb, crust	Fruit	j
Geosmin	<sup>b</sup> Bread	Musty	ad
4-Decen-1-ol	Crumb	Green odour	t
5-Methyl-2-furanmethanol	Crust	Honey, sweet	t
3-Decen-1-ol	Crumb	<sup>a</sup> nf	v
2-Propanol	Crumb	Pungent smell	n
2-Pentanol	Crumb	Fermented type	n
2-Cyclohexenol	<sup>b</sup> Bread	<sup>a</sup> nf	s
2-Heptanol	<sup>b</sup> Bread	Citrus type	k
4-Methyl-4-nonenol	<sup>b</sup> Bread	<sup>a</sup> nf	k
2-Nonen-1-ol	<sup>b</sup> Bread	Waxy melon	m
1-Methoxy-2-propanol	<sup>b</sup> Bread	Mild ether odour	x
2-Undecanol	<sup>b</sup> Bread	Fruity type	m
2,4-Bis(1,1-dimethylethyl)phenol	<sup>b</sup> Bread	Weak aromatic	s
1-Dodecanol	Crumb	Waxy type	d
Nitrobenzol	Crumb, crust	Bitter almond	ac

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