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Effects of aroma–texture congruency within dairy custard on satiation and food intake

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ABSTRACT

Food intake regulation comprises numerous components from peripheral and central pathways, including sensory and cognitive elements. This study investigated if congruency in different aroma–texture combinations within a dairy product influences satiation and food consumption in humans. Among seven different aromas, vanilla was rated as congruent and lemon as incongruent aroma in the context of creamy texture, while both aromas were highly liked and familiar. Creamy custard, either vanilla- or lemon-aromatised, was given to 32 subjects in a preload – *ad libitum* regimen. Satiation was measured on visual analogue scales and by salivary α-amylase concentration. Finally, the amount of *ad libitum* intake was determined. No effects of congruency were found on *ad libitum* consumption and perceived satiation. Subjects felt more satiated when preload and *ad libitum* intakes shared the identical aroma compared to varied aromas. This was not supported by increased salivary α-amylase levels, although those increased overall with intake. In conclusion, there was no relation between congruency in aroma and texture in dairy custard and food intake, but aroma perception possibly modulates perceived satiation.

1. Introduction

Food intake regulation in humans involves a variety of homeostatic, behavioural, sensory and hedonic components controlled by systems conveying both peripheral and central pathways. Mostly peripheral signals provide information about the body's nutritional state, which can serve as physiological biomarkers of energy balance, and the central nervous system integrates episodic hunger and satiety signalling towards a functional output that controls metabolism with accompanying behaviour (Gale, Castracane, & Mantzoros, 2004; Schwartz, Woods, Porte, Seeley, & Baskin, 2000). Recently, we demonstrated a strong association between perceived satiety and the autonomic nervous system status as well as saliva composition, including salivary α-amylase levels, in humans (Harthoorn et al., 2007; Harthoorn & Dransfield, 2008). While signalling between periphery and brain is crucial in coordinating integrative processes for metabolism, it can also be anticipatory as it can occur even before food is ingested (Bellisle, Louis-Sylvestre, Demozay, Blazy, & Le Magnen, 1985; Mattes, 1997).

With regard to the effects of food intake on satiety, two distinct phases have been considered within the postulated "satiety cascade" (Blundell, Lawton, Cotton, & Macdiarmid, 1996). First, "satiation" is defined as a short-term process which develops during eating and brings an eating episode to an end. Second, "satiety" is termed as a longer-term state of inhibition over further eating. This satiety cascade takes into account properties of food, physiological processing of nutrients and factors that contribute to overall control of food intake, and it also conceptualises differences between immediate post-ingestive effects of food and effects produced later. In most cases active ingredients incorporated into food products are aimed to have their effects in the post-ingestive and post-absorptive phases. However, the use of sensory triggers and in particular aromas, which take part in the early phases of the satiety cascade and contribute to the process of meal termination, has also been reported (Hirsch & Gomez, 1995; Mayer, Davidson, & Hensley, 1999; Ruijschop, Boelrijk, De Ru, De Graaf, & Westerterp-Plantenga, 2008).

As food is eaten, continued exposure to its appearance, taste, mouth feel and smell, may result in reduced pleasantness and desire to eat that specific food. This phenomenon is called

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"sensory-specific satiety" because it occurs in the relatively short-term before a meal is digested and absorbed (Hetherington, 1996; Rolls, Rowe, & Rolls, 1982; Sørensen, Møller, Flint, Martens, & Raben, 2003). Factors that interrupt continued exposure, i.e. distractors introduced during a meal or variety in food and sensory properties, delay the expected decrease in appetite (Brunstrom & Mitchell, 2006; Romer et al., 2006). This implies that, when a food is eaten, introducing another food with different sensory properties slows the decline in desire to eat the food and increases meal size.

Previous studies have shown that aromas may enhance perceived taste intensity (Frank & Byram, 1988; Schifferstein & Verlegh, 1995), and even perceived properties like thickness and creaminess ~~(Bult, De Wijk, & Hummel, 2007)~~, provided that the aroma matches the sensory property that is enhanced. The perceptual match between aroma on the one hand and taste and texture on the other hand is referred to as aroma-taste and aroma–texture congruency. Aroma-taste and aroma–texture congruency may be exploited to influence the perceived taste- and texture properties of a food without changing its macronutrient composition. Assuming that the total amount of exposure to a food's sensory properties defines the total decline in desire to eat, it is expected that an enhancement of sensory properties by a congruent aroma will further reduce desire to eat. Hence, two determinants of meal size may be distinguished, i.e. congruency of taste, mouth feel and aroma within one stimulus and variation in successive exposure to taste, mouth feel or aroma. Meal sizes may then be reduced by increasing the congruency of combinations of aroma, texture and taste or by reducing the sensory variation in successively presented foods.

The present study was designed to determine if the level of congruency and temporal variation in sensory input of aroma–texture combinations influence satiation and subsequent food intake. It was hypothesised that satiation and food intake are affected by the level of congruency as well as by variation of successive exposure to aroma–texture combinations. Hereto, panellists were presented with dairy products (i.e. custards) with a creamy texture, which contained aromas that were either congruent or incongruent with creamy texture. To control for possible effects of familiarity or liking of the used aromas with intake measures, aromas were used that had received different congruency ratings with respect to the product in which they were used, but similar liking and familiarity ratings. Using a regimen of a fixed preload followed by an *ad libitum* meal of the creamy custard, the effects of four possible aroma combinations on the amount of *ad libitum* food intake were tested in a two-by-two full-factorial design. Perceived satiation was measured throughout the experimental sessions on visual analogue scales (VAS). Salivary α-amylase concentration was measured as an alternative and more physiological measure of satiation (Harthoorn & Dransfield, 2008).

2. Materials and methods

2.1. Subjects

Thirty-two healthy women, aged between 20 and 40 years, participated in this study. They were recruited and screened for dietary restraint, eating disinhibition and hunger using a validated Dutch translation of the three-factor eating questionnaire (Stunkard & Messick, 1985; Westerterp-Plantenga, Rolland, Wilson, & Westerterp, 1999). Smokers and subjects with prescribed medication, except for contraceptives, were excluded from participating in the study. Subjects were paid for their involvement, and gave informed consent. Testing took place at NIZO Food Research (Ede, The Netherlands) in a laboratory setting by trained staff on four consecutive morning sessions of 1½-h each, from 8:15 a.m. to 9:45 a.m., with a minimum interval of 1 week between each session. All subjects arrived in a fasting state. Individual weight and height were measured while subjects wore indoor clothing and no shoes. The subjects were normal-weight subjects with a body mass index (BMI) varying between 20 and 25 kg/m^2, calculated as weight (kg) divided by height (m) squared.

2.2. Aromas

Five food-related aromas, i.e. vanilla (vanillin; 5 g/l), lemon (citral; 2.5 ml/l), strawberry (European COST 921 action; 2.5 ml/l), chocolate (3-methylbutanal; 2.5 ml/l) and buttery (2,3-butanedione; 2.5 ml/l), and two non-food-related aromas, i.e. rubbery (benzothiazol; 2.5 ml/l) and lavender (2,6-dimethyl-2-heptanol; 12.5 ml/l), were evaluated for their level of congruency with creamy texture as well as for liking and familiarity. Hereto, 51 panellists took a spoon full of the non-aromatised creamy custard while smelling the seven different aromas separately using dedicated flavour test strips (Aldrich, Zwijndrecht, The Netherlands). Subjects rated the congruency ("how well does this aroma fit with the custard?") of each aroma with the creamy texture of the custard and aroma-liking ("how much do you like this aroma?") and familiarity ("how familiar are you with this aroma?") using a 100-mm VAS labelled with "not at all" and "very much" at their ends. Of the aromas associated with foods, vanilla aroma was perceived as most congruent with respect to a creamy texture (Fig. 1) (2A02405, 2000 ppm) and lemon aroma was perceived as incongruent with respect to creamy texture (Fig. 1) (DU64668, 1000 ppm). Aroma concentrations were matched with regard to their subjective intensities in the custard.

2.3. Product preparation

Batches of non-aromatised creamy custard of 566 kJ/100 g were produced by Friesland Foods (Deventer, The Netherlands) and contai[illegible]0% milk, 3.1% starch, and 6.5% sugar, which corresponds to 7.6 (w/w)% fat, 14.1 (w/w)% carbohydrates, and 3.2 (w/w)% protein. Each batch was surveyed for microbiological safety and approved if appropriate according to the guidelines of the Dutch Food and Drug Act (VWS/VWA) and the European Directive 2073/2005. The two aromas were added to the creamy custard following a standard procedure of continuous stirring. Then the custards were left at 5 °C for at least 36 h before testing by the panellists, to allow a good equilibration of the aroma within the product.

2.4. Design and procedure

The subjects firstly consumed the fixed preload consisting of a 150 g portion (850 kJ) of either the vanilla- or the lemon-aromatised custard within 5 min, as illustrated in Fig. 2. Then, 15 min after finishing the preload intake, subjects were offered an *ad libitum* meal of 900 g of either the vanilla- or the lemon-aromatised custard, and were asked to eat of this portion as much as they would like until they felt pleasantly full. Congruency (high vs. low) and sensory variety in time of aroma–texture combinations were manipulated in a two-by-two full-factorial design. After *ad libitum* consumption, the left-over of the custards were weighed, and the amount of custard eaten was calculated. At eight specific time points during the test session, subjects were asked to rate their perceived satiation ("how satiated are you?") on 100-mm VAS, anchored at their ends by the descriptors "not at all" and "very much" (Fig. 2), as previously described (Flint, Raben, Blundell, & Astrup, 2000). In addition, after preload and after *ad libitum* consumption, subjects rated their liking for the product consumed ("how much do you like the product?") using 100-mm VAS with the descriptors "not at all" and "very much" at their ends (Fig. 2).

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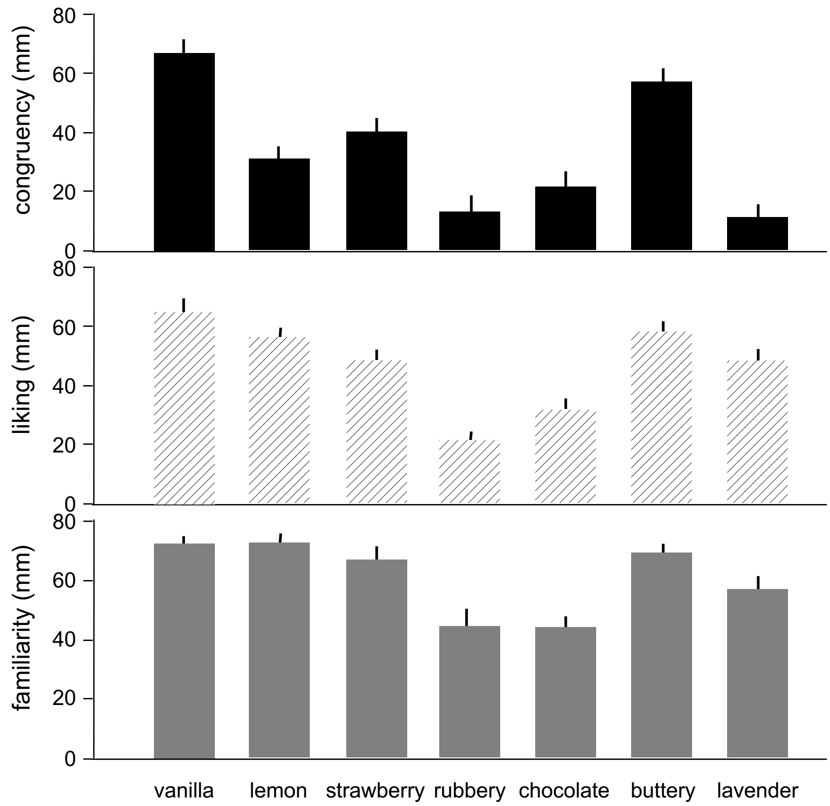

Fig. 1. Ratings of congruency to creamy texture, liking and familiarity of seven different aromas measured during intake of non-aromatised creamy custard. Bars are SEM of 51 subjects.

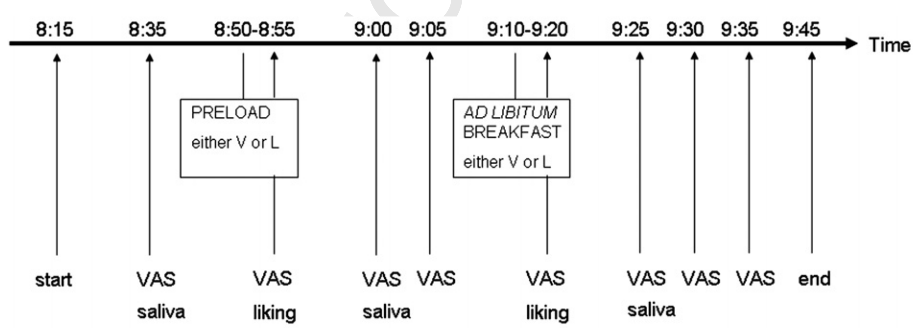

Fig. 2. Experimental setup with a preload – *ad libitum* regimen of four possible aroma (V = vanilla, L = lemon) combinations.

At three time points during the test session, i.e. before preload, between preload and *ad libitum* intake, and after *ad libitum* intake (Fig. 2), saliva was collected.

2.5. Salivary α-amylase analysis

For collection of saliva, subjects chewed on a rolled 25-cm^2 sheet of parafilm (Parafilm® M, Pechiney Plastic Packaging, Chicago, IL, USA) for up to 1 min and spat into a polystyrene tube (Greiner Bio-One, Kremsmünster, Austria). The saliva was immediately placed into a freezer at −80 °C. For further analysis, saliva samples were defrozen and centrifuged at 1000*g* for 2 min. Determination of *in vitro* salivary α-amylase activity was performed with 10 μl of saliva by means of an α-Amylase Kinetic Reaction Kit (Salimetrics LLC, State College, PA, USA). According to the manufacturer's protocol, 2-chloro-*p*-nitrophenol linked with maltotriose was used as chromogenic substrate and measured at 405 nm. The intra-assay variation was from 2.5% to 7.2%, and the inter-assay variation was from 3.6% to 5.8%.

2.6. Data analysis

Data are expressed as mean ± SEM, unless otherwise specified. VAS ratings on congruency, liking, familiarity, and satiation were measured in mm from the "not at all" end. Changes (delta) in satiation ratings were calculated by subtracting the rating at the time point before preload consumption from the ratings at the different time points after preload and *ad libitum* intake. Salivary α-amylase concentrations were determined as *in vitro* activity in U/ml. Also changes (delta) in salivary α-amylase levels were calculated by subtracting the α-amylase concentration at the time before preload consumption from the α-amylase concentration at the time

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points after intake. Effects of aroma–texture congruency and variation of successive exposure of aroma–texture combinations were tested on the amount of different aromatised custards consumed *ad libitum*, delta satiation rating, and (delta) salivary α-amylase concentration. Liking ratings were compared between the two aromatised custards at the two time points, i.e. after preload and *ad libitum* intake. Effect of time was tested for delta satiation ratings and salivary α-amylase. Also the effect of aroma type of the *ad libitum* meal was tested for the amount of *ad libitum* intake, for delta satiation ratings and for salivary α-amylase concentrations after the *ad libitum* intake. All effects were tested by repeated measures analysis of variance (ANOVA). Differences with *p*-values of 0.05 or less were considered to be statistically significant. All data were analysed by using the statistical packages SAS (version 9.1; SAS Institute, Cary, NC, USA) and SPSS (version 14.0; SPSS, Chicago, IL, USA).

3. Results

For all 32 subjects mean age (±SD) was 29.3 ± 6.2 years and mean BMI (± SD) was 23.4 ± 1.9 kg/m^2.

3.1. Congruency, liking and familiarity ratings

Congruency scores of aromas with respect to the creamy custard were highest for vanilla (67 mm), followed by buttery (57 mm) and strawberry (40 mm) aroma (Fig. 1). Fig. 1 further shows that lemon (31 mm) and chocolate (22 mm) scored considerably less on congruency, whereas rubbery (13 mm) and lavender (11 mm) were very incongruent aromas with respect to the creamy custard. Liking scores for vanilla (65 mm), buttery (59 mm) and lemon (56 mm) aromas were highest, whereas liking scores for strawberry and lavender aroma were lower (48 mm), and chocolate (32 mm) and rubbery (21 mm) were lowest. Furthermore, aromas of lemon (73 mm), vanilla (72 mm), buttery (69 mm) and strawberry (67 mm) were rated as highly familiar, while aromas of lavender (57 mm), rubbery (45 mm) and chocolate (44 mm) were rated lower for familiarity.

3.2. Ad libitum intake

After vanilla-aromatised preload intake, the amount of vanilla- and lemon-aromatised custard consumed *ad libitum* was 228 ± 31 g and 220 ± 33 g, respectively, while after lemon-aromatised preload intake, the amount of lemon- and vanilla-aromatised custard eaten *ad libitum* was 250 ± 35 g and 237 ± 33 g, respectively (Fig. 3). These amounts did not differ significantly between the two preload conditions, so no effect of congruency was found with respect to the food intake amount. Also, no effects were found for variety of aroma combinations and aroma type of the *ad libitum* meal on the *ad libitum* amount eaten. The averaged amount of custard consumed *ad libitum* was 241 ± 16 g (1365 ± 92 kJ), irrespectively of preload.

3.3. Satiation ratings

Immediately after preload consumption and 5 and 10 min after preload intake, delta satiation VAS ratings was 21 ± 3 mm for vanilla-aromatised custard and 21 ± 3 mm for lemon-aromatised custard. No effect of aroma–texture congruency was found on delta perceived satiation for the two differently aromatised intakes as measured at 5 min after preload intake. After *ad libitum* consumption, the averaged delta satiation VAS rating was 39 ± 3 mm as compared to before preload intake. An effect of variety in aroma–texture combinations on successive intakes was demonstrated for the delta satiation VAS ratings measured at 5 min after the *ad libitum* meal ($p < 0.05$) (Fig. 4), whereas no effect of last aroma type was found. Thus, consumption of identically aromatised preload and *ad libitum* meals resulted in higher delta satiation ratings than varied aromatised successive meals.

3.4. Liking ratings

With respect to liking of the vanilla- and lemon-aromatised custards rated after consumption of preload and *ad libitum* meal, subjects evaluated these two aromatised custards significantly different (Fig. 5), which is in line with the previous results on liking (Fig. 1). After preload intake, in one occasion, lemon-aromatised was less liked than vanilla-aromatised custard ($p < 0.05$). After *ad libitum* consumption, also in one occasion, the liking of lemon-aromatised custard was lower than the vanilla-aromatised custard ($p < 0.05$).

3.5. Salivary α-amylase

For all four combinations, an effect of time was found on salivary α-amylase concentrations ($p < 0.001$), shown by a first increase after preload intake and a second increase after *ad libitum* ingestion (Fig. 6). Neither an effect of custard combination nor interaction of time × custard combination was found. After preload

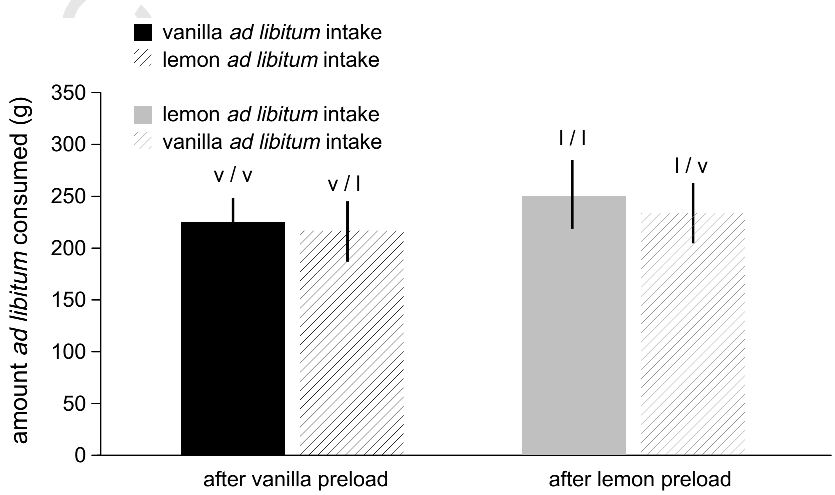

Fig. 3. Intake of the different aromatised creamy custards after preload consumption. Bars are SEM of 32 subjects.

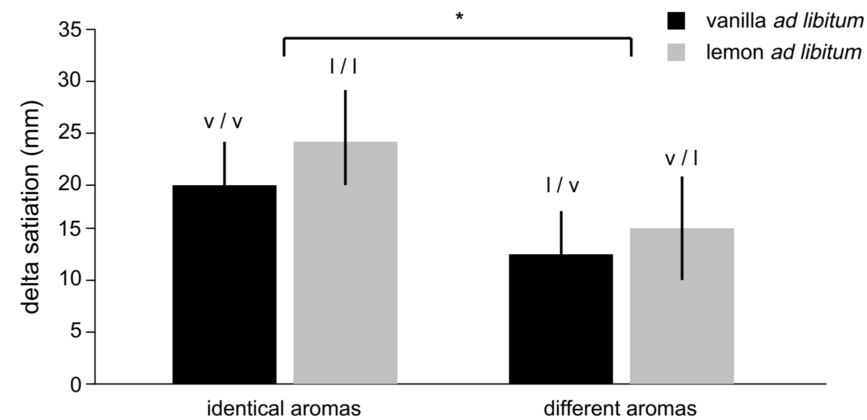

Fig. 4. Delta satiation VAS ratings after *ad libitum* consumption as compared to before *ad libitum* intake. Bars are SEM of 32 subjects. $^{*}p < 0.05$ (repeated measures ANOVA).

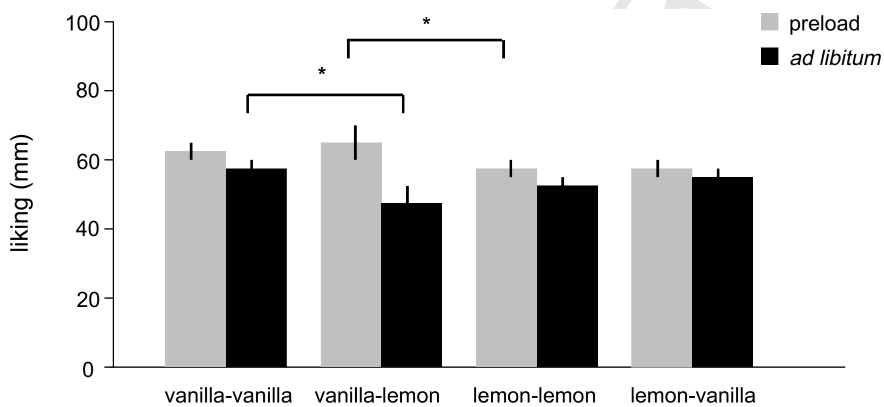

Fig. 5. Liking ratings of the two aromatised custards measured after preload and *ad libitum* intake at all four combinations were slightly different. Bars are SEM of 32 subjects. $^{*}p < 0.05$.

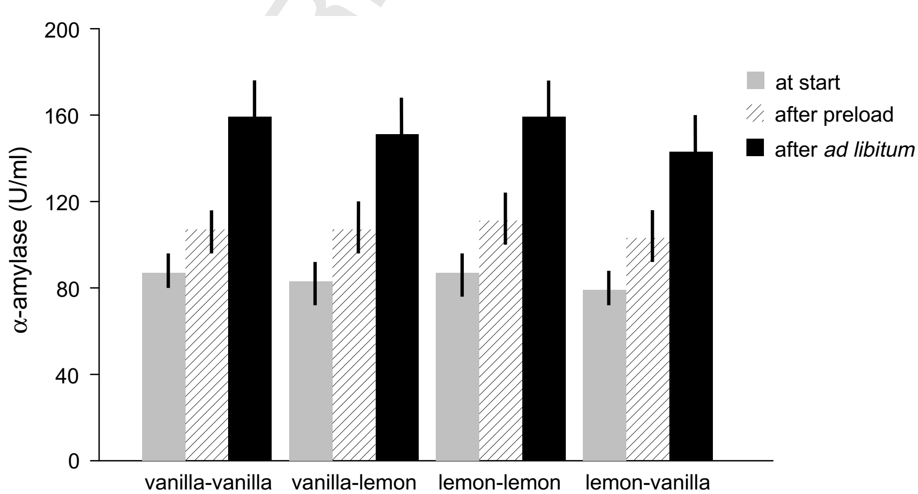

Fig. 6. Salivary α-amylase concentrations at start and after preload and *ad libitum* intake for all four combinations. Bars are SEM of 32 subjects.

ingestion, delta salivary α-amylase was 21.7 ± 4.7 U/ml for vanilla-aromatised custard and 23.7 ± 5.3 U/ml for lemon-aromatised custard. No effect of aroma–texture congruency for delta salivary α-amylase levels was found between the two differently aromatised preload intakes. No effect of variety in aroma combinations in the intakes was found for delta salivary α-amylase concentrations after the *ad libitum* intake (Fig. 7). Thus, consumption of identically aromatised preload and *ad libitum* meals in succession did not result in different salivary α-amylase concentrations in the end than intake of varied aromatised preload and *ad libitum* meals. There was no effect of aroma type of the *ad libitum* meal on salivary α-amylase concentration.

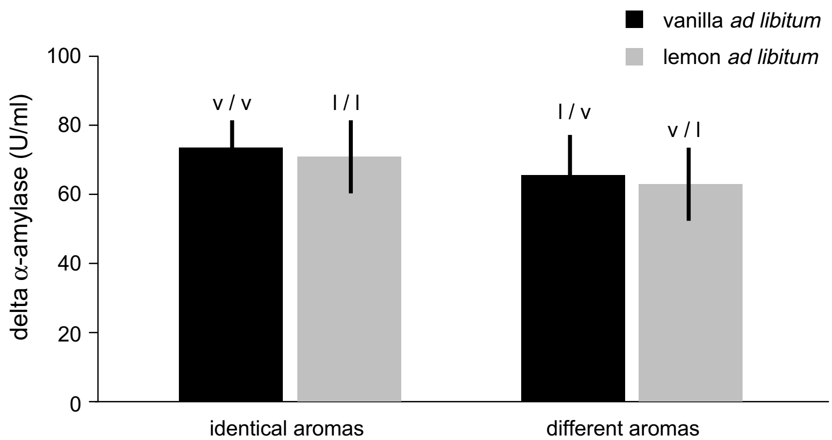

Fig. 7. Delta salivary α-amylase levels after *ad libitum* intake as compared to before *ad libitum* consumption of the different custard combinations. Bars are SEM of 32 subjects.

4. Discussion

In the present study, effects of congruency level of aroma–texture combinations within dairy custard and the effects of successive aroma variation of dairy custards were evaluated on satiation and the amount of food intake in humans. A preload – *ad libitum* intake regimen of creamy custards, either aromatised with a vanilla or a lemon aroma, congruent or incongruent to creamy texture, respectively, resulted in four possible combinations of aromatised custard consumption. In spite of the different congruency scores of these two aromas with respect to the custard, their liking and familiarity are more or less the same indicating that both aromas are well-recognized and congruency scores do not depend on familiarity scores. This gave the opportunity to study not only the amount of *ad libitum* intake possibly influenced by aroma–texture congruency and different successive aroma–texture combinations, but also to follow satiation patterns, that possibly influence the amount of a subsequent *ad libitum* meal in a fixed time period.

The presence of different aromas within custards did not influence the amounts of *ad libitum* intake, which shows that there was no effect of aroma–texture congruency of dairy custard on *ad libitum* food consumption. While the amount eaten *ad libitum* is a direct inverse measure for satiation for the custard, this finding is further substantiated by unchanged satiation during the different intakes, both VAS-rated and measured by salivary α-amylase levels. With regard to variation in successive exposure to aroma–texture combinations within dairy custard, subjects did not differ in their amount of *ad libitum* consumed custard between similarly aromatised custards in succession and varied aromatised custard combinations. Furthermore, no difference was found in satiation as measured by delta salivary α-amylase concentrations between the similarly and varied aromatised regimens, thus, no effect of successive variety in aroma combinations. However, the increase in perceived satiation VAS ratings was less after consuming custards accompanied by different aromas in varied combinations. Although, neither supported by changes in salivary α-amylase level nor attributed to differences in the *ad libitum* food consumption, this might point to a 'seeking for variety' principle in *ad libitum* meal situations, which has been reported previously on subjects eating sandwiches or yoghurts distinctive in taste, texture, and appearance (Rolls et al., 1981). Interestingly, in the present study this variety-seeking behaviour was induced by merely changing the aroma type of the product, while other food characteristics like appearance and ingredient composition, which largely determines texture, remained the same.

In this study subjects evaluated liking of the vanilla- and lemon-aromatised custards differently. First, liking of vanilla-aromatised custard was slightly higher compared to lemon-aromatised custard after preload intake. Second, after vanilla-aromatised preload consumption subjects liked the lemon-aromatised custard in the *ad libitum* meal less than the vanilla-aromatised one. Whether this is due to a difference in liking only or also to changes in perceived satiation is unclear. Liking assessments are complex, since different psychological or functional components of pleasure of eating can be distinguished as separate neural substrates mostly driven without conscious awareness (Berridge, 1996).

A final important point in this context is the role of sensory-specific satiation and food variation on energy intake and overweight in humans. Although overweight and normal-weight subjects do not differ in their sensitivity to sensory-specific satiety and hedonic control of food ingestion (Snoek, Huntjens, Van Gemert, De Graaf, & Weenen, 2004; Brondel et al., 2006), variation in food sensory characteristics may lead to overconsumption (Raynor & Epstein, 2001; Sørensen et al., 2003). In the present study, only at the perceptual level of satiation there is basis for a possibility of an increased food intake when variety of food sensory characteristics rises. This implies that if satiation is specific to a food that has been eaten, overeating may occur when a wide variety of foods is readily available.

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References

Bellisle, F., Louis-Sylvestre, J., Demozay, F., Blazy, D., & Le Magnen, J. (1985). Cephalic phase of insulin secretion and food stimulation in humans: A new perspective. *American Journal of Physiology – Endocrinology and Metabolism, 249*, E639–E645.

Berridge, K. C. (1996). Food reward: Brain substrates of wanting and liking. *Neuroscience and Biobehavioral Reviews, 20*, 1–25.

Blundell, J. E., Lawton, C. L., Cotton, J. R., & Macdiarmid, J. I. (1996). Control of human appetite: Implications for the intake of dietary fat. *Annual Review of Nutrition, 16*, 285–319.

Brondel, L., Romer, M., Van Wymelbeke, V., Walla, P., Jiang, T., & Deecke, L., et al. (2006). Sensory-specific satiety with simple foods in humans: No influence of BMI? *International Journal of Obesity, 31*, 987–995.

Brunstrom, J. M., & Mitchell, G. L. (2006). Effects of distraction on the development of satiety. *British Journal of Nutrition, 96*, 761–769.

Please cite this article in press as: Harthoorn, L. F. et al., Effects of aroma–texture congruency within dairy custard ..., *Food Quality and Preference* (2008), doi:10.1016/j.foodqual.2008.05.004

Bult, J. H. F., De Wijk, R. A., & Hummel, T. (2007). Investigations on multimodal sensory integration: Texture, taste, and ortho- and retronasal olfactory stimuli in concert. *Neuroscience Letters, 411*, 6–10.

Flint, A., Raben, A., Blundell, J. E., & Astrup, A. (2000). Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *International Journal of Obesity, 24*, 38–48.

Frank, R. A., & Byram, J. (1988). Taste-smell interactions are tastant and odorant dependent. *Chemical Senses, 13*, 445–455.

Gale, S. M., Castracane, V. D., & Mantzoros, C. S. (2004). Energy homeostasis, obesity and eating disorders: Recent advances in endocrinology. *Journal of Nutrition, 134*, 295–298.

Harthoorn, L. F., Schipper, R. G., Loof, A., Vereijken, P. F. G., Van Heerde, W. L., & Dransfield, E. (2007). Salivary biomarkers associated with perceived satiety and body mass in humans. *Proteomics Clinical Applications, 1*, 1525–1538.

Harthoorn, L. F., & Dransfield, E. (2008). Periprandial changes of the sympathetic-parasympathetic balance related to perceived satiety in humans. *European Journal of Applied Physiology, 102*, 601–608.

Hetherington, M. M. (1996). Sensory-specific satiety and its importance in meal termination. *Neuroscience and Biobehavioral Reviews, 20*, 113–117.

Hirsch, A. R., & Gomez, R. (1995). Weight reduction through inhalation of odorants. *Journal of Neurological and Orthopaedic Medicine and Surgery, 16*, 28–31.

Mattes, R. D. (1997). Physiologic responses to sensory stimulation by food: Nutritional implications. *Journal of the American Dietetic Association, 97*, 406–413.

Mayer, S. N., Davidson, R. S., & Hensley, C. B. (1999). The role of specific olfactory stimulation in appetite suppression and weight loss. *Journal of Advancement in Medicine, 12*, 13–21.

Raynor, H. A., & Epstein, L. H. (2001). Dietary variety, energy regulation, and obesity. *Psychological Bulletin, 127*, 325–341.

Rolls, B. J., Rowe, E. A., Rolls, E. T., Kingston, B., Megson, A., & Gunary, R. (1981). Variety in meal enhances food intake in man. *Physiology and Behavior, 26*, 215–221.

Rolls, B. J., Rowe, E. A., & Rolls, E. T. (1982). How sensory properties of food affect human feeding behaviour. *Physiology and Behavior, 29*, 409–417.

Romer, M., Lehrner, J., Van Wymelbeke, V., Jiang, T., Deecke, L., & Brondel, L. (2006). Does modification of olfacto-gustatory stimulation diminish sensory-specific satiety in humans? *Physiology and Behavior, 87*, 469–477.

Ruijschop, R. M., Boelrijk, A. E., De Ru, J. A., De Graaf, C., & Westerterp-Plantenga, M. S. (2008). Effects of retro-nasal aroma release on satiation. *British Journal of Nutrition, 99*, 1140–1148.

Schifferstein, H. N. J., & Verlegh, P. W. J. (1995). The role of congruency and pleasantness in odor-induced taste enhancement. *Acta Psychologica, 94*, 87–105.

Schwartz, M. W., Woods, S. C., Porte, D., Seeley, R. J., & Baskin, D. G. (2000). Central nervous system control of food intake. *Nature, 404*, 661–671.

Snoek, H. M., Huntjens, L., Van Gemert, L. J., De Graaf, C., & Weenen, H. (2004). Sensory-specific satiety in obese and normal-weight women. *American Journal of Clinical Nutrition, 80*, 823–831.

Sørensen, L. B., Møller, P., Flint, A., Martens, M., & Raben, A. (2003). Effect on sensory perception of foods on appetite and food intake: A review of studies in humans. *International Journal of Obesity, 27*, 1152–1166.

Stunkard, A. J., & Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research, 29*, 71–83.

Westerterp-Plantenga, M. S., Rolland, V., Wilson, S. A., & Westerterp, K. R. (1999). Satiety related to 24 h diet-induced thermogenesis during high protein/carbohydrate vs. high fat diets measured in a respiration chamber. *European Journal of Clinical Nutrition, 53*, 495–502.