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Could cider aroma modify cider mouthfeel properties?

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ABSTRACT

The objective of this work was to evaluate whether aroma–taste interactions could occur in cider due to cognitive interactions such as a dumping effect or a congruency phenomenon. Sixteen French ciders were selected with different organoleptic characteristics. Three different tasting conditions were compared in order to evaluate the presence of aroma interactions with taste. A trained panel was first asked to assess ciders, with and without a nose clip, on four attributes: sweetness, sourness, bitterness and astringency. Secondly, they had to score the same four attributes with seven aroma attributes added. It was shown that the perception of sweetness and astringency was modified in the presence of aroma. Ciders with fruity and caramel aromatic notes were perceived sweeter contrary to ciders with hay, animal and earthy notes, which were perceived less sweet. Moreover, the aroma interaction with sweetness was sugar concentration-dependent. It occurred only in cider containing around 40 g/L of sugar. Finally, ciders were perceived more astringent when tasted without wearing a nose clip.

1. Introduction

Cider is a slightly alcoholic beverage resulting from the fermentation of apple must. The main chemical constituents are water, ethanol, sugars (principally fructose), organic acids (principally malic acid), polyphenols and aromatic compounds (Lea & Drilleau, 2003). Mastering the quality and the regularity of production needs a better understanding of the way cider components interact to construct the final sensory characteristics of cider flavor. Although the interactions in this matrix between sugars, acids, ethanol and procyanidins impacting sweetness, sourness, bitterness and astringency are documented (Lea & Arnold, 1978; Symoneaux, Baron, Marnet, Bauduin, & Chollet, 2014; Symoneaux, Chollet, Bauduin, Le Quéré, & Baron, 2014), the impact of the aromatic fraction on cider taste has not been reported in the literature.

Interactions between taste and aroma are mainly investigated in model solutions, as reviewed by Poinot, Arvisenet, Ledauphin, Gaillard, and Prost (2013). Fewer works are dedicated to this topic in real food products and beverages. Model solutions are preferred because they are easier to parameter, even though some authors have concluded that these interactions are matrix– and concentration-dependent. This means that if producers want to understand the consumer perception of their products better, they need to study their own sensory product space to confirm whether such interactions occur.

There is some evidence that aroma can modify taste by physicochemical and cognitive interactions, including the dumping effect and congruency (Keast & Breslin, 2003; Valentin, Chrea, & Nguyen, 2006). Although gustation and olfaction are two anatomically and physiologically different entities, numerous examples indicate strong interactions between both inputs at the perceptual level (Delwiche, 2004; Lim, Fujimaru, & Linscott, 2014). Therefore, a taste could be perceived more intense if presented simultaneously with a congruent aroma.

For example, many studies report the enhancement of sweetness by "fruity" notes, which are associated with a sweet component by consumers (Boakes & Hemberger, 2012; Burseg, Camacho, Knoop, & Bult, 2010; Djordjevic, Zatorre, & Jones-Gotman, 2004; Frank & Byram, 1988; Labbe, Damevin, Vaccher, Morgenegg, & Martin, 2006; Lavin & Lawless, 1998; Le Calvé, Goichon, & Cayeux, 2008; Murphy & Cain, 1980; Prescott, 1999; Stevenson, Prescott, & Boakes, 1999; Tournier et al., 2009). "Caramel" aroma also impacts the sweet taste positively (Stevenson et al., 1999). In contrast, some odors not associated with sweetness (angelica oil and damascone) led to a decrease in the perceived sweetness of sucrose in a water solution (Stevenson et al., 1999). Aroma can also modify the perception of sourness. "Caramel" notes decreased the perception of sourness of a solution

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containing 1.44 g L^{-1} citric acid (Stevenson et al., 1999). In addition, a "lemon" aroma can enhance perceived acidity (Le Calvé et al., 2008; Valentin et al., 2006).

Concerning bitterness modulation by aromas, only a few works have been dedicated to this topic (Gaudette & Pickering, 2013). Cocoa and coffee aromas increase bitterness (Keast, 2008; Labbe et al., 2006). However, addition of an aromatic extract from a "fruity" white wine to a red wine slightly reduced the bitterness (Sáenz-Navajas et al., 2012) although the decrease in bitterness by sweet congruent aromas does not work in all contexts (Labbe et al., 2006). These authors observed an insignificant effect of vanilla aroma on the bitterness of cocoa beverages.

Finally, aroma can modulate astringency. A recent work indicated that the presence of aromatic compounds, with fruity, leather and smoked notes, in solutions with phenolic compounds (catechin or epicatechin) increased their astringency (Ferrer-Gallego, Hernández-Hierro, Rivas-Gonzalo, & Escribano-Bailón, 2014). However, a decrease in astringency was observed by adding a "fruity" aromatic fraction to reconstituted wines (Sáenz-Navajas et al., 2012).

The study of aroma–taste interactions in real food products needs specific conditions in order to demonstrate whether psychological interactions occur. Among cognitive interactions, the dumping effect, observed by Frank, van der Klaauw, and Schifferstein (1993) and confirmed by Clark and Lawless (1994), generates an overestimation of some attributes when the list of attributes is incomplete and lacks appropriate response categories. This can be assessed by comparing answers of panelists when they are asked to score a short list of attributes and a longer list containing adapted aromatic notes (Clark & Lawless, 1994; Frank et al., 1993). This procedure is used to report the possible overestimation of an attribute score (i.e. sweetness) when the appropriate attributes are lacking (i.e. strawberry). Another interesting aroma taste interaction is called congruency. Even if taste and olfaction are two anatomically and physiologically distinct entities, there is a lot of evidences that gustation and retronasal olfaction interact closely with one another (Delwiche, 2004; Lim et al., 2014). Thus, a taste (i.e. sweetness) can be perceived more intense when it is evaluated with a congruent aroma (i.e. caramel note) (Prescott, Stevenson, & Boakes, 1996). A way to reveal this psychological origin of aroma–taste interaction is to use a strategy with sensory input blockers (Poinot et al., 2011; Sáenz-Navajas et al., 2012). It can be assessed by comparing the scores for taste attributes obtained with and without the use of a nose clip.

In cider, no works have described aroma–taste interactions. Nevertheless, "Apples, Cooked Apples, Fruity, and Caramel" odors and aromas can be present in ciders (Le Quéré, Husson, Renard, & Primault, 2006; Piggott & Watson, 1992). Therefore, based on the literature, we hypothesized that these notes could modulate cider taste and astringency. The aim of the present work was to investigate the interactions between aromas and four sensory characteristics: sweetness, sourness, bitterness and astringency in commercial ciders. Three different conditions were compared. The first two consisted of scoring the four sensory attributes with and without wearing a nose clip to reveal the presence of a congruency effect in cider. Congruency generates a modification of taste intensity depending on aromatic characteristics. If taste intensity for some products changed depending on the presence of nose clip, it would indicate that aroma note modify cider taste by congruency. The third condition was the evaluation of the same list of four attributes without a nose clip but completed by seven aromatic attributes. Comparing the results for the four attributes in the conditions without a nose clip should reveal the presence of a dumping effect due to the lack of appropriate attributes in the sensory profile, aromatic in the present experiment. If the intensity of one of the four attributes was modified when the extended list was presented to the panelists, it would indicate that the panelists' perception and scores was influenced by the absence of specific aromatic notes during the characterization process.

2. Materials and methods

2.1. Commercial ciders

Sixteen ciders with different sensory profiles were selected based on the professional expertise of four experts working for at least 5 years in cider production as an oenologist, technical adviser or quality manager. They were asked to provide samples of ciders from their area of production with very different tastes and aromas. A selection of sixteen ciders was made after an informal tasting organized with a small team of the sensory laboratory.

Ciders were first characterized by their pH and titratable acidity expressed in g L^{-1} eq malic acid. Sugar content (fructose, sucrose, glucose) was measured by an enzymatic methodology (Megazyme Sucrose/Fructose/D-Glucose Assay Kit – K-SUFRG) and expressed according to the equation: Total sugar = sucrose + (0.95 × (glucose + fructose)). Total procyanidins and their average degree of polymerization (aDP) were quantified following the method described by Guyot, Marnet, Laraba, Sanoner, and Drilleau (1998).

Products were tasted at 11 ± 1 °C in INAO normalized glasses. Bottles of cider were opened at the beginning of the session and were capped between each service.

2.2. Sensory evaluation by a trained panel

Fifteen panelists took part in this experiment. They were occasional cider consumers (a minimum of 10 times a year). They had previously been involved in a sensory project for the evaluation of odor and aroma in apples (Charles, 2013) and were trained in the flavor evaluation of cider in this context. Then, they were trained for about 60 h in the taste evaluation of model cider solutions (Symoneaux, Chollet, et al., 2014). At the beginning of the present experiment, they were familiarized with cider aroma recognition using seven references presented on sniff paper stickers (Table 1).

In order to assess the impact of aroma on taste perception, a nose clip was used but this requires some training to perform the sensory task in a comfortable way for a sparkling product. For this reason, without explaining the aim of the experiment, two sessions were devoted to evaluating the cider taste with a nose clip, performing ranking and scoring tasks on several commercial ciders.

2.3. Design of the sensory experiment

Three conditions were used during the test: (i) the evaluation of sweetness, sourness, bitterness and astringency without a nose clip (Wout.NC condition), (ii) the evaluation of the same attributes with

Table 1
Reference molecules for training on cider aroma.

Attributes	Selected references
Citrus fruit	Limonene 10% ethanol
Caramel/apple purée	Ethyl acetoacetate 1% ethanol + ethyl maltol 1% ethanol
Animal	para-Cresol 1% ethanol
Hay	Hay absolute 10%
Fruity	cis-3-Hexenyl acetate 1% ethanol Hexyl acetate 1% ethanol
Floral/honey	Phenyl ethyl acetate 10% ethanol
Earthy	Geosmin 0.01% ethanol