Quantitative and Qualitative Variation of Fat in Model Vanilla Custard Desserts: Effects on Sensory Properties and Consumer Acceptance

Maja Tomaschunas, Ehrhard Köhn, Petra Bennwitz, Jörg Hinrichs, and Mechthild Busch-Stockfisch

Abstract: The effects of variation in fat content (0.1% to 15.8%) and type of fat, using different types of milk, dairy cream, or vegetable fat cream, on sensory characteristics and consumer acceptance of starch-based vanilla model custards were studied. Descriptive analysis with trained panelists and consumer testing with untrained assessors were applied. Descriptive data were related to hedonic data using principal component analysis to determine drivers of liking and disliking. Results demonstrated an increasing effect of fat concerning visual and oral thickness, creamy flavor, and fat-related texture properties, as well as a decreasing effect concerning yellow color and surface shine. A lack of fat caused moderate intensities in pudding-like flavor attributes and an intensive jelly texture. Adding a vegetable fat cream led to lower intensities in attributes yellow color, cooked flavor, thick, and jelly texture, whereas intensities in vegetable fat flavor and fat-related texture properties increased. All consumers favored custards with medium fat contents, being high in pudding-like and vegetable fat flavor as well as in fat-related texture attributes. Nonfat custards were rejected due to jelly texture and moderate intensities in pudding-flavor attributes. High-fat samples were liked by some consumers, but their high intensities in thickness, white color, and creamy flavor also drove disliking for others.

Keywords: consumer acceptability, descriptive analysis, fat content, principal component analysis, vanilla custard

Practical Application: Consumers' concerns about obesity, diseases, and fat in foods change and the demand for fat reduced food increases. Therefore, the food industry is facing a challenge to produce fat-reduced products with comparable characteristics to the full-fat counterparts. With the intention of reducing fat in food, it is important to evaluate its effect on sensory properties. Furthermore, it has to be examined, how fat affects consumer liking and which sensory properties are responsible for the results. Representing a semisolid model food, the effects of fat were studied in model vanilla custard.

Introduction

Due to the increasing consumer interest for energy and fat-reduced products, it is necessary to replace fat in food without decreasing the food quality and eating pleasure and this is one of the leading priorities of researchers in today's food industry. But fat affects appearance, flavor, and texture and many desired attributes are linked to the fat content of a food product (Drewnowski 1987). For instance, if the expected appearance of a food changes due to fat reduction such as lack of gloss or opacity, the consumer might suppose a less rich and less creamy texture (Civille 1990). Moreover, changing the amount of fat changes the fullness of texture or the perceived creamy texture as well as the flavor strength and the duration of flavor perception (Shamil and others 1991/1992; De Roos 1997; Frost and Janhoj 2007). However, the perception of fat is food-specific (Drewnowski and others 1989; Mela and Sacchetti 1991) and therefore an illustration of the impact of fat in a certain food matrix and how it can be replaced is required.

Vanilla flavored dairy desserts are widely consumed in Europe such as "Natillas" in Spain, "Vanilla vla" in The Netherlands, and "Crème dessert" in France and they are favored by the consumer due to their sensory properties but also due to their nutritional value (Tárrega and Costell 2007). In Germany, vanilla custards are known as "Vanillepudding". Custards are useful model foods representing semisolid dairy products due to their simple structure and the relatively small number of ingredients (milk, sucrose, thickeners, colorants, and aroma).

Numerous studies have been published dealing with the sensory and/or rheological evaluation of commercially available vanilla custards (De Wijk and others 2003a; Tárrega and others 2004; 2005; Weenen and others 2005; González-Tomás and Costell 2006; De Wijk and Prinz 2007) or model vanilla custard desserts (De Wijk and others 2003b; Vélez-Ruiz and others 2005; De Wijk and others 2006; Tárrega and Costell 2006), amongst others studying the effect of fat. Elmore and others (1999) evaluated the sensory characteristics as well as the liking of creamy texture of vanilla puddings with varying amounts of milk fat and sodium salts, and variations in the amount and type of starch. But little or no research was conducted about the effects of variation in fat content and type of fat in model custard desserts regarding both

MS 20121720 Submitted 12/14/2012, Accepted 7/3/2013. *Authors Tomaschunas, Khn, and BuschStockfisch are with Dept. of Nutrition and Home Economics, Faculty of Life Sciences, Hamburg Univ. of Applied Sciences (HAW), Lohbruegger Kirchstrasse 65, 21033 Hamburg, Germany. Author Bennwitz is with Dr. August Oetker Nahrungsmittel KG, Research and Development, Artur-Ladebeck-Strasse 100, 33647 Bielefeld, Germany. Author Hinrichs is with Dept. of Dairy Science and Technology, Inst. of Food Science and Biotechnology, Univ. of Hohenheim, Garbenstrasse 21, 70599 Stuttgart, Germany. Direct inquiries to author Tomaschunas (E-mail: majatomaschunas@gmx.de).*

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Table 1–Composition of the liquid phase, total fat content, and sample identification of the evaluated 6 custard variants.

Liquid phase composition	Total fat content in%	Sample identification
100% UHT milk (0.1% fat)	0.1	0.1% (only milk)
100% UHT milk (1.5% fat)	1.5	1.5% (only milk)
75% UHT milk (1.5% fat), 25% vegetable fat cream (7.0% fat)	2.9	2.9% (with vegetable fat)
100% UHT milk (3.5% fat)	3.5	3.5% (only milk)
75% UHT milk (1.5% fat), 25% UHT dairy cream (30.0% fat)	8.6	8.6% (with dairy cream)
50% UHT milk (1.5% fat), 50% UHT dairy cream (30.0% fat)	15.8	15.8% (with dairy cream)

Abbreviations are: UHT, ultra-high temperature.

Table 2–Ingredient list of the liquid-phase components that consisted of more than 1 ingredient.

Liquid phase components	Ingredients
UHT dairy cream (30.0% fat)	Cream, carrageenan
Vegetable fat cream (7.0% fat)	Water, skim milk (20%), buttermilk (12%), vegetable fat (3.5%), vegetable oil (3.5%), modified starch, milk sugar, stabilizers (methyl cellulose, xanthan gum, carrageenan), sugar, emulsifier E 435, aroma, colorant carotene

Abbreviations are: UHT, ultra-high temperature.

the sensory properties and consumer acceptance as well as relations between both data sets.

The objectives of the present study were to examine the influence of qualitative and quantitative variation in fat on sensory properties of starch-based vanilla model custard desserts (1), to evaluate associated effects on consumers' acceptability (2) as well as to determine accordant drivers of liking and disliking (3).

Materials and Methods

Samples

Vanilla custard samples were prepared on the basis of a starch-based vanilla custard powder that requires cooking, kindly provided by Dr. August Oetker Nahrungsmittel KG, Bielefeld, Germany. The custard powder, from the same batch, consisted of starch, salt, aroma, and colorant β-carotene. The prepared samples differed in fat content (0.1% to 15.8%) due to the fat content of the used milk, the addition of dairy cream, or the addition of a commercially available vegetable fat cream (an alternative mix of milk, vegetable fats, and stabilizers). Table 1 shows the liquid-phase compositions and the total fat contents of the 6 sample variants. Additionally, Table 2 demonstrates the particular ingredients of those liquid-phase components consisting of more than 1 ingredient.

Each sample batch was prepared from 111 g custard powder, 120 g sucrose, and 1500 g of the required liquids, resulting in 23 portions of, respectively, 65 to 75 g for the panelists or 34 portions of, respectively, 40 to 50 g for the consumers. Consequently, samples for panelists were, respectively, prepared from 1 batch, whereas samples for consumers needed the preparation of 2 batches. The custard powder was sifted and then mixed manually with the sugar using a whisk in a stainless steel bowl. Subsequently, 150 g of the wet ingredients or rather 300 g, when containing cream or vegetable fat cream (due to a higher viscosity), were gradually added to the dry ingredients and mixed manually with a whisk, free from lumps. The remaining wet ingredients were heated in a cooking pot on a mobile ceramic glass cooktop at maximum capacity up to endpoint cooking temperature (98 °C). Frequent manual stirring with a whisk during heating was necessary to avoid scorching. After turning the cooktop off, the cooking pot was first removed, and then the dry solid–liquid phase mix was stirred to the heated liquid phase with a whisk. Afterward, it was heated on the cooktop for 60 s using the residual heat. Custards were filled in 100 mL transparent plastic cups, coded with 3-digit random numbers. Samples cooled down at room temperature for 1 h, were capped, and refrigerated at 8 °C for approximately 24 h up to 90 min prior to the evaluation.

Sensory analysis

Sensory descriptive analysis adapted from quantitative descriptive analysis (QDA®) procedure (Stone and Sidel 1985) was applied to evaluate sensory properties and to identify differences and similarities between the custard samples. Descriptive analysis was carried out at the Sensory Laboratory at Hamburg Univ. of Applied Sciences, Hamburg, Germany. Consumer acceptability testing was conducted at the Sensory Laboratory of Dr. August Oetker Nahrungsmittel KG, Bielefeld, Germany. Both descriptive analysis and consumer testing were carried out in June 2010, in a standard room equipped with 12 separate booths according to international standards for test rooms (ISO 2007) at room temperature (21 ± 2 °C). Panelists and consumers evaluated the 6 samples, being served with filtered tap water, cucumber pieces, and matzo for neutralization between attributes and samples. Custards were positioned in randomized order among panelists and consumers corresponding to Williams Latin Square (MacFie and others 1989) and were evaluated semi-monadically. Data collection was carried out using FIZZ software (Biosystèmes, Couternon, France, version 2.31 G), at which each attribute appeared on a monitor. Using a mouse, panelists and consumers rated the different properties on the accordant scale.

Sensory descriptive analysis

Panel selection. A group of 22 panelists (4 males and 18 females, aged between 18 and 24), which were students from Hamburg Univ. of Applied Sciences, was selected based on motivation, availability, ability to discriminate between samples, and liking of vanilla custard. They were previously trained according to ISO guidelines (ISO 1993) and were experienced (1 y) in sensory evaluation of dairy products and various food systems varying in fat content.

Generation of sensory descriptors and panel training. Term generation was carried out using commercial and differently prepared model custards representing a large product space. After three 1-h training sessions, including generation, discussion, and reduction of sensory attributes, 16 descriptors concerning appearance (4), odor (1), flavor/taste (6), and texture/mouth feel (5) were found to describe the sensory properties and to discriminate among starch-based vanilla custards. Attributes, in order of perception and their descriptions, which were verbally defined by the panel, are given in Table 3.

Providing various commercial and model custards as well as further suitable food samples as references for the selected descriptors, panelists were trained during 4 additional 1-h sessions to share a similar understanding of the properties. Assessors who showed different rating tendency were given additional training. Being

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Table 3–Sensory attributes with definitions describing model vanilla custards.

	Attribute	Definition
Odor	**Vanilla**	**Intensity of vanilla aroma**
Appearance	Color	Color intensity, from pale/white to yellow
	Skin formation	Thickness of skin at the surface
	Surface shine	Degree of shine on the surface/reflected light from the surface
	Thick	Visual thickness
Flavor/taste	Sweet	Intensity of sweetness
	Vanilla	Intensity of vanilla flavor
	Cooked	Intensity of cooked milk flavor
	Vegetable fat	Intensity of vegetable oil/fat flavor
	Creamy	Intensity of perceived flavor associated with fresh dairy cream
	Harmonious	Intensity of a harmonious taste sensation, absence of any off-flavors, and too intensive flavors
Texture/ mouth feel	Thick	Perceived thickness in the mouth
	Jelly	Intensity of jelly texture, reminding of gelatin
	Sticky	Sticky/adhesive feeling in the mouth/difficult to swallow and to remove
	Creamy	Personal definition of creaminess in the mouth, associated with a velvety and smooth mouth feel
	Fatty	Fatty/oily consistency and layer, reminding of mayonnaise

Anchors: very little—very much.

familiar with the attributes' definitions, pilot tests were carried out over 2 sessions in order to familiarize the assessors with the scaling procedure as well as to test the panel consonance (training was continued until results showed good reproducibility, data not shown). Results and difficulties were discussed after each training session in consensus.

Evaluation procedure. The 6 custard samples were evaluated in duplicate over 2 sessions using an 11-point categorical scale, ranging from "very little" (0) to "very much" (10). Attribute definition sheets were provided in order to avoid uncertainty. The order of attributes among panelists and sessions was the same, starting with odor and continuing with appearance, flavor/taste, and texture/mouth feel attributes. Time intervals between attributes and samples were chosen individually.

Consumer acceptability test

Selection of consumers. The consumer panel included 66 consumers (50 females and 16 males, aged between 18 and 71) without previous experience in sensory descriptive analysis but with experience in different consumer tests. They were selected at random from an in-house Database of Dr. August Oetker Nahrungsmittel KG, Bielefeld, Germany, consisting of private person. However, selection was based on liking as well as on regular usage of vanilla custard.

Evaluation procedure. Consumers were first instructed on the evaluation procedure. The hedonic test started with questions about demographics (age, gender) and product usage information (frequency of usage, data not shown). Afterward, consumers evaluated the samples for appearance, flavor, texture, and overall liking using a 9-point hedonic scale that was ranged from "dislike extremely" (1) to "like extremely" (9). The 6 custard samples were evaluated over 1 session. Consumers individually chose the time interval between the different custards.

Statistical analysis

All statistical calculations were performed using the statistical analysis software XLSTAT (Addinsoft, Andernach, Germany, version 2012.1.01).

Descriptive analysis. In order to identify sensory attributes that discriminated between the custard samples, a 1-factor analysis of variance (ANOVA) was performed on each sensory descriptor. Tukey's test ($P < 0.05$) was exerted to determine significant differences between the custards. Furthermore, principal component analysis (PCA) was applied on the mean attribute scores of attributes that discriminated significantly between the custards to reduce the sensory dimensions and to visualize relations between samples and attributes. For sake of clarity, PCA was applied separately for properties appearance, flavor/taste, and texture/mouth feel. Trained panel data of the 1st and 2nd repetition were compared by means of ANOVA to control the panel performance and showed a reliable reproducibility of the data (data not shown).

Consumer acceptability test. Hedonic judgments concerning appearance, flavor, texture, and overall liking were also analyzed by means of a 1-factor ANOVA and Tukey's test ($P < 0.05$) to identify the best and least liked samples. Additionally, using Ward's agglomerative hierarchical clustering with Euclidean distances, cluster analysis was performed on the overall liking data, followed by a 1-factor ANOVA and Tukey's test on the liking scores of the obtained clusters.

Relationships between descriptive and hedonic data. PCA was also applied to relate overall liking data to sensory descriptive data and to identify the drivers of liking and disliking. For this purpose, the product overall liking means of the obtained clusters were used as supplementary variables.

Results and Discussion

Sensory descriptive analysis

Mean values of descriptive analysis, averaged across subjects and replicates, are given in Table 4. ANOVA results revealed significant differences among the samples in each attribute with the exception of odor attribute vanilla and flavor attribute sweet. Therefore, these attributes were excluded from further analysis. Relations between custard samples and sensory attributes are displayed in the PCA biplots, as shown in Figure 1, 2, and 3, separated into properties appearance, flavor/taste, and texture/mouth feel. The accordant factor loadings of the attributes are given in Table 5.

The reduction or elimination of fat in dairy products leads to changes in color, flavor, and particularly in texture properties due to changes in composition, structure as well as interactions among components (Guinard and others 1997; González-Tomás and others 2007). Comparing the ultra-high temperature (UHT) samples as well as the samples containing dairy cream, conclusions concerning the effect of fat can be drawn. In general, the comparison of the UHT custard samples showed that differences between fat contents 1.5% and 3.5% were marginal, whereas the sample with 0.1% fat differed largely from samples with 1.5% and 3.5% fat. This is comparable with the findings of Frost and others (2001), who observed that the influence of fat on sensory properties of milk was not linear. Larger sensory differences were detected between milk with 0.1% and 1.3% fat than between milk with 1.3% and 3.5% fat.

Table 4–Mean values of sensory attributes with Tukey's significant differences for the 6 custard samples.

	Attributes	0.1% (only milk)	1.5% (only milk)	2.9% (with vegetable fat)	3.5% (only milk)	8.6% (with dairy cream)	15.8% (with dairy cream)
Odor	Vanilla	4.3^{a}	5.2^{a}	5.3^{a}	5.0^{a}	4.8^{a}	4.6^{a}
Appearance	Color	6.6^{d}	4.1^{c}	3.1^{b}	2.9^{b}	1.8^{a}	2.0^{ab}
	Skin formation	4.3^{ab}	4.5^{ab}	3.8^{ab}	5.3^{b}	5.3^{b}	3.3^{a}
	Surface shine	5.1^{bc}	5.4^{bc}	6.0^{c}	4.5^{b}	2.4^{a}	1.1^{a}
	Thick	6.9^{bc}	6.2^{b}	4.1^{a}	6.6^{b}	7.7^{cd}	8.6^{d}
Flavor/taste	Sweet	5.7^{a}	6.5^{a}	6.8^{a}	6.1^{a}	5.7^{a}	6.2^{a}
	Vanilla	3.6^{a}	5.9^{b}	5.6^{b}	5.5^{b}	5.2^{b}	4.8^{ab}
	Cooked	2.4^{a}	4.7^{cd}	2.4^{ab}	5.2^{d}	4.6^{bcd}	3.1^{abc}
	Vegetable fat	0.6^{a}	1.1^{ab}	6.2^{c}	1.2^{ab}	1.9^{ab}	2.5^{b}
	Creamy	0.7^{a}	2.0^{ab}	1.7^{ab}	3.3^{bc}	5.0^{cd}	6.3^{d}
	Harmonious	2.8^{a}	6.1^{c}	5.1^{bc}	5.1^{bc}	5.1^{bc}	4.6^{b}
Texture/mouth feel	Thick	4.4^{b}	4.7^{b}	2.5^{a}	4.7^{b}	6.5^{c}	7.2^{c}
	Jelly	5.6^{c}	4.1^{b}	1.2^{a}	3.7^{b}	3.8^{b}	3.4^{b}
	Sticky	3.3^{a}	4.0^{ab}	5.5^{bc}	4.0^{abc}	5.1^{bc}	5.5^{c}
	Creamy	2.0^{a}	4.6^{b}	7.3^{c}	5.4^{bc}	5.3^{bc}	5.1^{b}
	Fatty	2.7^{a}	4.3^{b}	7.1^{d}	5.1^{bc}	5.7^{cd}	7.0^{d}

$^{a\text{-}d}$Means followed by the same letters within a row did not differ significantly ($P < 0.05$). Intensities were scored on an 11-point categorical scale. Identification of samples can be seen in Table 1.

Effect of fat on appearance. Regarding the PCA on appearance, results indicated that the first 2 components explained 80.4% of the variance (Figure 1). Principal component (PC) 1 (55.0% of the variance) ran from thick, correlating negatively with it, to color/surface shine, correlating positively with it. Consequently, thicker samples were more matt and less yellow, whereas visually softer samples were more yellow with a shiny surface. PC2 (25.4% of the variance) described the presence or absence of a skin. Being associated with the color/surface shine end and therefore being lower in thickness, samples with 0.1% and 1.5% fat were relatively similar, with the nonfat sample being more yellow and shiny. Additionally, these samples showed medium to moderate intensities in skin formation. The sample with 3.5% fat was associated with the skin formation end and showed medium intensities in PC1 attributes. Both cream samples were related to the thickness end and were whiter as well as less shiny than the other custards, but the custard with 8.6% fat had a thicker skin.

Regarding ANOVA (Table 4) and PCA results (Figure 1), decreased yellowness and therefore increased whiteness are assumed with increasing fat content, but without a significant difference between the cream samples. Similar results were found by Elmore and others (1999) who found fat to be responsible for a less yellow color. The increasing yellowness of the custards with decreasing fat content and the associated decreasing whiteness could be explained by color changes of milk with varying fat content. Phillips and others (1995) found out that milk samples became whiter

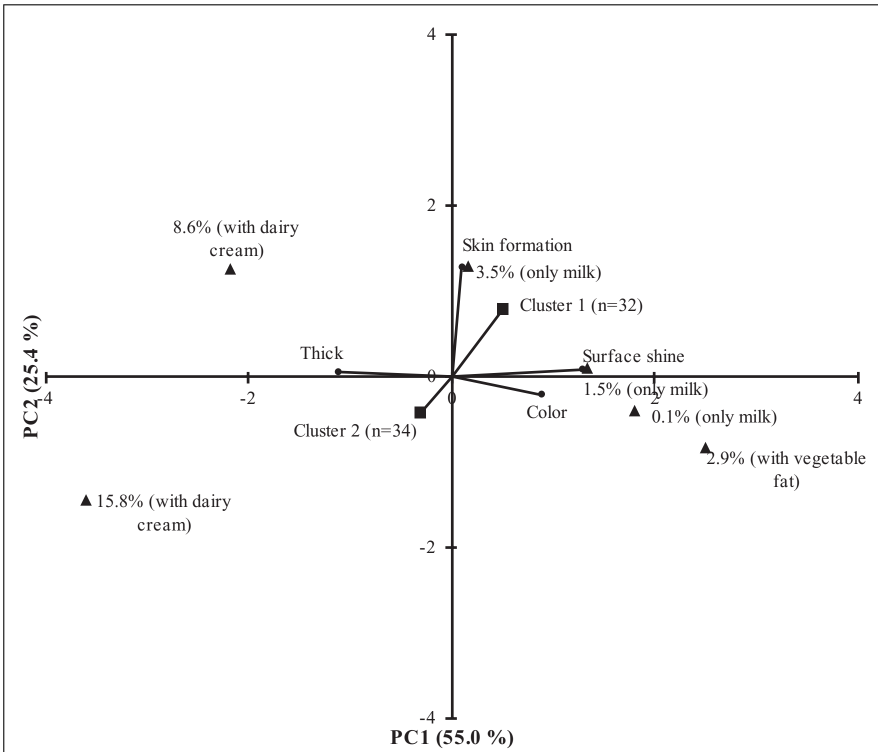

Figure 1–Parameter loadings and factor scores for principal component 1 (PC1) and principal component 2 (PC2), representing the relation between appearance attributes, the 6 custard samples and consumer clusters obtained from cluster analysis. The vectors of the clusters represent their direction of liking. Identification of samples can be seen in Table 1. Identification of clusters can be seen in Table 7.

with increasing fat content. Furthermore, fat posseses a whitening property, especially when products are homogenized (Dunkley 1982). The reduced whiteness or rather lightness with fat reduction could also be explained by reduced light scattering due to the light scattering properties of fat droplets (Chung and others 2013). Fat also affected the surface shine and visual thickness but differences were merely significant when comparing the UHT samples to the cream samples. Samples became matter and thicker when fat increased but this effect only related to larger differences in fat content or rather when dairy cream was added to the formulation. Differences in skin formation were merely significant between the high-fat (15.8%) sample and custards with 3.5% and 8.6% fat, with the high-fat sample having a thicker skin. Hence, no clear effect of fat on the skin formation could be detected.

Effect of fat on flavor/taste. PCA on flavor/taste revealed 3 meaningful dimensions. The PCA biplot (Figure 2) indicated that the first 2 components explained 80.8% of the total variance. PC1, describing 52.0% of the variance, was characterized by pudding-like flavor attributes (cooked flavor, vanilla flavor, and harmonious), which correlated positively with it. Whereas PC2 (28.8% of the variance) showed, whether a vegetable fat flavor occurred or not. PC3 accounted for further 17.7% of the variance and loaded heavily with creamy flavor. The nonfat sample (0.1%) was separated from the other samples and showed moderate

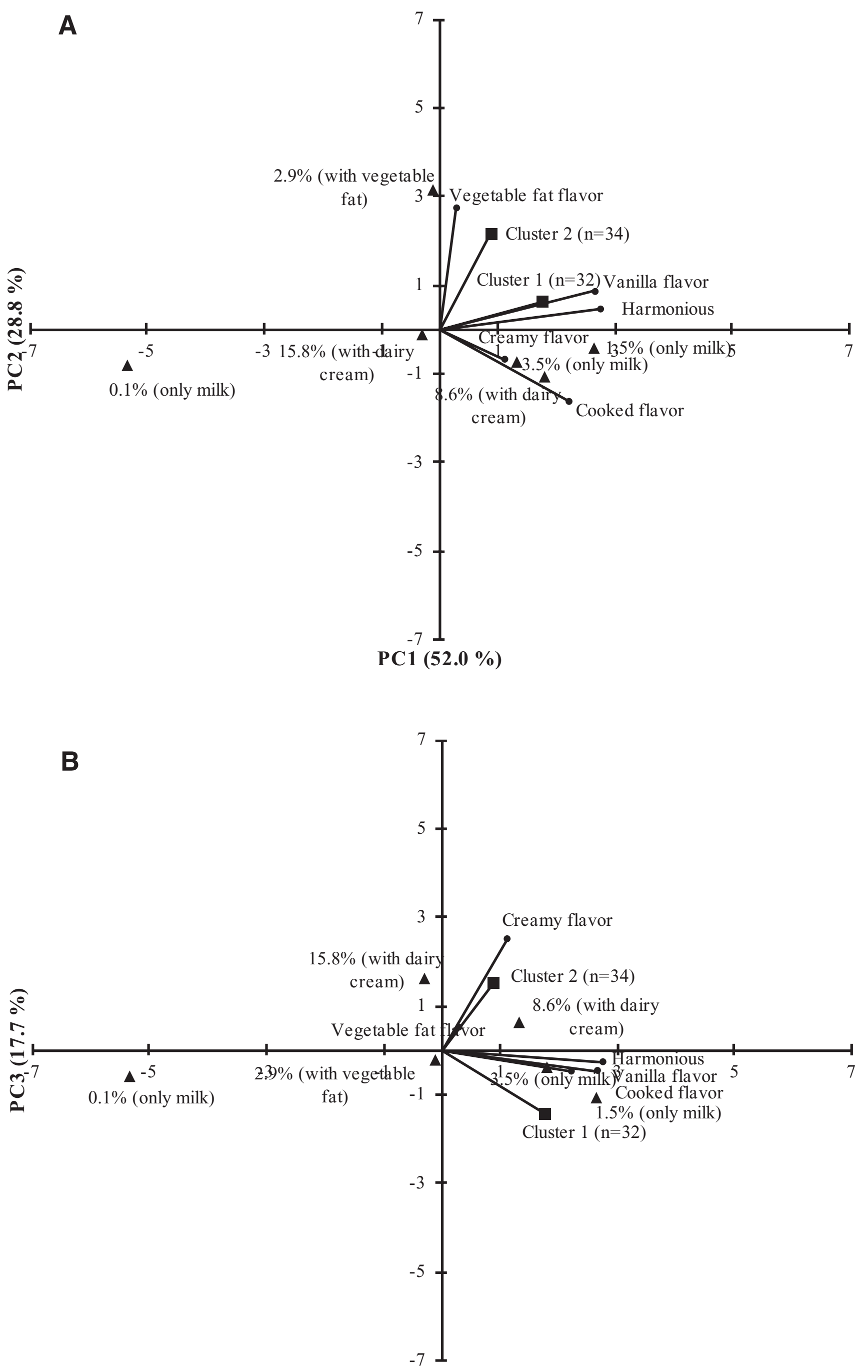

Figure 2–Parameter loadings and factor scores for principal component 1 (PC1) and principal component 2 (PC2) (A) as well as principal component 1 (PC1) and principal component 3 (PC3) (B), representing the relation between flavor/taste attributes, the 6 custard samples and consumer clusters obtained from cluster analysis. The vectors of the clusters represent their direction of liking. Identification of samples can be seen in Table 1. Identification of clusters can be seen in Table 7.

Table 5–Factor loadings for the first 3 principal components of the separate PCAs for appearance, flavor/taste, and texture/mouthfeel for the sensory attributes, which differed significantly between the samples.

	Attributes	PC 1	PC 2	PC 3
Appearance	Color	0.715	− 0.156	0.681
	Skin formation	0.076	0.993	0.094
	Surface shine	0.991	0.071	− 0.066
	Thick	− 0.865	0.046	0.495
Flavor/taste	Vanilla	0.939	0.302	− 0.160
	Cooked	0.781	− 0.573	− 0.166
	Vegetable fat	0.102	0.968	0.185
	Creamy	0.393	− 0.237	0.888
	Harmonious	0.972	0.163	− 0.091
Texture/mouth feel	Thick	− 0.103	0.989	0.102
	Jelly	− 0.956	0.290	0.029
	Sticky	0.920	0.332	− 0.194
	Creamy	0.954	− 0.164	0.247
	Fatty	0.966	0.237	− 0.020

Abbreviations are: PC, principal component.

intensities in all flavor attributes. Samples with 1.5%, 3.5%, and 8.6% fat were similar and high in pudding-like flavor attributes, but 8.6% fat caused a higher creamy flavor. The sample with 15.8% fat showed medium intensities in pudding-like flavor attributes and the most intensive creamy flavor.

If cream was added to the formulation, creamy flavor increased significantly with increasing amount, which is self-explanatory. But creamy flavor was also significantly higher at 3.5% fat than at 0.1% fat. Comparable results were found by Elmore and others (1999) who determined a stronger dairy flavor in custards with higher fat contents. Dunkley (1982) reported that milk flavor is apparent in products containing higher amounts of fat such as cream, particularly when it is used warm. Compared to the other samples that contained more milk fat, the pudding-like flavor was significantly lower at 0.1% fat. Hence, a lack of milk fat caused moderate sensations in flavor attributes vanilla, cooked, and harmonious, presumably due to the effect of fat to act as the main solvent for various aroma compounds (Frost and Janhoj 2007). De Wijk and others (2003a) also found custards with high fat contents to produce more flavors and suggested a relation to the flavor-releasing properties of fat. Due to the effect of fat to slow flavor release, it exerts influence concerning the intensity, the duration, and balance of other flavors (Lucca and Tepper 1994). Kersiene and others (2008) showed a crucial influence of milk fat in model custards on the release of flavor compounds, retaining the flavor compounds due to hydrophobic interactions. Differences in pudding-like flavor attributes between the remaining UHT and both cream samples were not significant with the exception of the custard with 15.8% fat, being less harmonious and having a lower cooked flavor. Presumably, its creamy flavor predominated and covered the intensity of the other flavor attributes.

Effect of fat on texture/mouth feel. The first 2 components of the PCA describing the texture properties explained 97.4% of the total variance with PC1 (72.3%), running from jelly on the negative side to fat-related texture properties (sticky, creamy, and fatty) on the positive side (Figure 3). The stickier, fattier, and creamier the custard, the less jelly was its texture. PC2 accounted for 25.1% of the variance and reflected the difference in oral thickness. The nonfat (0.1%) custard had an intensive jelly texture, was therefore low in fat-related texture properties, and was furthermore medium in thickness. Samples with 1.5% and 3.5% fat were similar and showed medium intensities in all the texture attributes, but they loaded stronger on the jelly side than on the fat-related texture properties side. Both samples containing cream were relatively similar to each other, being high in fat-related properties and thickness.

ANOVA (Table 4) and PCA results (Figure 3) for texture/mouth feel indicated that jelly texture was significantly higher in the

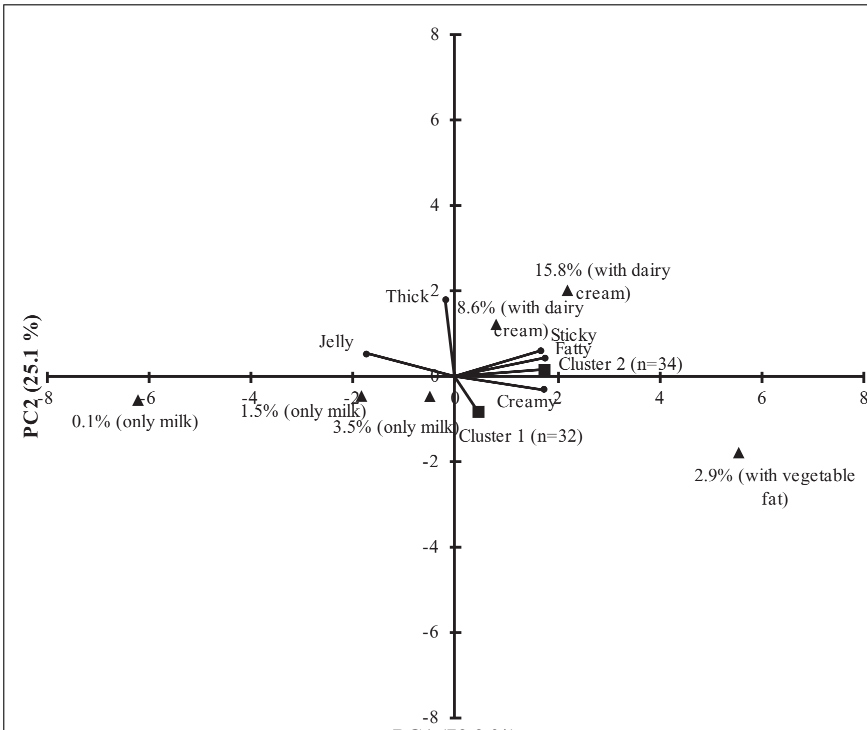

Figure 3–Parameter loadings and factor scores for principal component 1 (PC1) and principal component 2 (PC2), representing the relation between texture/mouth feel attributes, the 6 custard samples and consumer clusters obtained from cluster analysis. The vectors of the clusters represent their direction of liking. Identification of samples can be seen in Table 1. Identification of clusters can be seen in Table 7.

Table 6–Mean liking scores for the evaluated 6 custard samples for properties appearance, flavor, texture, and overall liking.

Sample	0.1% (only milk)	1.5% (only milk)	2.9% (with vegetable fat)	3.5% (only milk)	8.6% (with dairy cream)	15.8% (with dairy cream)
Appearance liking	6.5[a]	6.5[a]	6.8[a]	6.3[a]	6.9[a]	6.6[a]
Flavor liking	5.3[a]	6.2[b]	6.3[b]	6.3[b]	6.3[b]	5.8[ab]
Texture liking	5.3[ab]	5.5[bc]	7.3[d]	5.9[bc]	6.2[c]	4.5[a]
Overall liking	5.6[a]	6.3[a]	6.4[a]	6.1[a]	6.4[a]	5.7[a]

[a–d]Means followed by the same letters within a row did not differ significantly ($P < 0.05$). Intensities were scored on a 9-point hedonic scale. Identification of samples can be seen in Table 1.

Table 7–Overall mean liking scores for the evaluated 6 custard samples derived from cluster analysis.

Overall liking	0.1% (only milk)	1.5% (only milk)	2.9% (with vegetable fat)	3.5% (only milk)	8.6% (with dairy cream)	15.8% (with dairy cream)
Cluster 1 (n = 32)	4.5[ab]	5.7[c]	5.6[c]	5.3[bc]	5.7[c]	4.1[a]
Cluster 2 (n = 34)	6.7[a]	6.8[ab]	7.3[b]	6.8[ab]	7.1[ab]	7.1[ab]

[a–c]Means followed by the same letters within a row did not differ significantly ($P < 0.05$). Intensities were scored on a 9-point hedonic scale. Identification of samples can be seen in Table 1. Abbreviations are: n, number of consumers.

nonfat custard (0.1%) than in custards containing higher amounts of fat. Intensities in fat-related texture properties fatty, sticky, and creamy increased with increasing fat content. Largest differences occurred between the nonfat custard and the other samples. The thickness of the model custards significantly increased at larger differences in fat content or rather when the fat content was raised with dairy cream. Other studies dealing with the effect of fat in model or commercially available vanilla custards also showed positive relations between the fat content and attributes creamy, fattiness, fatty mouth feel, fatty after feel, and thick and supposed these effects to occur due the lubricating and coating properties of fat (De Wijk and others 2003a,b; 2006; De Wijk and Prinz 2007). Creaminess in dairy products is often connected to milk fat globules, and consequently high creaminess is connected to a high fat content (Frost and Janhoj 2007).

Effect of the addition of a vegetable fat cream. As the vegetable fat cream contained plenty of further ingredients such as fats, oils, modified starch, stabilizers, and an emulsifier, no assumptions can be made concerning the effect of fat. But comparing custards with 2.9% and 1.5% fat, as they only differed in the presence of the vegetable fat cream, it is noticeable that the addition of vegetable fat cream caused a less yellow or rather a whiter color and a visually softer texture. Additionally, an intensive and dominant vegetable fat flavor occurred and cooked flavor decreased. Furthermore, the vegetable fat cream caused a creamier, fattier, stickier, softer, and less jelly texture, presumably caused by the textural properties of starch and hydrocolloids and their interactions (Williams and Phillips 2000). No significant differences occurred concerning the attributes skin formation, surface shine, vanilla, creamy flavor, harmonious, and sticky. It is remarkable that the fat-related texture properties were highest in the custard containing vegetable fat, although the fat content was medium.

Consumer acceptability test

Appearance, flavor, texture, and overall liking scores and the accordant results of ANOVA and Tukey's test are listed in Table 6. No significant differences among consumers were found in appearance liking (6.3 to 6.9). But ANOVA indicated significant differences for flavor and texture liking. Mean acceptance of flavor ranged between 5.3 and 6.3, with the nonfat (0.1%) and high-fat (15.8%) samples being significantly least-liked and the other samples being best-liked. Acceptability scores for texture liking ranged between 4.5 and 7.3, where the custard with 2.9% fat was liked the most, followed by the sample with 8.6% fat and then samples with 1.5% and 3.5% fat. The nonfat and high-fat samples were again least-liked for texture properties. As no significant differences were found for overall liking (5.6 to 6.4), cluster analysis on the overall liking data was applied to separate consumers according to their liking, resulting in 2 subgroups. Table 7 shows the mean overall liking scores from the identified clusters. The 1st cluster included 32 consumers with mean values ranging from 4.1 to 5.7, preferring custards with 1.5%, 2.9%, 3.5%, and 8.6% fat and rejecting custards with 0.1% and 15.8% fat. The 2nd cluster represented 34 assessors showing mean values between 6.7 and 7.3, and did not differentiated significantly between the samples, with the exception of the best-liked sample (2.9% fat) and the least-liked sample (0.1% fat).

Relationships between sensory attributes and consumer ratings and the effect of fat on consumers' acceptability

Descriptive data were related to overall liking data obtained from cluster analysis to determine drivers of liking and disliking. Figure 1, 2, and 3 display the relation between clusters' overall liking and the accordant sensory attributes of the custard samples. Cluster 1 preferred custards high in pudding-like flavor attributes and medium to high in fat-related texture properties. A stronger thickness, white color, and creamy flavor up to certain intensity (8.6% fat) as well as vegetable fat flavor were also liked. Contrariwise, as custards with 0.1% and 15.8% fat were rejected, neither flavorless custards, nor custards with a too intensive creamy flavor, jelly, and thick texture and a too white color were liked. Pudding-like flavor attributes, vegetable fat flavor as well as fat-related texture properties drove liking of the 2nd cluster, whereas a jelly texture drove disliking.

Results showed an effect of fat on consumers' preferences as high-fat custards and especially nonfat custards were least liked. No significant differences in liking were found between custards with medium fat contents (1.5% to 8.6%), which were best-liked. Consequently, too low and too high fat contents predominantly led to a rejection of vanilla custards. Contrariwise, Elmore and others (1999) observed higher acceptance ratings for custards with higher amounts of fat. They determined consumer preferences for thicker, creamier, and slower melting custards, which were more mouth coating and dense.

Due to the fact that the consumer sample size in our study was relatively low, further studies are needed to prove our findings using a larger sample size.

Conclusions

Sensory profiles of model vanilla custards varying in fat content and type of fat were established in our study. Our results demonstrated that fat increased the intensities of visual and oral thickness, creamy flavor, and fat-related texture properties (fatty, creamy, and sticky) and decreased yellowness and surface shine. In nonfat custards, pudding-like flavor (vanilla, cooked, and harmonious) was low and jelly texture high. The addition of a vegetable fat cream increased intensities in vegetable fat flavor and fat-related texture properties, whereas yellowness, cooked flavor intensity, jelly texture, and visual and oral thickness were reduced. An effect of fat on consumers' preferences can be concluded, as consumers' overall liking results indicated that nonfat custards (all consumers) and high-fat custards (some consumers) were least liked. Mean values for flavor and texture liking showed lowest scores for both products. Custards with medium fat contents (1.5% to 8.6%) showed best acceptability results. Pudding-like flavor attributes, vegetable fat flavor, and fat-related properties were intrinsic factors that drove liking of all consumers. Too high intensities in attributes thick, creamy flavor, and white color drove disliking of some consumers, whereas a too jelly texture drove disliking of all consumers. The addition of vegetable fat cream demonstrated a good alternative for well-accepted medium-fat vanilla custards.

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