PHYSICAL AND PERCEPTUAL INTERACTIONS IN THE PERCEPTION OF CHEESE

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ABSTRACT

When eating cheese, the sensations of taste, smell, touch, sight, and sometimes pain/irritation are stimulated. This paper reviews how all these sensations interact, impacting the perception of one another and resulting in a holistic, complex experience. Interactions between taste and smell, and interactions of the remaining sensations with taste and smell are explored, and practical implications of these interactions are considered.

INTRODUCTION

When a person eats cheese, the experience is multi-modal. It begins with the stimulation of vision, with the appearance of the cheese, its color, shine, and shape affecting expectations. The senses of taste, smell and touch are all stimulated with the first bite and the amalgam of these sensations result in the experience of eating cheese. The subsequent affective reaction to the cheese, the enjoyment or aversion to it, the liking or disliking, depends upon a variety of factors that are beyond the scope of this article. Instead, it will focus on the interaction of multi-modal sensations that precede the hedonic response.

There are more than 500 types of cheese throughout the world (Singh et al. 2003). They vary in texture, taste and aroma, ranging from soft and smooth to hard and flakey, mild to sharp, and practically odorless to nearly overwhelming in aroma. Texture, particularly the tendency to stretch and melt, is affected by changes in pH that in turn affect chemical changes in the cheese curd protein network. In general, curds with a low pH have a crumbly texture while high pH curds tend to be more elastic (Singh et al. 2003). The sourness of a cheese, which will impact sharpness, will also be influenced by the pH. Cheese odors largely originate from degradation of the major milk constituents also known as caseins, including lactose, citrate, milk lipids, and milk proteins (Singh et al. 2003). As cheeses ripen, there are a variety of changes that occur to texture, aromatic compounds, and taste compounds. The flavor of the cheese changes accordingly, and these changes are due both directly and indirectly to physical changes in the cheeses. While changes in the physical charatistics are relatively well-documented (e.g., Singh et al. 2003), there has been less discussion of more indirect factors, namely cross-modal interactions (Delwiche 2004), which is the focus of this manuscript.

Interaction of Taste and Smell

There are many indications that the sensations of taste and smell interact, including both psychophysical and neuroimaging data. One psychophysical study (Dalton et al. 2000) demonstrated subthreshold concentrations of sodium saccharin (sweet taste) and benzaldehyde (cherry/almond aroma) could be detected when presented simultaneously, suggesting central integration of taste and smell. Other studies indicate ratings of odor intensity increase as taste compound concentrations increase, and ratings of taste intensity increase as odor compound concentrations increase (Bonnans and Noble 1993; Frank et al. 1989; Murphy and Cain 1980; Mutphy et al. 1977; Philipsen et al. 1995). Further, evidence indicates increases in odor and taste intensity ratings are stronger for harmonious taste-odor pairs, or taste-odor pairs that are typically encountered together, than inharmonious or atypical pairs (Frank and Byram 1988; Kuo et al. 1993; Schifferstein and Verlegh 1996). In addition, there is neuroimaging evidence of taste and smell

integration. A recent study using event-related fMRI (functional magnetic resonance imaging) indicated increased blood oxygen level demand in certain areas of the brain when taste and smell were presented in combination, above the summed activity of taste and smell presented alone (Small and Jones-Gotman 2001).

These types of taste-odor interactions can result in complicated changes in perceived flavor with complex stimuli like cheese. For example, when sucrose was added to fruit juices, not only were perceived levels of bitterness and sourness reduced and perceived sweetness increased, but 'vinegar' and 'green' ratings decreased while 'fruity,' 'berry-like,' 'fragrant,' and 'sweet odor' ratings increased (von Sydow et al. 1974). Similarly, if the pH of a cheese were decreased, it is likely that sourness and sharpness ratings, as well as certain odor ratings, such as pungency, would also increase.

Interaction with Irritation

Chemical irritation, or chemesthesis, is mediated by nonspecific, multimodal somatosensory fibers and are a property of the skin (Green and Lawless 1991). Some compounds typically thought of as being purely gustatory or purely olfactory, such as salt (NaCl), citric acid, quinine, and butyl acetate (a fruity odor) show irritant properties at moderate and high concentrations (Cain 1974; Dessirier et al. 2001; Gilmore and Green 1993; Green 1989; McCutcheon and Tennissen 1989; Prescott et al. 1993; Stevens and Lawless 1986). Certain taste ratings are impacted by capsaicin, the irritant in red chili peppers (Prescott et al. 1993; Prescott and Stevenson 1995), while certain tastes can impact burn ratings (Prescott et al. 1993). Similarly, irritants can inhibit the perception of odors, and odor compounds inhibit irritation - although the former inhibition tends to be stronger (Cain and Murphy 1980).

The impact of irritation on the perception of cheese flavor has not been heavily explored, but its importance is likely most important for specialty cheeses, such as "pepper jack" cheeses. However, it is possible that certain intensity ratings, especially those of pungency, are also impacted by chemesthesis.

Interaction with Temperature

As a sample is heated, there is an increase in released volatiles (Atkins and Locke 2002). Thus, odors become more intense as a given sample is heated (Herrmann and Abd-El-Salam 1981; Herrmann and Poeschel 1973; Voirol and Daget 1989). This means that a cheese might contain volatile compounds that are below threshold levels when it is chilled, but that are detectable as it is warmed.

The interaction of temperature and taste is more ambiguous, agreeing that cooling or heating taste solutions above or below ~30°C tends to raise detection thresholds and alters suprathreshold taste sensations, but disagreeing about the magnitude of the effects and the temperatures at which they occur (Green and Frankmann 1987; Pangborn et al. 1970; Schiffman et al. 2000). Some research has indicated that reducing tongue temperature, more so than reducing solution temperature, is the critical factor for reducing perceived intensity of some, but not all, taste compounds (Frankmann and Green 1987; Green and Frankmann 1987). Other work has indicated that temperature itself can elicit the perception of taste, although this effect was not found with all subjects, nor were the researchers able to produce all taste sensations on all parts of the tongue (Cruz and Green 2000).

Given these findings, it can be safely assumed that the perception of cheese flavor will vary depending upon the temperature at which it is sampled. A cheese presented chilled will have less aroma than the same cheese presented at room temperature. The taste also will be different at these two temperatures, although it is difficult to predict the nature of this difference.

Interaction with Color

The only factor of visual appearance that has been heavily investigated in regards to its impact on taste, smell and flavor is color. It has been shown repeatedly that the flavor of uncolored and

miscolored foods and beverages are identified correctly less frequently than appropriately colored items (DuBose et al. 1980; Hall 1958; Moir 1936; Philipsen et al. 1995; Stillman 1993; Teerling 1992), likely due to learned associations between certain colors and flavors. Research also suggests taste and/or flavor intensity increases as the color level increases (DuBose et al. 1980; Johnson et al. 1982; Johnson and Clydesdale 1982; Johnson et al. 1983; Norton and Johnson 1987; Teerling 1992), which could be due to experience with diluting beverage concentrates, etc. Other research has shown that colors can impact taste ratings, although the impact of a particular color on taste ratings has been inconsistent across studies (Frank et al. 1989; Maga 1974; Pangborn 1960; Pangborn et al. 1963; Pangborn and Hansen 1963).

Morrot, Brochet, and Dubourdieu (2001) found that when white wine was colored red, it was described with more red wine odor terms (which tended to describe red or dark objects) instead of white wine odor terms (which tended to describe yellow or clear objects). When the white wine was left uncolored, it was described primarily with white wine terms, despite the fact that in both instances the same wine was tasted. Similarly, Delwiche (2003) found that coloring a white wine so it appeared pink or red had a significant impact on ratings of fruitiness, fullness/body, complexity and maturity. These findings indicate that color can have a complex impact upon the perception of a real food product. It seems likely that altering the color of a cheese would also have a complex impact upon its perception.

Interaction with Texture

Texture controls the accessibility of volatile odor and nonvolatile taste compounds to olfactory neurons and taste buds, with that availability at a given time depending upon the breakdown of the food matrix (Crocker 1945). Differences in milk composition and processing factors lead to recognizable compositional, textural, and flavor differences in different cheese varieties (Singh et al. 2003). The processes that cause changes in cheese texture will result in a multitude of other changes that will impact cheese flavor by changing the taste and odor compounds present, as well as accessibility to the taste buds and olfactory neurons. Many studies have shown that increasing viscosity of a liquid decreases taste and flavor intensity ratings (Arabie and Moskowitz 1971; Baloga et al. 1994; Christensen 1980; Kokini 1985; Kokini 1987; Kokini et al. 1982; Marshall and Vaisey 1972; Moskowitz and Arabie 1970; Pangborn et al. 1978; Pangborn and Szczesniak 1974; Pangborn et al. 1973; Stone and Oliver 1966; Vaisey et al. 1969).

Recent research suggests that in addition to altering compound accessibility, tactile stimuli can alter the perception of taste and aroma more directly (Baek et al. 1999; Cook et al. 2003; Hollowood et al. 2002; Weel et al. 2002). For example, increasing gel thickness resulted in significant changes in odor and flavor perception, even though it did not significantly alter the concentration of volatiles in the nose (Baek et al. 1999; Cook et al. 2003; Hollowood et al. 2002; Weel et al. 2002). These findings suggest that altering the texture of a cheese even if the concentrations of taste and odor compounds remains unaltered can result in complex changes in the perceived cheese flavor.

Practical Implications

There are several implications of these cross-modal interactions. First, it demonstrates that the multi-modal experience of eating cheese is impacted by almost all the senses: taste, smell, touch and sight. Altering any of these aspects of a cheese will impact upon its perceived flavor and can potentially have an impact upon consumer reaction. It also indicates that when assessing cheese quality, it is important to assess a cheese on all these aspects, and not just along one sensory dimension. As each attribute contributes not only to the perception of itself, but also to the perception of the other attributes present, this implies that when conducting sensory analysis of a product, asking a panelist to ignore a particular aspect of the product will not be effective, regardless of amount of training. It simply is not possible for a person to ignore an odor or texture while making taste assessments, and vice versa.

In sum, it seems that all of the sensations experienced while eating cheese or other foods are crucial to that experience, and that these sensations are combined at a cognitive level largely beyond conscious control. It is this blending of different sensations that allows for the indulgent experience of eating high-quality cheese and appreciation of the complex and sometimes subtle differences between cheese types.

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