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Review

Sourdough volatile compounds and their contribution to bread: A review

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ABSTRACT

Background: Sourdough has been used in **bread** production for decades to improve its preservation, texture and flavor. Today it is mostly used as a bread flavor improver. For many years, bread volatile compounds have been referenced and more than 540 have now been reported. In contrast, sourdough volatile compounds have been less studied. No listing of these compounds has been previously carried out and their origins have not been reported in a review.
Scope and Approach: The scope of this review is to detail the volatile compounds previously reported in sourdough and sourdough bread in order to highlight the most common ones. Methods for studying volatiles in sourdough and sourdough bread are first listed. Then the volatile compounds identified from previous papers about sourdough aroma are characterized to understand their origins and their contribution to bread aroma.
Key Findings and Conclusions: According to this review, the main extraction technique applied to sourdough and sourdough bread is headspace solid-phase micro-extraction. To date, 196 volatile compounds have been reported in sourdough and sourdough bread including 43 aldehydes, 35 alcohols, 33 esters, 19 ketones, 14 acids, 13 furans, 11 pyrazines, 2 lactones, 2 sulfurs, 21 others and alkanes. The most recent characteristics of most of these volatile compounds (origins, odors and odor thresholds) are reported as well as their presence in sourdough, sourdough bread or bread. This report underlines the production levers that could modify sourdough and bread aroma.

1. Introduction

Sourdough is a mixture of flour and water that is fermented using yeast and lactic acid bacteria (LAB). Sourdough has been used in bread production for dough leavening (Roussel & Chiron, 2002), but it also extends shelf life, improves nutritional properties, increases bioactive compound contents and makes bread flavor better (Banu, Vasilean, & Aprodu, 2011; De Vuyst et al., 2013; Gänzle & Gobbetti, 2013). Today, sourdough is mainly used as an aroma improver and to confer typicality on wheat and rye breads. Flavor, as a combination of smell and taste, is undoubtedly the most important attribute determining consumption (Hansen & Schieberle, 2005). Smell is characterized by volatile compounds with different olfactory characteristics while taste is due to aromatic and sapid compounds. Volatile compounds have been extensively studied in bread products and more than 540 volatiles have been reported in different papers (Quílez et al., 2006; Pico, Bernal, & Gomez, 2015). Reviews on bread aroma have previously been published by Cho and Peterson (2010), Grosch & Schieberle (1991, 1997), Maga (1974, p. 1978), Pico et al. (2015), Pozo-Bayon, Guichard, and Cayo (2006), Rothe (1974) and Schieberle (1996). In contrast, sourdough has generally been studied in terms of its microflora diversity or its textural and sensory effects on bread (Charmaine & Arendt, 2005; Chavan & Chavan, 2011; Corsetti & Settanni, 2007; De Vuyst & Neysens, 2005). Sourdough volatile compounds have been less studied than those of bread and no recent review has included the diversity of volatiles in sourdough or sourdough bread (SD-bread). To our knowledge, the latest review on sourdough aroma was published by Hansen & Schieberle, 2005. Therefore, the aim of this paper is to review sourdough volatile compounds, including their possible origins, odor, and contribution to bread aroma, as well as the most recent methods for studying them.

Sourdough is a complex ecosystem in which lactic acid bacteria

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(LAB) and yeast interact together and with the ingredients depending on the process parameters (Zotta, Piraino, Ricciardi, McSweeney, & Parente, 2006). In addition to flour and water, some extra ingredients can be added to boost the microflora fermentation such as sugar or enzymes. Depending on the proportion of these ingredients and on the bread process parameters (fermentation and baking), SD-bread has a specific volatile profile. The proportion of sourdough added in SD-bread is a major factor influencing the bread volatile profile. Spontaneous and inoculated sourdough can also be distinguished. In spontaneous sourdough, fermentation is due to wild flour microflora, which is well adapted to this ecosystem and evolves during fermentation, while in inoculated sourdough selected starters are added to the mixture. The spontaneous sourdoughs are generally specific to a region because LAB and yeast species depend on ecological factors (De Vuyst & Neysens, 2005). In spontaneous sourdoughs, alcohols from yeast fermentation occur in greater concentrations compared to those in inoculated sourdoughs (Hansen & Lund, 1987). Temperature, time and the number of backsloppings influence the yeast and lactic acid bacteria (LAB) fermentations and lipid oxidation and hence the volatile profile of sourdough. Clearly, the sourdough volatile profile influences that of SD-bread and thus its sensory properties. In recent sourdough development, it has been dried to obtain a specific aroma (Brandt, 2007). Many factors impact the sensory properties of sourdough bread. The effects on volatile compounds and the sensory profile variation of sourdough and SD-bread production parameters are described in Fig. 1.

The evaluation of the volatile compound profile requires the extraction, identification and quantification of the compounds. To explain the sensory evaluation, gas-chromatography-olfactometry (GC-O) (also named “GC-sniffing”) is generally used to identify volatile compound odors. These results are then compared to sensory evaluation to understand the impact of all the parameters on bread sensory properties.

The objectives of this review are: to name all the volatile compounds reported in wheat sourdough, rye sourdough and sourdough breads, to list their origin and to understand the variation levers in their processing. The volatile compound extraction methods used for sourdough and SD-bread evaluation and the associated identification and quantification methods are also listed and compared. This approach is descriptive and also aimed to identify the origin of the volatile compounds. Lastly, the impacts of these volatile compounds on SD-bread aroma and its sensory characteristics are described.

2. Methods for studying volatiles in sourdough and sourdough bread

Preliminary isolation remains an essential step in such extraction procedures despite rapid developments in measurement techniques. Depending on the study objectives, different extraction methods are used. Each one has some advantages and some limitations and extracts preferentially one kind of volatile. According to 28 studies on bread, SD-bread and sourdough (Table 1), 3 major extraction methods are used: solvent extraction, purge and trap, and headspace solid-phase microextraction.

2.1. Extraction methods based on solvent affinity

The first extraction methods were vacuum distillation and solvent extraction. In this kind of method, solvents are used to extract volatile compounds from the matrix (Grosch, 2007; Prost, Poinot, Rannou, & Arvisenet, 2012). This method is based on the diffusion of volatiles from the food matrix to the solvent and thus the extracted volatiles have a high affinity for the solvent used. This method enables the extraction of a large variety of volatile compounds (Side, Robards, & Helliwell, 2000) but has some limitations. Firstly, the solvent can limit the identification of volatile compounds and secondly, solvent elimination requires a heating process that can lead to thermal decomposition artifacts (Side et al., 2000). Solvent extraction has notably been used for the extraction of bread volatiles by Frasse et al. (1992), Schieberle & Grosch (1994), Gassenmeier and Schieberle (1995) and Zehentbauer and Grosch (1998) and for sourdoughs by Hansen et al. (1989) and Hansen & Hansen (1994). Today, solvent extraction methods are less used due to their constraints and limitations.

2.2. Extraction methods based on compound volatility

Headspace extraction methods have been developed to avoid the drawbacks of the solvent method. In this case, the gaseous phase above the product is collected and hence the volatile compounds collected are more likely to represent the odor perceived by the consumer (Grosch, 2007; Prost et al., 2012). Although headspace samples are generally cleaner, they contain fewer compounds than those obtained by solvent extraction (Side et al., 2000). These solvent-free methods also enable volatile compound odors to be studied directly. Dynamic and static methods are available.

In static extraction, the sample is placed in a hermetic vial until

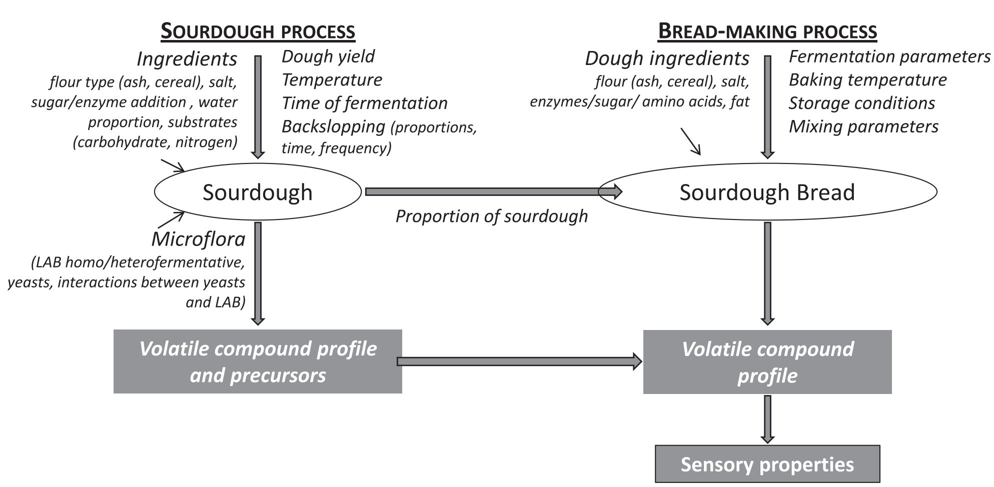

Fig. 1. Sourdough and sourdough-bread volatile compounds: variations in parameters.