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Effect of sucrose and fat aroma on the perception of sweetness and fattiness of milk

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Abstract

Sensory methodology was used to examine the effect of fat aroma on the perception of fattiness and sweetness of milk. Four samples of milk (5% fat-5% sweet, 5% fat-10% sweet, 10% fat-5% sweet and 10% fat-10% sweet) were prepared by using sucrose for sweatiness and cream for fattiness. The samples prepared were presented to twelve trained panellists. Their response was recorded and analysed by using Compusense software. Significant difference ($p<0.05$) was found in sweet perception, whereas, no significant difference ($p>0.05$) was observed in fat perception. Descriptive analysis suggested that rating of sweetness intensity rose with the increase of both sucrose and fat concentration. In contrast, rating of fat content of milk was poorly linked to fat stimulus. It was concluded that fat aroma does effect on the perception of sweetness whereas, increasing concentration of sucrose levels masked the fattiness of milk. The finding suggests that sucrose disguises the sensory attribute of fat in milk and this phenomenon can assist to describe why sweet-high fat food products are usually regarded only as carbohydrate rich foods. These findings will help food industrialist to adjust the fat content of food products since this can effect on the taste perception. Moreover, the understanding about effect of fat on the sensory properties of milk will help in developing fat alternatives for addition to fat-free milk.

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Introduction

Sensory perception of foods starts from chemosensation, which includes the detection of tastants, odorants, and textural attributes of foods, followed by the integration of sensory signals by the brain. Sensory processes are initiated with the keeping of food in the mouth, dilution with saliva, oral perception of temperature and texture, and the binding of taste and flavour molecules to receptors in the oral and nasal cavities. Activated receptors then send a chemical signal via sensory nerves to the brain. Upon incorporation of sensory input, one becomes aware of the taste, aroma, and texture of foods (Fig. 1) (Chandrashekar *et al.*, 2006; Engelen and Van der Bilt, 2008; Gierczynski *et al.*, 2011).

Milk is a complex mixture of carbohydrate (lactose), lipid (fat), protein (casein) and minerals, all dissolved or suspended in water as well as numerous volatile compounds (Jensen *et al.*, 1991). For choice of milk, taste is a major determinant. However, sensory attributes for milk varies with the change in the constituents of milk especially carbohydrate and lipid content. Previously, various researchers have demonstrated the effect of different constituents of milk on the taste, perception, creaminess, sweetness and fattiness of milk. For example, Wham (2000), found that the majority of the respondents showed positive attributes (>73%) towards the taste of milk, but no-one could distinguish between types of milk. Brewer *et al.,* (1999), found that participants preferred whole milk rather than skimmed milk, and with increasing fat content the sensory score for perception and liking was also increased. Another study conducted by Richardson-Harman (2000), suggests that taste perception of milk depends upon its fat content and its aroma. It has been reported that not only the fat content in milk, but also its physical state (liquid or crystal form) also influences on the flavour and in turn on the perception of milk and dairy products (Drewnowski *et al.*, 1990). Tuorila *et al.* (1993 & 1995), have reported the effect of fat levels and sweetener types on the perception of fattiness, sweetness and sourness in flavoured yogurts. Similarly, research conducted by Tuorila (1986), reveals that sensory properties of milk are influenced by the fat percentage in milk. Another study conducted by Francis *et al.* (2004), suggests the change in the perception of sweet taste with the fat content of milk.

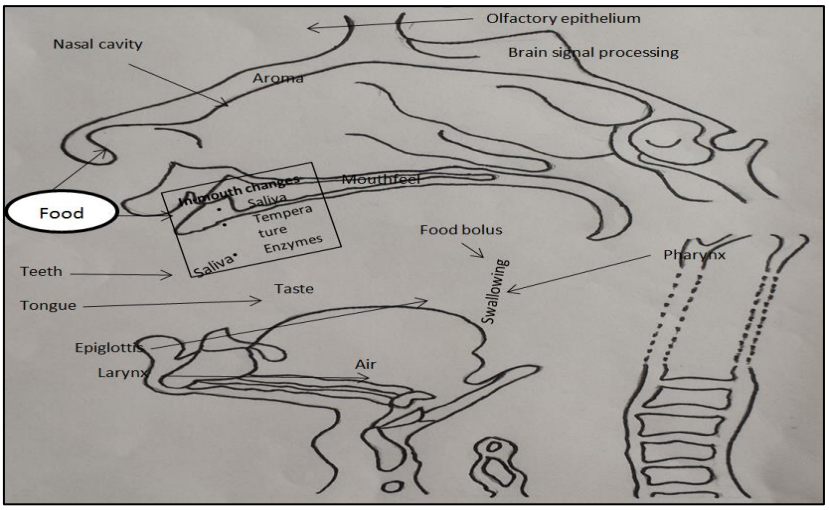

Fig. 1. Perception mechanism of sensory stimuli during food consumption (Modified from: Gierczynski *et al.*, 2011).

Since odours can attain taste-like properties, it is worth to evaluate whether odours can effect on the perception of real taste. This formed the basis for the current study, wherein effect of fat aroma on the perception of fattiness and sweetness of milk was evaluated to get the understanding of taste-aroma interactions.

Material and methods

Panellists

Twelve panellists including students and teachers of London Metropolitan University, London participated in this study (Ages 23 to 64 years). Of those 8 were males and 4 were females.

Training of panellists

Each panelist was trained on food taste, flavor, aroma, mouthfeel and texture attributes (although current study is focused on taste and aroma) using the previously tested spectrum method (Meilgaard *et al.*, 2007). Panellists were also trained for another session of sensory properties evaluation as per method described by Drake *et al.*, (2003) and Croissant *et al.*, (2007). At the end of both sessions, all panellists had training experience of 50 hours.

Preparation of milk samples

Four milk samples were prepared, comprising two concentrations of fat and two concentrations of sucrose: 5% fat and 5% sucrose (low-fat, low-sweet milk), 5% fat and 10% sucrose (low-fat, high-sweet milk), 10% fat and 5% sucrose (high-fat, low-sweet milk) and 10% fat and 10% sucrose (high-fat, high-sweet milk). For fattiness, dairy cream (50.5% fat) (Tesco) was mixed in skimmed milk (0.1% fat) (Tesco) and for sweetness, sucrose (Thermo scientific) was mixed in skimmed milk at the required concentrations. All the milk samples were prepared 15 minutes prior to experimental session. For avoiding any light oxidation of milk samples, overhead lights were switched off.

Evaluation of milk samples

In the beginning of evaluation session, panellists were warm-up by presenting them two commercial samples of milk including skimmed and whole milk. All the panellists were suggested to expectorate the samples followed by rinsing with deionized water. Finally, panellists were suggested to use unsalted crackers to clean their palate. A two minute wait between samples was imposed to minimize carryover effects. For test samples, about 15 ml of each milk sample was presented to each of the 12 panellists in disposable black plastic glasses (100mL) with lids having 3-digit codes. Presentation order was balanced by randomizing the samples, so that each sample occurred an equal number of times at each position. The assessment of the samples took place under sensory laboratory conditions where each panellists sat in separate booth and had Personal System computer. The panellists were asked to take the whole sample into their mouth, swirl it about for 3 seconds and expectorate and panellists were asked to give their overall opinion about fattiness and sweetness of milk samples by moving computer mouse for selecting the score on vertical line scale of 0-10 (Separate response for sweetness and fattiness) displayed on the computer screen. Where 0 meant no fattiness or no sweetness and 10 meant extremely strong fattiness or sweetness. Panellists were also presented with water in disposable plastic glasses and were suggested to take some water between testing four samples. In addition, a two minute wait between samples was imposed. The method followed in this study has been previously tested by other researchers (King *et al.*, 2000 and Sundqvist *et al.*, 2006). At the time of this experiment, the temperature of samples was 10°C and room temperature was 15°C.

Statistical analysis of data

Rating scores selected by each of the 12 participants for fattiness and sweetness of each sample of milk were analysed by using Compusense software. Results were expressed as mean ± standard deviation (S.D). Analysis of variance (ANOVA) was also performed to observe the significant difference ($p<0.05$) among samples as perceived by panellists.

Results and discussion

The perception results recorded on line scale (0-10) were expressed into % values, where 0 on line scale was considered as 0% fattiness or sweetness and 10 on line scale was considered as 100% fattiness or sweetness. The perception of sweetness increased with increasing sucrose concentration ($p <0.05$). The effect of sucrose on sweet perception was highly significant ($p <0.05$) since all the panellists generally percept the same level of sweetness in milk samples (Fig. 2). The perception of sweetness with increasing fat content also followed same trend ($p <0.05$) (Fig. 2). These results align with previous study conducted by McCarthy *et al.*, (2017). Their study demonstrated increase in sweet taste and sweet aromatic flavor with the increase in fat. In contrast with these results, Weit *et al.*, (1993), sweetness of milk (containing sucralose

and aspartame as sweetener) decreased with increase in fat content, especially at lower sweetener concentrations. Whereas, study conducted by Li *et al.*, (1997) suggested no effect on sweetness perception with differences in fat content. According to a neuro-anatomical study, smell and taste are very different senses (Abdi, 2002), however, information coming from gustatory (taste) and olfactory (odour) systems are combined at a complex level of processing in the brain to produce a unique perception referred as flavour (Prescott, 1999). One of the consequences of interactions between taste and olfactory senses is that they produce long lasting changes so that the flavour's elements are perceived (Stevenson *et al.*, 1995). It has also been reported that taste like properties of smells resemble with the real taste equivalents in many ways and a tasty smell may be developed under laboratory conditions (Small and Prescott, 2005).

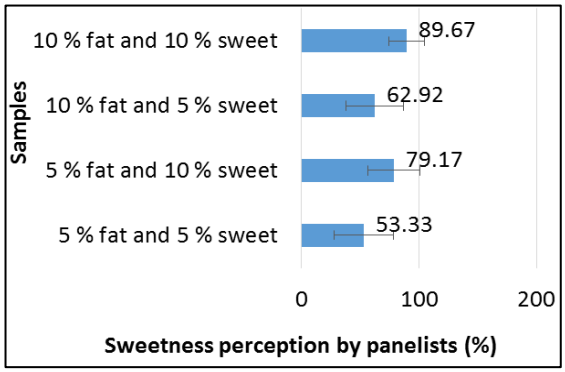

Fig. 2. The perception of panellists for sweetness of milk.

In contrast with sweet perception, the perception of fattiness did not increase consistently with increasing fat (P >0.05) (Fig. 3) and effect of fat on fattiness perception was also not significant (P >0.05). In this case panellists generally could not percept the same level of fattiness in milk samples. Similar results were obtained by Pangborn *et al.*, (1984) their study panellists were presented milk containing varied amount of fat (0-4%) but panellists could not discriminate the differences among samples. Pangborn *et al.*, (1984) concludes that visual add could help the panellists to discern the fat content in milk. However, results of current study for fat perception contrast with some studies (Phillips *et al.*, 1995; Francis *et al.*, 2005). Greater differentiation in fat attribute was noted in the current study compared with previous work, perhaps due to less panel training or because panellists were not given reference samples to compare their perception. In addition, it is possible that perception of fattiness was masked with increasing concentration of sweetener (sucrose) as reported by Drewnowski and Schwartz (1990) and King *et al.*, (2000). This could be because of sucrose and fat interaction or change in mouthfeel due to presence of sucrose in milk as it has been reported that perception of fat depends upon its texture and also the mouthfeel (Pangborn and Dunkley, 2001). More milk samples (Large sample size) with increased concentration of fat could have presented the relation of aroma of fat or fat content of milk with fat stimulus. In addition, temperature of samples in this study during evaluation (10°C) could have effected on the perception of fattiness since previous study (Phillips, 1995) suggests that many of the volatile substances are better perceived at temperature higher than the refrigerator temperatures (4-10°C). Some researchers have suggested that collecting the data from panellists at various time points for example, a) Introduction of sample in mouth, b) When the sample is swallowed, and c) after swallowing, can give more persistent fat perception values (Saint-Eve *et al.*, 2006; Gierczynski *et al.*, 2008; Gierczynski *et al.*, 2011).

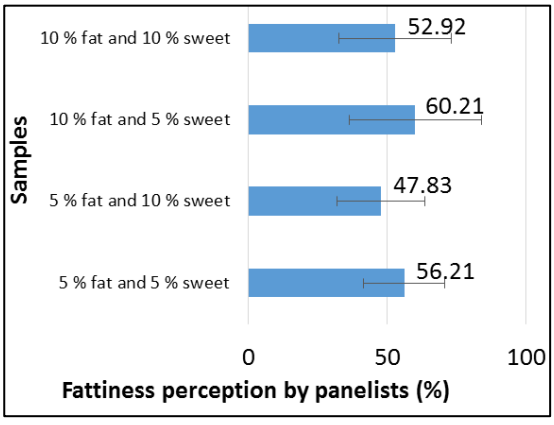

Fig. 3. The perception of panellists for fattiness of milk.

Although the results in this study demonstrate that fat can positively effect on the perception of sweetness of milk and sucrose can negatively effect on the perception of fattiness in milk, it is unknown that at

what extent the results obtained in this experiment for the perceived fattiness of milk by panellists can be extended to the general population.

Nevertheless, the perception of fattiness obtained from large number of more experienced sensory panellists can provide a clear and detailed picture of human sensory perception of fattiness, since more trained panel can distinguish even small variation in fat content of milk. In future, for finding the effect of fat on fattiness one should also consider the panellists who typically drink non-fat milk because they will be better at discriminating varied fat percentages compared to the panellists who use higher fat milk.

Conclusion

The present experiment confirms that aroma of fat does effect on the perception of sweetness of milk whereas, presence of sucrose masked the perception of fattiness in milk because panellists who participated in this experiment could not judge the fattiness in milk.

The finding that sucrose suppresses the sensory attribute of fat in milk may assist to describe why sweet high-fat food products especially milk are usually regarded as carbohydrate rich foods. In addition, findings of this study can also guide the food industrialist to develop dairy products that can fulfill the consumer's requirement. Moreover, the understanding about effect of fat on the sensory properties of milk will help in developing fat alternatives for addition to fat-free milk.

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