Acceptance of sugar reduction in flavored yogurt

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ABSTRACT

To investigate what level of sugar reduction is accepted in flavored yogurt, we conducted a hedonic test focusing on the degree of liking of the products and on optimal sweetness and aroma levels. For both flavorings (strawberry and coffee), consumers preferred yogurt containing 10% added sugar. However, yogurt containing 7% added sugar was also acceptable. On the just-about-right scale, yogurt containing 10% sugar was more often described as too sweet compared with yogurt containing 7% sugar. On the other hand, the sweetness and aroma intensity for yogurt containing 5% sugar was judged as too low. A second test was conducted to determine the effect of flavoring concentration on the acceptance of yogurt containing 7% sugar. Yogurts containing the highest concentrations of flavoring (11% strawberry, 0.75% coffee) were less appreciated. Additionally, the largest percentage of consumers perceived these yogurts as “not sweet enough.” These results indicate that consumers would accept flavored yogurts with 7% added sugar instead of 10%, but 5% sugar would be too low. Additionally, an increase in flavor concentration is undesirable for yogurt containing 7% added sugar.

Key words: yogurt, sugar reduction, acceptance, flavoring

INTRODUCTION

Many studies have shown that consumers prefer high concentrations of sucrose in food. This trend can be observed for children as well as for adults and the elderly (Barnes et al., 1991; Kälviäinen et al., 2003; Thompson et al., 2007). However, preferences vary according to age and food type (Kälviäinen et al., 2003; Liem and de Graaf, 2004). Still, regardless of age, the human body requires sugar because it is a good energy source that is used for the maintenance of human metabolism (Barclay et al., 2008). Although a moderate intake of sugar keeps us alive, a constant oversupply

can lead to disease. Several diseases are associated with a high level of sugar consumption, including obesity, insulin resistance, and diabetes mellitus type 2, as well as caries and fatty liver. Therefore, low sugar intake is strongly recommended (FAO/WHO, 2003). This recommendation is addressed not only to the consumer—the food industry must also address the reduction of sugar content in processed food (Barclay et al., 2008). This task poses a major challenge as products have to be reformulated with less sugar while maintaining their popularity and appealing character.

Yogurt is perceived as a healthy food because of the presence of live and active cultures (Popa and Ustunol, 2011), and this positive image should not be harmed by high levels of added sugar or by the use of artificial ingredients such as sweeteners. Because of the growing health consciousness of the consumer, there is a demand for sugar reduction in yogurt. This fact was confirmed by a survey conducted by Agroscope (Berne, Switzerland) in 2009 with Swiss participants over the age of 50 yr, where 51% of the participants ($n = 253$) stated that flavored yogurts available in the market are too sweet (Gille et al., 2012).

Not only is sugar essential for the sweet taste of yogurt products, but it also contributes to the total solids of the product and provides texture, body, viscosity, and moisture retention (Popa and Ustunol, 2011). As preferences for yogurt products are principally influenced by texture, aroma, and taste (Kälviäinen et al., 2003; Bayarri et al., 2011; Routray and Mishra, 2011; Grygorczyk et al., 2013), the concentration of sugar in yogurt products is crucial. Indeed, the health benefits of a dairy product cannot outweigh its sensory properties, and its acceptance depends on the degree of satisfaction given to the consumers (Bayarri et al., 2011). Therefore, the objective of the first study was to investigate which concentration of added sugar in flavored yogurt was favored by the Swiss population and whether consumer preferences differed.

Adding fruity flavorings generally increases the sensory acceptance of yogurt by consumers (Routray and Mishra, 2011). In several studies, the addition of various flavor compounds (strawberry aroma, vanilla aroma, benzaldehyde, furaneol) in sweet matrices was found to enhance consumers' perception of sweet-

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ness (Tournier et al., 2007, 2009; Labbe et al., 2010). However, these studies mainly dealt with a model food matrix and with either a small number of consumers or only trained panelists. Hence, it is still unknown if adding more flavoring could improve the acceptability of sugar-reduced yogurt.

Yogurt flavorings can be separated into 2 main categories. The first category includes the fruity and lightly sour flavorings such as strawberry, pineapple, raspberry, and peach. The second one comprises the so-called brown flavorings, such as caramel, vanilla, chocolate, and coffee. The interactions between yogurt's typical aroma, the sugar, and the sensory characteristics of the added flavoring may affect the flavored yogurt's overall acceptability. Subsequently, the aim of the second test was to determine the effect of the amount of flavoring on the acceptance of sugar-reduced yogurt in the Swiss population.

MATERIALS AND METHODS

First Test: Yogurt with Different Concentrations of Added Sugar

Sample Preparation. Coffee and strawberry yogurt samples were manufactured at "Molkerei Wasserfallen," a small dairy factory in Switzerland. Sugar was added to a mild type of plain yogurt along with 2 different flavorings: a strawberry fruit mass (805.10 Erdbeere geschnitten, Schweizer Getränke AG, Obermeilen, Switzerland) and a powdered coffee extract (Mocafin 202-DS, Haco AG, Gümligen, Switzerland). The strawberry flavoring was chosen because strawberry yogurt is the most frequently consumed flavored yogurt in Switzerland and popular around the world (Thompson et al., 2007), and it represents the group of fruity and lightly sour flavorings. The coffee flavoring was chosen to represent the so-called brown flavoring family. Both

flavoring concentrations corresponded to the recommendation of the producer.

Three sucrose concentrations (10, 7, and 5% added sugar) were selected. The concentration of 10% added sugar was chosen because it corresponds to the average sugar concentration for flavored yogurt in Switzerland. The 5% concentration corresponded to that used in a project of the Swiss Federal Office of Public Health aiming to reduce the sugar intake of the Swiss population. Finally, the 7% concentration was chosen as an intermediate level.

For the preparation of the mild yogurt, 2% skim milk powder (Cremo, Freiburg, Switzerland) was mixed with whole milk (3.5% fat), homogenized at 70°C at 8 MPa, and pasteurized for 60 s at 91°C. Yogurt starter cultures (Hansen YC-x1, Chr. Hansen, Hørsholm, Denmark) were added, and the mix was fermented at 43°C to a pH of 4.6. Sugar (Zuckerfabrik Aarberg + Frauenfeld AG, Aarberg, Switzerland), flavoring, and yogurt were blended according to the desired total added sugar content (Table 1). Yogurts were poured into 75-g plastic cups with lids (SwissPrimePack AG, Altstätten, Switzerland) and refrigerated at 5°C for 5 to 7 d until sensory descriptive analysis and the consumer test were conducted.

Sensory Descriptive Analysis. A trained sensory panel ($n = 9$) with experience in the evaluation of dairy products evaluated the 6 yogurt samples (3 strawberry-flavored and 3 coffee-flavored yogurts). A descriptive analysis focusing on the attributes sweetness, sourness, and strawberry or coffee aroma (i.e., retronasal odor) was performed. The intensity of these attributes was evaluated on 10-cm unstructured line scales, anchored on the left with "not sweet/sour/aromatic" and on the right with "very sweet/sour/aromatic." Water solutions of sucrose and citric acid were given as references to the panel for quality and intensity standardization during

Table 1. Overall liking of yogurt with different concentrations of sugar

Flavoring	Flavoring (%)	Sugar ¹ (%)	Overall liking ²	
			Mean	SD
Strawberry	9	10	7.48 ^a	1.80
	9	7	6.23 ^b	1.76
	9	5	4.79 ^c	2.06
Coffee	0.52	10	6.84 ^x	2.27
	0.52	7	5.84 ^y	1.99
	0.52	5	4.29 ^z	2.05

^{a-c}Means within a column for strawberry flavoring with different superscripts differ significantly ($P < 0.05$) by Fisher least significant difference test.

^{x-z}Means within a column for coffee flavoring with different superscripts differ significantly ($P < 0.05$) by Fisher least significant difference test.

¹Represents sucrose from fruit mass and added sugar, without lactose.

²The degree of liking was rated on a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely).

the training phase. The panelists evaluated 6 samples per session (3 strawberry and 3 coffee samples; the temperature of the samples ranged from 8 to 10°C). Rinsing between samples was performed using tap water. The 3 samples of each flavoring type were served in a randomized order, and panelists evaluated the samples monadically. The test was replicated twice during 2 separate testing sessions. The presentation order of both flavoring types was reversed between the 2 testing sessions. Tests took place in individual booths in the sensory laboratory of Agroscope under red light conditions. The software Fizz (version 2.46B, Biosystemes, Couternon, France) was used for data collection.

Consumer Test. Consumers of all age groups were recruited during 2 fairs in Switzerland (BEA in Berne and Swiss Expo in Lausanne). The respondents could choose to test either the strawberry or the coffee yogurt according to their preference. One hundred ninety-two participants tested the samples with strawberry flavoring and 197 participants tested the samples with the coffee flavoring. Consumers first rated the samples on their overall liking, and then answered a question on the appropriateness of sweetness and aroma intensity. The degree of liking was rated on a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). The evaluation of the intensity appropriateness of sweetness and aroma was made using a 9-point just-about-right (JAR) scale (1 = not nearly sweet enough/much too weak, 5 = just about right, 9 = much too sweet/much too strong). The 3 yogurt samples were presented simultaneously in the original coded 75-g beakers, and the order of presentation was randomized across subjects. The samples were evaluated at normal light at a temperature of 12 to 14°C. Background information on participants' age, sex, and frequency of consumption of yogurt products was collected using paper ballots.

The data were then transcribed into the software Fizz (version 2.46B, Biosystemes).

Second Test: Yogurt with Different Concentrations of Flavoring

Sample Preparation. For the second test, the sugar concentration was kept the same for all yogurts (7%) but the concentration of flavoring was modified. Both chosen flavorings are commonly used in small and medium Swiss dairies for the production of flavored yogurt. The fruit mass contained strawberry fruit pieces, strawberry juice, sugar, waxy maize starch, aroma, and coloring. The coffee flavoring was pure coffee extract powder of lyophilized coffee beans without other aromas or coloring. Three flavoring levels (low, medium, and high; Table 2) were used. The medium concentration was chosen because it corresponds to the concentration normally used in the products available on the market. The 2 other concentrations represented an increase and decrease of 40% compared with the medium concentration. A greater increase was not considered because it would adversely affect ingredient costs.

Sample preparation was the same as for the first test. Strawberry food coloring (E121, Werna W. Schweizer AG, Wilen bei Wollerau, Switzerland), sugar, flavoring, and yogurt were mixed according to the desired flavoring concentration (Table 2).

Sensory Descriptive Analysis. The 6 yogurt samples (3 strawberry-flavored and 3 coffee-flavored yogurts) were evaluated following the same procedure and by the same trained sensory panel ($n = 9$) as in the first test.

Consumer Test. For the second test, consumers were recruited during an agricultural event in Switzerland (Nutrill in Posieux). Two hundred fifty-six

Table 2. Overall liking and willingness to purchase for sugar-reduced yogurt with different concentrations of flavoring

Flavoring	Flavoring (%)	Sugar ¹ (%)	Overall liking ²		Willingness to purchase (%)
			Mean	SD	
Strawberry	11	7	5.82 ^b	1.19	45
	8	7	6.54 ^a	1.86	36
	5	7	6.33 ^a	2.09	20*
Coffee	0.750	7	5.66 ^x	2.07	29*
	0.525	7	5.84 ^x	1.96	36
	0.300	7	6.11 ^x	1.87	34

^{a,b}Means within a column for strawberry flavoring with different superscripts differ significantly ($P < 0.05$) by Fisher least significant difference test.

^xMeans within a column for coffee flavoring with different superscripts differ significantly ($P < 0.05$) by Fisher least significant difference test.

¹Represents sucrose from fruit mass and added sugar, without lactose.

²The degree of liking was rated on a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely).

* $P < 0.05$ by Chi-squared test.

Table 3. Sociodemographic breakdown of the participants of the consumer tests¹

Item	First consumer test		Second consumer test	
	Strawberry yogurt (n = 192)	Coffee yogurt (n = 197)	Strawberry yogurt (n ² = 250)	Coffee yogurt (n ³ = 257)
Sex (%)				
Male	56	47	41	62
Female	44	53	59	38
Age (%)				
15–29 yr	26	21	20	21
30–44 yr	22	24	35	30
45–59 yr	27	32	27	37
>60 yr	26	23	18	12

¹n = number of consumers who tested the products.

²Italian-speaking participants were not included for the statistical analysis (6 participants).

³Italian-speaking participants were not included for the statistical analysis (4 participants).

participants tested strawberry-flavored yogurts and 261 participants tested coffee-flavored yogurts. The test settings were the same as in the first consumer test. In addition to the questions on overall liking and appropriateness of sweetness and aroma intensity, consumers had to state whether they would buy one of the products and, if yes, which one. Background information on age and sex was collected (Table 3). Because Switzerland has 3 principal linguistic regions (German, French, and Italian), the testers were asked to note their language and choose between “French,” “German,” and “Italian.”

Statistical Analyses

Sensory Descriptive Analysis. Data were analyzed using a 3-way ANOVA on the factors sample, judge, and repetition. In the case of significant differences ($P \leq 0.05$), mean values of intensity were compared using Fisher's least significant difference (LSD) test. The analysis was performed using the Fizz Calculation software, version 2.46 (Biosystemes).

Consumer Test. The software Systat version 12 (Systat Software, Chicago, IL) was used for statistical analyses. Differences between the samples were analyzed with the Friedman test. A general linear model (GLM) was used to determine the influence of sugar and flavoring concentrations, as well as the influence of consumer age and sex on overall liking. Fisher's LSD test ($P \leq 0.05$) was used to establish significant differences. Interactions were not included in the model. For the second study, GLM was also used to determine the influence of origin (French, German, or Italian) on overall liking. An insufficient number of testers were from the Italian-speaking part of Switzerland, so only results from participants from the French- and German-speaking regions were used.

The frequency distribution of the scores was calculated for the JAR questions. The original 9-point scales were reduced to 3 points (1–4 = too weak, 5 = just about right, 6–9 = too strong), and the percentage of scores in each category was calculated. A Chi-squared test was used to compare the distributions among the products. The GLM was again used to determine the influence of sugar and flavoring concentrations, as well as the influence of age and sex on the appropriateness of sweetness and aroma. Again, the main effect was sugar concentration in the first study, and flavoring concentration in the second study. In the second study, the GLM was used to determine the influence of origin and only results from the French-speaking and German-speaking parts of Switzerland were used. Interactions were not calculated in the model.

RESULTS

First Test: Yogurts with Different Concentrations of Added Sugar

Sensory Descriptive Analysis. The ANOVA showed significant differences ($P < 0.05$) among the strawberry yogurt samples with regard to the 3 attributes studied (Figure 1). Sweetness decreased significantly with decreasing sugar concentration. The strawberry yogurt with the highest content of sugar was significantly less sour than the yogurt with only 5% sugar. Finally, the yogurt containing 5% sugar was significantly less aromatic than the other 2 yogurts.

Significant differences for the 3 evaluated attributes were also found among the coffee yogurts. Sweetness decreased significantly with decreasing sugar concentration. The coffee yogurt with 10% sugar was significantly

Figure 1. Mean values of the sensory descriptive analysis ($n = 9$) of the test comparing yogurts with different concentrations of sugar (5, 7, and 10%; first test). Means for strawberry (a–c) and coffee (x–z) yogurts with different letters differed significantly ($P < 0.05$).

less sour than the other 2 yogurts. Yogurt containing 5% sugar was significantly less aromatic than the other 2 yogurts.

Consumer Test for Strawberry Yogurt. Strawberry yogurt was tested by 192 French-speaking (42.7%) and German-speaking (57.3%) individuals; 56% of these were men. Consumers were almost equally distributed in 4 age categories (15–29, 30–44, 45–59, and >60 yr; Table 3). Fifty-seven percent of participants declared that they consumed yogurt products more than once a week, 21% more than once a day, 14% more than once a month, and 8% less than once a month.

The yogurt with 10% added sugar was significantly more liked than the yogurts with 7% and 5% sugar. The yogurt containing 7% added sugar had an average score of 6.23 on a 9-point hedonic scale; thus it was slightly liked by the consumers (Table 1). The GLM analysis showed no effect of sex or age on overall liking; only the

sugar concentration affected how much consumers liked each type of yogurt.

The frequency distribution on the JAR scale for sweetness showed a shift toward the upper end of the scale with increased sugar concentrations. The yogurt containing 10% sugar was judged as “too sweet” by 48% of the testers, as “just about right” by 44%, and as “not sweet enough” by fewer than 8%. The yogurt containing 7% sugar was perceived as “just about right” by 44% of the testers within this yogurt type. On the other hand, sweetness for the yogurt containing 5% sugar was judged as “too low” by 78% (Table 4). The GLM analysis also showed that only sugar concentration had a significant effect on the perception of sweetness appropriateness.

Sixty percent of the consumers testing the yogurt containing 10% sugar described its aroma intensity as “just about right.” The yogurts containing 7% and 5%

Table 4. Breakdown of responses for sweetness and flavoring for different concentrations of sugar

Sugar	Flavor	Sweetness				Flavoring			
		Not enough (%)	Just about right (%)	Too much (%)	P-value	Not enough (%)	Just about right (%)	Too much (%)	P-value
5%	Strawberry	78.1	17.2	4.7	***	73.4	17.7	8.9	***
	Coffee	78.2	15.2	6.6	***	73.6	15.7	10.7	***
7%	Strawberry	41.1	44.3	14.6	***	49.9	35.5	15.1	***
	Coffee	43.7	40.1	16.2	***	50.8	33	16.2	***
10%	Strawberry	7.3	44.3	48.4	***	14.1	59.9	26.6	***
	Coffee	9.6	35.5	54.8	***	21.8	51.3	26.9	***

*** $P < 0.001$, by Chi-squared test.

sugar were perceived as lacking sufficient aroma for 50% and 73% of the testers, respectively (Table 4).

The GLM analysis showed that sugar concentration as well as sex of tester had an effect on the perception of the ideal level of aroma. Women and men judged the strawberry aroma as “too weak” (mean = 4.12 and 4.55, respectively) but men were closer to “just about right.”

Consumer Test for Coffee Yogurt. Coffee yogurt was tested by 197 French-speaking (42.6%) and German (57.4%) speaking participants; 47% of these were men. The largest percentage of testers were aged between 45 and 59 yr (32%) and the rest were equally spread in the other age categories (Table 3). Fifty-four percent of the participants consumed yogurt products more than once a week, 23% more than once a month, 21% more than once a day, and 2% less than once a month.

We observed a significant difference between the yogurts for overall liking. The most-liked yogurt was that with the highest sugar concentration, and the least-appreciated yogurt was the one with the lowest sugar concentration (Table 1). The GLM analysis showed no effect of sex on yogurt preferences but showed an effect of sugar concentration and age of tester. According to the Fisher LSD test, participants over 60 yr of age gave significantly higher liking scores (mean = 6.38) than younger participants (mean = 5.44 for 15–29 yr, 5.23 for 30–44 yr, 5.60 for 45–59 yr).

As for the appropriate level of sweetness, the yogurt containing 10% sugar was perceived as “too sweet” by 55% of the participants, as “just about right” by 35%, and as “not sweet enough” by 10%. Although the majority of evaluations (44%) of the yogurt with 7% sugar indicated that the product was “not sweet enough,” 40% described it as “just about right.” The yogurt with the lowest sugar concentration was perceived as “not sweet enough” by 78% of the testers (Table 4). The GLM analysis also showed an effect of sugar concentration and age on the appropriateness of sweetness intensity. In particular, testers between 15 and 29 yr of age generally considered the coffee yogurt to be “not sweet enough” (mean = 4.17). Participants between 45 and 59 yr of age perceived the sweetness as significantly higher; the mean value was 4.84, which means they considered the sweetness closer to “just about right.”

The yogurt containing 10% sugar was scored as “just about right” for aroma by 51% of the consumers. Yogurts containing less sugar were perceived as lacking sufficient aroma by 51% (7% sugar) and 74% (5% sugar) of the testers, respectively (Table 4). The GLM analysis showed that the sugar concentration had an effect on aroma appropriateness but no sex or age effects were found.

Second Test: Sugar-Reduced Yogurts with Different Concentrations of Flavoring

Sensory Descriptive Analysis. No significant sample effect was found for any of the attributes tested (Figure 2) in strawberry-flavored yogurts. The perceived aroma intensity decreased with reduced amounts of flavoring, but not in a significant way.

A significant difference regarding aroma intensity was found in the coffee yogurts, where the perceived aroma intensity significantly decreased with decreased amounts of flavoring. No significant difference was observed for the attributes sweet and sour in the coffee yogurts.

Consumer Test for Strawberry Yogurt. Strawberry yogurt was tasted by 256 participants, 41% of whom were men (Table 3). One hundred seven testers were German speaking, 143 French speaking, and 6 participants Italian speaking. The largest percentage of the participants was between 30 and 59 yr old (Table 3).

The yogurt with the highest concentration of flavoring (11%) was significantly less appreciated than those containing less flavoring (8 or 5%). No significant differences of overall liking for the yogurt containing 5 or 8% flavoring were observed (Table 2). The GLM analysis also showed no effect of consumer sex, origin, or age on the overall liking; only the flavoring concentration was significant.

According to the frequency distribution on the JAR scale for sweetness, the yogurt containing 8% fruit mass was judged as “just about right” by 48% of the consumers. For both extreme flavoring concentrations (5% and 11%), 39% of the testers perceived these yogurts as “just about right.” Nevertheless, 48% of consumers perceived the yogurt containing 5% fruit mass as “too sweet,” whereas 49% of the consumers graded the yogurt containing 11% fruit mass as “not sweet enough” (Table 5). For the appropriateness of sweetness intensity, GLM analysis showed an effect of the flavoring concentration but no effect of tester sex, origin, or age. A higher mean for sweetness appropriateness was obtained with a decrease in strawberry fruit mass concentration (mean = 4.25 for 11% strawberry flavoring, 4.95 for 8%, and 5.96 for 5%).

The largest percentage of the testers perceived the aroma intensity as “just about right” for either 5% or 8% fruit mass (43 and 41%, respectively). Surprisingly, the yogurt containing the highest concentration of flavoring was perceived as “not sufficiently aromatic” by 44% of the testers (Table 5). The GLM analysis showed no effect of sex, origin, or flavoring concentration on the appropriateness of the aroma intensity, but

Table 5. Breakdown of responses for sweetness and flavoring for sugar-reduced yogurt (7% added sugar) with different concentrations of flavoring

Item	Sweetness				Flavoring			
	Not enough (%)	Just about right (%)	Too much (%)	<i>P</i> -value	Not enough (%)	Just about right (%)	Too much (%)	<i>P</i> -value
Low flavoring								
5% Strawberry	12.5	39.8	47.7	***	34.8	42.6	22.7	***
0.3% Coffee	23.4	47.9	28.7	***	62.1	28.7	9.2	***
Standard flavoring								
8% Strawberry	27.7	48.0	24.2	***	39.1	41.0	19.9	***
0.525% Coffee	35.6	46.4	18	***	56.3	28.4	15.3	***
High flavoring								
11% Strawberry	49.2	39.8	10.9	***	43.7	36.3	19.9	***
0.75% Coffee	43.7	39.8	16.5	***	24.1	34.5	41.4	**

*** $P < 0.001$, ** $P < 0.01$, by Chi-squared test.

a significant difference was observed based on the age of the consumers. According to the Fisher LSD test, consumers aged between 30 and 44 and those >60 yr evaluated the average aroma intensity of the 3 yogurts as closer to “just about right” (mean = 4.89 and 4.79) than younger consumers (15–29 yr) and those between 45 and 59 yr old. For these participants, the strawberry yogurts were not aromatic enough (mean = 4.47 for 15–29 yr and 4.40 for 45–59 yr).

Consumer Test for Coffee Yogurt. Two hundred sixty-one participants tested coffee yogurt; 38% of these were men (Table 3). One hundred twenty-two testers were German speaking, 135 were French speaking, and 4 were Italian speaking. The majority of the testers were between 30 and 59 yr old (Table 3).

According to the Friedman test, we observed no significant difference for overall liking and found a tendency for consumers to appreciate the yogurt with 0.3% coffee extract more than that with 0.75% coffee extract (Table 2). The GLM analysis showed no effect of sex, age, or origin on consumers’ overall liking of the yogurt.

A shift toward the higher end of the JAR scale for sweetness appropriateness was observed with a decrease in coffee flavoring concentration. Respectively, 48 and 47% of the testers perceived the yogurt containing the lowest or the medium flavoring concentrations as “just about right,” and 29% of the testers even perceived the lowest concentration as “too sweet.” On the other hand, the yogurt containing the highest concentration

Figure 2. Mean values of the sensory descriptive analysis ($n = 9$) of the test comparing yogurts with different concentrations of strawberry (5, 8, and 11%) or coffee (0.3, 0.525, and 0.75%) flavoring (second test). Means with different letters (x–z) differed significantly ($P < 0.05$).

of coffee was perceived as “not sweet enough” by 44% of consumers (Table 5). The GLM analysis showed an influence of the concentration of coffee extract and age on the appropriateness of sweetness intensity. The elderly (>60 yr old) evaluated the average sweetness intensity of the 3 yogurts as slightly too sweet. Indeed, the mean for sweetness adequacy for the age category >60 yr was significantly higher (mean = 5.28) than for younger participants. However, we found no significant differences between the other age categories (mean = 4.56 for 15–29 yr, 4.57 for 30–44 yr, 4.78 for 45–59 yr).

For yogurt containing 0.75% coffee extract, the aroma intensity was judged as “too strong” by 41% and “just about right” by 35%, the latter being the largest percentage of “just about right” scores of the 3 flavoring concentrations. The yogurts with less flavoring (0.3 and 0.5%) were perceived as “too weak” by 62 and 56% of consumers, respectively (Table 5). The GLM analysis also showed an effect of coffee concentration on the appropriateness of the aroma intensity, but no effect of sex, age, or origin.

Willingness to Purchase. Ninety-nine percent of the participants stated that they would buy one of the proposed yogurts. For strawberry, the yogurt containing the least flavoring was chosen significantly less often than the others, whereas the opposite was observed for the coffee yogurt (Table 2).

DISCUSSION

First Test: Yogurt with Different Concentrations of Added Sugar

According to previous studies, a higher concentration of sugar was expected to lead to increased preference (Barnes et al., 1991; Thompson et al., 2007; Johansen et al., 2010). The highest overall liking score for the yogurt containing 10% sugar complied with the results from a hedonic test conducted in Finland where the most appreciated strawberry yogurt contained 10% sugar and the samples with the lowest sugar concentration were liked the least (Tuorila et al., 1993). However, yogurts containing 7% sugar were also slightly liked, which is in line with a study conducted in the United States with 99 panelists, where strawberry yogurt containing 7% sucrose was also judged as acceptable (Bayarri et al., 2011).

Experiments conducted by Mojet et al. (2005) showed a significant sex effect on the perceived pleasantness. Men reported higher liking scores than women for iced tea, tomato soup, broth, chocolate drink, and mayonnaise. In another study, male consumers preferred high sweetness and fattiness and low sourness in strawberry yogurt, but women did not show any clear tendencies

(Tuorila et al., 1993). Therefore, we expected that sex would influence the appreciation of the yogurt. In fact, in our study, as well as in the study from Thai et al. (2011) with cola beverages, sex did not influence the rating of overall liking or the evaluation of sweetness adequacy of both flavored yogurts. However, men in our study evaluated the average aroma intensity of the strawberry yogurt as being closer to “just about right” than women. An explanation of these results may be that the consumers could choose which flavoring they wanted to test and that more men chose the strawberry flavoring.

The panelists perceived the yogurt with greater amounts of sugar as being sweeter, less sour, and more aromatic. For consumers, increasing sucrose concentrations caused a shift toward the upper end of the JAR scale for sweetness and aroma. This trend has previously been observed for orange-flavored yogurt-type snacks in Finland (Kälviäinen et al., 2003). For coffee-flavored and strawberry-flavored yogurts, the largest percentage of consumers perceived the yogurt with 10% sugar as “too sweet” and “just about right” for the aroma. The strawberry yogurt containing 7% sugar was perceived as “just about right” in terms of sweetness from the largest percentage (44%) of the testers within this yogurt type. For coffee, almost equal numbers of “not sweet enough” and “just about right” answers were recorded.

These results show that even if there is a significant higher overall liking for yogurt with 10% sugar, which corresponds to commercial samples, many consumers rate the sweetness intensity of this sugar concentration as too high. This discrepancy is not surprising in consumer science. As reported by Köster (2009), consumer decisions are, most of the time, unconscious. By asking a question they normally never ask themselves, consumers develop an analytical attitude where they want to conform to social or cultural convention or to demonstrate that they are reasonable, instead of acting spontaneously. Healthy eating campaigns are conducted regularly in Switzerland and people are aware that high sugar intake is not good for their health. Asking a question on sweetness appropriateness may have put the respondents in such an analytical attitude (Johansen et al., 2010). Nevertheless, both flavored yogurts with 7% sugar were slightly liked and more than 40% of the testers perceived their sweetness intensity as “just about right,” leading to the assumption that many consumers would not mind products with less sugar than those currently on the market.

As our consumer test was conducted at agricultural fairs, it represented a subgroup of the Swiss population with a specific sociocultural background and interest in agricultural matters, which may have influenced their

acceptance for a less sweet yogurt. Indeed, sweetness acceptability varies among consumers. In a study in Spain, some consumers' (10%) dislike of yogurt was driven by sweetness, whereas, in another subgroup (52%), liking was correlated positively with sweetness (Bayarri et al., 2011). In another study performed in the United States, key drivers for consumer preferences for drinkable strawberry-flavored yogurts were natural strawberry flavor or aroma and sweet taste. Three distinct consumer clusters were identified and characterized. In one cluster, excessively high sweet taste was not liked and in another cluster, moderate to high intensities of sweetness were liked. In the third cluster, sensory properties did not appear to influence liking (Thompson et al., 2007). Furthermore, Finnish consumers who consider convenience, familiarity, mood, and price to be important factors in their food choices found sweeter yogurt to be more pleasant (Pohjanheimo and Sandell, 2009). It was also suggested that some people are willing to consume yogurt that is less sweet when they appreciate natural ingredients and avoid additives (Pohjanheimo and Sandell, 2009). In a study in Norway, consumers who liked the less sweet yogurts were also those with a more positive attitude toward the healthy aspects (Endrizzi et al., 2011).

Second Test: Sugar-Reduced Yogurts with Different Concentrations of Flavoring

Because sweetness intensity but also aroma influences consumer's preference (Pohjanheimo and Sandell, 2009), the second study aimed to verify whether the acceptance of sugar-reduced yogurt could be improved with either a reduction or an increase in flavoring concentration. Generally, yogurts containing only 7% added sugar were accepted by the consumers (Table 2). After the tasting, the tasters had to state whether they would buy one of the products and, if yes, which one. Ninety-nine percent of the tasters responded that they would buy one of the proposed yogurts. Surprisingly, the results from the consumer test for overall liking did not correspond with the answers for the willingness to purchase for strawberry yogurt. On the one hand, the overall liking was significantly lower for the yogurt containing 11% strawberry flavoring, although willingness to purchase was significantly higher than for the 5% samples (Table 2). However, even though the strawberry flavoring concentrations varied between 5 and 11%, the designed levels of variation may not have been noticeable enough. Indeed, the trained panelists reported a significant intensity decrease for the coffee aroma in response to reduced amounts of coffee flavoring but not regarding the strawberry flavoring. In the consumer panel, we observed a tendency to ap-

preciate the yogurt with 0.75% coffee extract less than the yogurt with 0.3% coffee extract, and the willingness to purchase was significantly lower for the yogurt with the highest concentration of coffee flavoring. This trend corresponds to the study from Kälviäinen et al. (2003) where yogurt-type snack samples with low aroma (0.05% orange aroma) were preferred over the high aroma samples (0.25% orange aroma). However, people may consider a wide range of aroma intensities as appropriate, even when they notice differences between them (Kälviäinen et al., 2003).

According to Saint Eve et al. (2004), yogurts with the same sucrose content were perceived to be sweeter by panelists when a strawberry flavoring was added. Therefore, in our study, we expected that the sugar-reduced yogurt containing more strawberry flavoring would also be perceived as sweeter. In fact, no significant sample effects were perceived for the attributes "sourness" or "sweetness" by the trained panelists for the strawberry and coffee flavoring. For the consumers, increasing flavoring concentrations caused a shift toward the lower end of the JAR scale for sweetness. Indeed, the highest percentage of consumers evaluated the strawberry and the coffee yogurts with the most flavoring as "not sweet enough." These results suggest that the flavoring in sugar-reduced yogurt should be reduced rather than heightened to increase the appropriateness of sweetness intensity. Because sweetness perception depends also on viscosity, texture, and mouthfeel (Tuorila et al., 1993; Kälviäinen et al., 2003; Zijlstra et al., 2008; Tournier et al., 2009), further studies with different texturizers and fat contents should be conducted to determine their effects on the appreciation of sugar-reduced yogurts.

Effect of Age on Appreciation of Yogurt

The percentage of people aged 60 yr or more is increasing; thus, elderly consumers are an important consumer segment and their desires should be well understood. We expected that elderly individuals would appreciate the yogurt less as taste perception decreases with age (Mojet et al., 2001). Indeed, in a Malaysian study with cola beverages, sweetness intensity perception and pleasantness ratings decreased significantly with age (Thai et al., 2011). In our first study, the elderly (> 60 yr old) ranked coffee yogurt more highly for overall liking than younger people, but this was not the case for strawberry yogurt in the first study or for the second study. In a study with orange yogurt-type snacks (Kälviäinen et al., 2003) and in a later study from Mojet et al. (2005), the elderly also rated the overall pleasantness of the food samples more highly than their younger counterparts.

According to the study from Mojet et al. (2005), the elderly showed a higher optimum for sucrose in iced tea than the young. In our first study, the sweetness appreciation for coffee yogurt was not the same for all age categories; in particular, the youngest (<29 yr) considered the yogurt not sweet enough. We observed a trend showing that older consumers generally found these yogurts more pleasant and that they rated the average sweetness nearer to “just about right.” In the second study, the elderly also rated the sweetness intensity appropriateness of the coffee yogurts differently than did the younger people. They described these yogurts as slightly too sweet (mean = 5.28 for the elderly), even if they had less sugar (7%) compared with the flavored yogurt sold on the market (10%). In a prior survey from Agroscope (Gille et al., 2012), Swiss people over the age of 50 yr stated that flavored yogurts sold on the market are too sweet. This may be because this population was used to another type of yogurt. Traditionally, yogurt used to be made with cultures that gave it a more sour taste. Additionally, according to a Swedish study on drinkable yogurt, younger consumers considered sweetness and smoothness important sensory characteristics, whereas older consumers preferred thickness and sourness (Pohjanheimo and Sandell, 2009).

In contrast to previous studies (de Graaf et al., 1994) in which the elderly tended to have higher optimal preferred flavoring concentrations in aqueous solution than younger persons, in our study elderly and young participants gave similar scores for overall liking, and both age groups preferred yogurts with less flavoring. The studies from Mojet et al. (2005) and Kremer et al. (2007) with real food products also do not support the widely spread assumption that taste losses with age lead to a preference for stronger-tasting products among the elderly. Although losses in taste sensitivity have been proven, the elderly showed no increase in preferred concentration when real food products were tasted. As interest in healthy eating increases with age (Grunert et al., 2012), it may be advantageous for the dairy industry to develop products with less sugar for older generations and to determine if a more sour yogurt with less added flavoring would be accepted in this population.

CONCLUSIONS

Several diseases are associated with a high consumption of sugar; therefore, low intake of this macronutrient is strongly recommended. However, the sensory properties of a sugar-reduced product have to be acceptable to the consumer. The results of both studies indicate that consumers would accept flavored yogurt with 7% added sugar instead of 10% added sugar. On the JAR

scale, yogurt containing 10% sugar was more often described as too sweet compared with yogurt containing 7% sugar. Therefore, we recommend that the dairy industry reduces the level of sugar in flavored yogurts. For yogurt containing 7% sugar, an increase in flavoring concentration lowered the level of appreciation and liking of the yogurt by consumers. In contrast, a shift toward the lower end of the JAR scale for sweetness was observed with an increase in strawberry fruit mass or coffee flavoring concentration. Therefore, an increase in flavor concentration is undesirable for yogurt containing 7% added sugar.

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