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Aroma–taste interactions between a model cheese aroma and five basic tastes in solution

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ABSTRACT

The flavour perception of cheese results from complex sensory interactions between tastes and aromas. Using a model cheese solution, this study investigated perceived interactions between each of five basic tastes and a cheese aroma mixture containing ten volatile compounds commonly found in cheese. The five tastes – sucrose (sweetness), sodium chloride (NaCl) (saltiness), monosodium glutamate (MSG) (umami), lactic acid (sourness), and caffeine (bitterness) – were individually mixed with cheese aroma in water using a 5 taste level (0.2 log series) by 3 aroma level (0.5 log series) design. Aroma controls with no added taste were also included. This resulted in 18 samples for each single taste–aroma combination. An additional 18 samples were produced using a mixture of all 5 tastes with the 3 aroma levels. A panel of trained assessors ($n = 10$) evaluated *cheese flavour intensity* and *taste intensity* using 100 point line scales. Evaluation was carried out in duplicate, with samples grouped by taste type; 1 evaluation session per taste per replicate. Within type, order of presentation was balanced, and taste type order was randomised between replicates. Cheese flavour intensity was enhanced by sucrose and NaCl, while being suppressed by lactic acid. NaCl enhanced cheese flavour intensity the most at high aroma level, while lactic acid suppressed the most at low aroma level. When MSG level was increased, cheese flavour intensity was enhanced at both low and medium aroma levels, but was suppressed at the high aroma level. The greatest enhancement of cheese flavour intensity was found with the mixture of 5 tastes. Aroma significantly enhanced umami and bitterness, but did not enhance sweetness, saltiness, or sourness. This study showed that the perceived interaction between taste and cheese aroma depended on taste type and on the concentration levels of both taste type and aroma. The mixture of tastes was more effective at enhancing cheese flavour intensity than single tastes. This study provides knowledge that will underpin further study of taste–aroma interactions in a model cheese that aims to optimise cheese flavour intensity and character.

1. Introduction

Flavour is of key importance to consumers' acceptance of cheese. The flavour perception of cheese is influenced by multiple sensory modalities, before and during consumption, including appearance, taste, aroma, chemical irritation, and texture (Delahunty & Drake, 2004).

Aroma perception occurs by olfaction: aroma active compounds stimulate olfactory receptors situated on the roof of the nasal cavity. In the context of flavour perception during consumption, aroma compounds are perceived retronasally (Rozin, 1982). Many different types of aroma compounds are responsible for the aroma of cheeses, including short to medium chain fatty acids, aldehydes, alcohols, ketones, esters, and sulphur compounds (Curioni & Bosset, 2002). The aroma character of a cheese is determined by the combination of aroma compounds and is not characteristic of any single compound (Zehentbauer & Reineccius, 2002). Different cheeses can share many of the same aroma compounds, but their varying proportion differentiates one type of cheese from another (Engels, Dekker, de Jong, Neeter, & Visser, 1997).

Taste perception occurs during gustation as taste active compounds stimulate taste receptors on the tongue. Taste perception can be separated into five basic taste characters, including sweetness, saltiness, umami, sourness, and bitterness, all of which are

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present in the taste of cheeses. Compounds identified as contributing to the basic taste characters of a variety of cheese types include NaCl for saltiness, organic acids for sourness, amino acids (particularly glutamate) for umami, hydrolysed peptides with hydrophobic amino acids and mineral salts contributing to bitterness, and salt propionates and amino acids contributing to sweetness (Andersen, Ardö, & Bredie, 2010; Engel, Septier, Leconte, Salles, & Le Quéré, 2001; Kubıcková & Grosch, 1998; Salles, Septier, Roudotalgaron, Guillot, & Etievant, 1995; Salles et al., 2002; Taborda et al., 2008; Toelstede & Hofmann, 2008a, 2008b; Warmke, Belitz, & Grosch, 1996). However, the relative contribution of each taste character towards the overall cheese taste perception is not well known.

The combined stimulation of aroma and taste influences the perceived intensity of each other, despite gustatory and olfactory receptors and their neural pathways to the brain being physiologically separate. The resultant effect is a cross-modal sensory interaction, and can result in an enhancement or suppression of attribute intensities (Noble, 1996). For enhancements to occur, it is believed that the taste and aroma must be harmonious or congruent with each other (Schifferstein & Verlegh, 1996). It is possible for congruency to arise from learning through repeated exposure to a particular aroma and taste combination (Prescott, 2012). During the perception of a congruent mixture of taste and aroma, it is thought that cross modal interaction is integrated in specific areas of the brain. The orbitofrontal cortex, the anterior cingulated cortex, and the insula have been shown to be the important areas for integration (Eldeghaidy et al., 2011; Small & Prescott, 2005; Small et al., 2004). Congruent mixtures of aroma and taste show consistent enhancements across replicate measurements (Green, Nachtigal, Hammond, & Lim, 2012). Mixtures of stimuli that are incongruent can either show no change in perception from when the stimuli are individually perceived, or suppression (Prescott, 1999; Stevenson, Prescott, & Boakes, 1999).

A number of studies have reported that perceived taste, including sweetness, bitterness, saltiness, and sourness, can be enhanced by aroma (Bonnans & Noble, 1993; Caporale, Policastro, & Monteleone, 2004; Djordjevic, Zatorre, & Jones-Gotman, 2004). In the context of cheese, cross-modal interactions have not received much research attention. Recently, with salt reduction as the aim, it was demonstrated that perceived saltiness of both a solution, and a model cheese matrix representing mozzarella, could be enhanced by the addition of specific aroma characters, including Comté cheese, goats' cheese, Roquefort cheese, or a combination of pure compounds commonly found in cheese (Lawrence, Salles, Septier, Busch, & Thomas-Danguin, 2009; Lawrence et al., 2011; Pionnier et al., 2004). There is limited knowledge on how taste characters such as sweetness, sourness, umami, and bitterness influence perceived cheese flavour. Early work revealed that the combination of tastes as a whole contributes significantly to the flavour intensity of cheeses (Aston & Creamer, 1986; McGugan, Emmons, & Armond, 1979). No further reports have been shown that follow through with these findings.

The objective of the current study was to investigate cross-modal sensory interactions between each of the five basic taste types and a cheese aroma. All 5 basic taste characters, sweet, salty, sour, umami, and bitter, were tested with a complex cheese aroma consisting of 10 compounds. Each character was tested individually, and then all 5 tastes were mixed with aroma.

2. Materials and methods

2.1. Samples

The taste types used to represent pure taste characters of sweetness, saltiness, umami, sourness, and bitterness and were sucrose (Bundaberg Sugar, Spring Hill, QLD, Australia), sodium chloride (NaCl) (Sigma Aldrich, Sydney, NSW, Australia), monosodium glutamate (MSG), DL-lactic acid (85%, FCC Kosher, food grade SAFC supply solutions, Australia), and caffeine (Sigma–Aldrich), respectively. The MSG was prepared by mixing sodium hydroxide (98%) (Sigma Ultra, food grade: Sigma–Aldrich) with L-glutamic acid (98.5%, FCC Kosher, food grade: SAFC, Sydney, NSW, Australia) in water. Aroma compounds were 2-butanone, 2-heptanone, 2-nonanone, diacetyl, ethyl butyrate, butyric acid, methional, 3-methylbutanal (all obtained from Givaudan Australia Pty Ltd, Sydney, NSW, Australia), ethyl hexanoate (Firmenich Ltd, Balgowlah, NSW, Australia), and 3-methylbutanoic acid (Sigma–Aldrich).

2.2. Experimental design

The five tastes; sucrose, NaCl, MSG, lactic acid, and caffeine, were individually mixed with cheese aroma in water using a 5 level of taste by 3 level of aroma design (Tables 1 and 2). For each taste and aroma combination, taste controls at each of the three aroma levels were also prepared; these samples were aroma solutions that did not contain taste, meaning that the same taste control samples were always used. This resulted in 18 samples for each single-taste and aroma combination, also using the same design as above. The taste concentration levels were chosen to represent the taste intensity range for each type, typically found in foods. The highest concentrations for each type were matched by panel intensity ratings. The concentration ranges for each of these tastes were obtained by reducing the concentrations in 0.2 log steps four times from the highest concentration. A solution containing a mixture of all five tastes was also combined with the aroma. The tastes were mixed at equal concentration levels to when compared singly, as shown in Table 1. For example at taste level 1, the levels of all five tastes in that row of Table 1 were combined together. This gave a mixture of sucrose, NaCl, MSG, lactic acid, and caffeine at concentrations of 1.9%, 0.13%, 0.07%, 0.07%, and 0.03%, w/v, respectively. This was repeated at other taste levels to give levels 2, 3, 4, and 5.

Table 1
Five concentrations of five taste types used for the aroma–taste interactions; controls of each taste type were 0% (w/v).

Tastant level	Sucrose (%, w/v)	NaCl (%, w/v)	MSG (%, w/v)	Lactic acid (%, w/v)	Caffeine (%, w/v)
1	1.90	0.13	0.07	0.07	0.03
2	3.01	0.20	0.11	0.11	0.05
3	4.78	0.32	0.18	0.18	0.08
4	7.57	0.50	0.28	0.28	0.13
5	12.00	0.80	0.45	0.45	0.20

Table 2
Concentrations of 10 aroma compounds that represent cheese aroma.

Compound[a]	CAS-No.	Aroma level (μg/L)		
		Low	Medium	High
2-Butanone	78-93-3	0.200	0.630	2.000
2-Heptanone	110-43-0	0.120	0.380	1.200
2-Nonanone	821-55-6	0.040	0.130	0.400
3-Methylbutanal	590-86-3	0.020	0.060	0.200
3-Methylbutanoic acid	503-74-2	0.060	0.190	0.600
Butyric acid	107-92-6	0.800	2.530	8.000
Diacetyl	431-03-8	0.200	0.630	2.000
Ethyl butyrate	105-54-4	0.120	0.380	1.200
Ethyl hexanoate	123-66-0	0.040	0.130	0.400
Methional	3268-49-3	0.020	0.060	0.200

[a] Levels increased by 0.5 log series, in an equal proportion for all compounds.