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Effect of different combined mechanical and thermal treatments on the volatile fingerprint of a mixed tomato–carrot system

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A B S T R A C T

The effect of volatile profiles of a mixed vegetable puree comprised of tomato and carrot due to different thermo-mechanical process conditions has been thoroughly investigated using an untargeted GC–MS chemical fingerprinting approach. This resulted in a selection of discriminative marker volatile compounds in mixed vegetable puree, which acting as the witness of the process footprint and can therefore be related to the quality changes like micro-structure, heat distribution, etc. Moreover, when individual component, in a mixed vegetable system, are processed together ('all-in-one processed') vis-a-vis processed separately and then mixed together ('split-stream processed') different extent of chemical and enzymatic reactions can potentially induce change in volatile profiles. This work showed the potential of different process types to generate distinct headspace profiles of a mixed tomato–carrot system. This consciousness can be a starting point for more targeted tailoring of the flavour of mixed tomato–carrot products.

1. Introduction

Led by the consumer demand, the food industry has shown an increased interest in the production of healthier, more tasty and more natural fruit- and vegetable-based food products, such as drinks, soups and sauces. Carrot and tomato are frequently used in these vegetable-based applications (Patras et al., 2009). Looking to the vegetable-based food portfolio, most of them are mixed ingredient systems. However, in literature the effect of processing (both mechanical as well as thermal) has mostly been studied on single ingredient system. Hence, understanding the influence of processing on mixed vegetable systems might help to design food products with improved quality parameters.

Thermal processing of foods is typically used to inactivate microorganisms and/or enzymes to a targeted level in order to increase the product stability (Awuah et al., 2007). For producing homogenised food systems (e.g. vegetable puree), different combinations of unit operations like heating, shear, etc. are applied. The effect of varied process conditions can be envisioned as comparing (a) different process parameters e.g. temperature, pressure, etc. and/or (b) different sequences of unit operations. The thermo-mechanical process applied in current study consists of two unit operations – thermal treatment and shear. The process sequence where vegetables were first undergo mechanical shear and then further heated was termed, in the current study, as 'cold break' (CB), having the aim to break the plant tissue under cold condition. Similarly, when vegetables were first heated and then submitted to mechanical shear, the aim was to break the tissue under hot condition which was termed, in current study, as 'hot break' (HB). Such order of thermal and mechanical treatments has been described as to influence microstructures with different flow properties in tomato and carrot purees (Lopez-Sanchez et al., 2011) without providing any insight about the effect on volatile profile in a mixed vegetable system.

In literature, mainly two analytical approaches have been explored and reported to compare the quality of products as a function of processing conditions ranging from single response/univariate to multi-response/multivariate and from targeted to untargeted volatile measurements (Charve et al., 2011; Charve and Reineccius, 2010; De Vos et al., 2010; Hiller et al., 2009; Kebede et al., 2013a; Kim et al., 2012; Oey et al., 2008; Tikunov et al., 2005; Wang et al., 2008). In the targeted approach, one or more specific volatile compounds were selected, based on a

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previously performed key compounds analysis, and their quantitative change as a function of processing parameters was evaluated. On the other hand, the aim of an untargeted approach was to measure the comprehensive profile of volatile entities of a particular food matrix, without any prior bias and then combined with appropriate multivariate data analysis to perform qualitative screening (also called fingerprinting) in order to exclusively compare and classify difference between samples (Grauwet et al., 2014; Kebede et al., 2014; Nicolotti et al., 2013; Vervoort et al., 2012). Such fingerprinting approach resulted into a selection of discriminative markers comprised of volatile compounds which were clearly different in concentration from one sample to the other. These were further identified and could potentially link to process parameters or particular food characteristics. The advantage of untargeted volatile analysis is to enable more holistic and unbiased analysis of samples, thereby taking account of comprehensive information comprising both unknown and known (volatile) compounds without being restricted to prior knowledge (De Vos et al., 2010). In that sense, untargeted volatile analysis compared to the targeted approach is more exploratory than hypothesis driven.

Although literature showed changes in volatile profile of single vegetables as a function of process parameters like temperature or pressure (Kebede et al., 2014; Vervoort et al., 2012), to the best of our knowledge, there is no report evaluating impact of GC–MS based fingerprinting of mixed vegetables system as a function of process sequence variation. Typical industrial products consist of processed mixed vegetable which can effectively bring added complexity in their combined volatile profile due to the interaction between components. Thus, the general objective of this paper was to study the effect of different thermo-mechanical process sequences on the volatile profile of the mixed vegetable puree comprised of tomato and carrot. Many of these compounds are known to be common end-products of process-induced chemical reactions (e.g. Maillard reaction or lipid oxidation) as well as secondary end products of various biochemical pathways impacting aroma of raw vegetables. Thus, any change of these volatiles can be a witness of the process footprint in relation to concomitant quality change in a mixed vegetable system.

2. Materials and methods

2.1. Materials

Frozen tomato (*Solanum lycopersicum*, var. *Arvento*) and carrot (*Daucus carota*, var. *Winterpeen*) cut into standardized small cubes (0.4–0.6 cm) were purchased from Ardo (Zundert, The Netherlands). The same batch of each vegetable was used for the preparation of all samples studied in this paper. The vegetables were transported and stored at −20 °C until processing. Carrot cubes were blanched by the supplier (no enzyme activity found when checked) but tomato cubes were not blanched. Before experiments, the cubes were thawed overnight at +4 °C.

2.2. Sample preparation

As described before, in the present study, the term 'cold break' (CB) is used when thawed vegetables cubes were applied shear (i.e. blended) and then heated, whereas in 'hot break' (HB) similar cubes were first heated then applied shear (i.e. blended). The detailed parameters of the 'blending step' and the 'heating step' are discussed below and such process steps were performed in a closed system using a Thermomix (Vorwek, Wuppertal, Germany).

30% deionized water was added to the thawed vegetable cubes before processing steps. In the blending step, the vegetable system was blended at high speed (8000 rpm) for 10 min with 1 min interval for every 1 min of blending. The interval was needed to prevent heating of the system. In the heating step, the vegetable system was first heated up for 10 min until the temperature of 90 °C was reached. Then heating continued at 90 °C for 10 min. During the heating, the samples were gently stirred (40 rpm) to promote uniform heat transfer. During this processing, the temperature was externally monitored by the use of a digital sensor. In total, as schematically represented in Fig. 1, six different tomato–carrot mixes were prepared with varying processing conditions. In case of mix_1 and mix_2, the same amounts of tomato and carrot (1:1) were mixed together after which; they were treated within a HB or CB process, respectively (called all-in-one processing, Fig. 1).

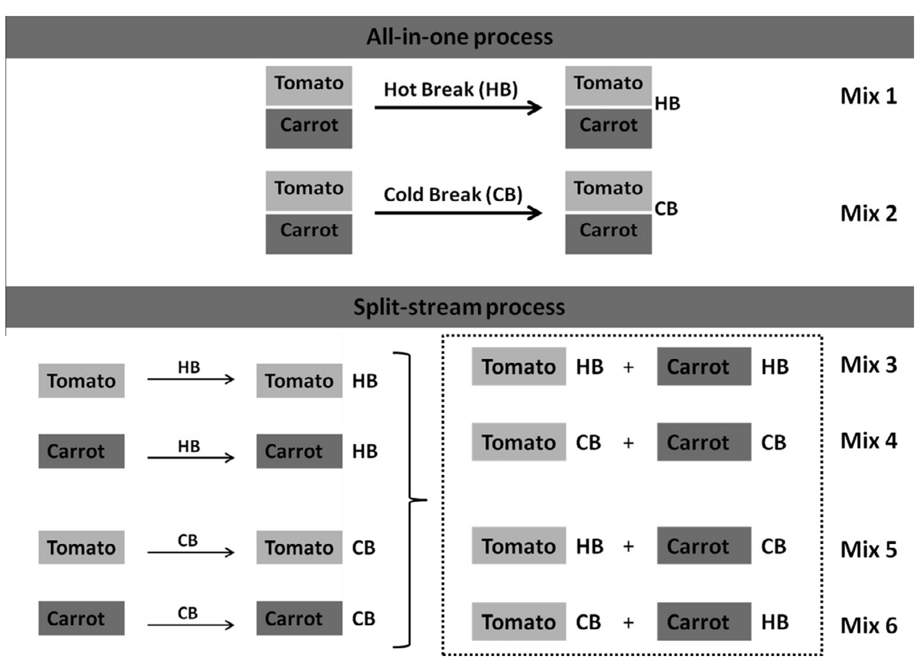

Fig. 1. Schematic overview of sample preparation. In mix_1 and mix_2, vegetables were mixed first and then processed together (i.e. all-in-one processing). In mix_3 – mix_6, single vegetables were processed individually and then mixed together (i.e. split-stream processing).