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Sensory Evaluation of the Strawberry Flavored Yoghurt with Stevia and Sucrose Addition

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Summary

As obesity is a growing problem in the world the target of food industries is to produce low calorie products safe for the human health. According to the non-caloric value of stevia and its beneficial influence on human health, there is a great possibility of its use in the food industry. Plain yoghurts were produced by fermentation with ABT-5 cultures (Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium spp.) and flavored by addition of 0.2 mL/100 g strawberry aroma. Yoghurts were sweetened by the addition of 1) sucrose 2) stevia and 3) equal portion of sucrose and stevia in three different concentrations. Sensory properties of yoghurt where evaluated by panel using two methods; ranking test and 20 – point scaling system of weighted factors. Viscosity was measured by viscosimeter. According to sensory panel it was determined that 6 g of stevia was equal to 1000 g of sucrose. The best sensory evaluation had the yoghurts sweetened with addition of 4.5 g/100 g equal portions of sucrose and stevia. Addition of sweeteners weren't influenced the apparent viscosity.

Keywords: sensory evaluation, stevia, sucrose, sweetness profile, viscosity

INTRODUCTION

Stevia rebaudiana Bertoni is a shrub-like plant from the *Asteraceae* family, originating from Paraguay and Brazil, where was for hundreds of years used as a sweetener for bitter medical preparations, teas and other beverages. Sweetener is obtained from leaves extraction (Prakash et al., 2008). Glycosides, which are found in the most part in the leaves, are responsible for the sweet taste. The most represented steviosides are glycosides, rebaudiosides A-F, steviolbiosides and dulcosides (Gardana et al., 2003, Guggisberg et al., 2011) where amount of steviosides and rebaudiosides varies between 4 - 20% which depends on variety and growing conditions. Glycosides, steviosides and rebaudioside have competitive properties of which are the most important no degradation in the human body and thermostability. Rebaudioside is the least bitter and that makes it most suitable for use in human nutrition and without effect on flavor when it is added in foods and beverages. The sweetness of stevioside and rebaudioside is 200-300 times sweeter than sucrose. Stevia is a natural sweetener that, like sugar, does not causes tooth decay and undesirable flavor tolerance. It prevents the formation of dental plaque, has a bactericidal effect, no calories and no harmful effects such as artificial sweeteners. Stevia leaves are rich in many micronutrients such as iron, calcium, sodium, potassium, magnesium, phosphorus, zinc, flavonoids and vitamins A and C (Genus, 2003).

Stevia is stable at high temperatures and in aqueous solutions. It is without the caloric value and it is suitable for use in the diet for diabetics, people with phenylketonuria and obesity (Figlewicz et al., 2009). It is used for sweetening of soft drinks, soy sauce, dairy products, chewing gum, tobacco products and many other foods. The main advantages of using stevia in the industry is its high stability in acidic and alkaline media, heat stability (up to 200 °C), good solubility and good light stability.

Stevia has a beneficial effect on human health (Gardana et al., 2003, Nunes et al., 2007). Some studies have shown that it reduces blood pressure, doesn't causes allergic reactions, accelerates wound healing, helps with the symptoms of osteoporosis, muscle tension, has a beneficial effect on dermatitis and acts as an antioxidant. It was also shown that improves kidney function by increasing water excretion (Atteh et al., 2008). Also, stevia act as an immune stimulant by stimulating cellular immunity (Sehar et al., 2008). Stevia reduces blood sugar levels and doesn't affect the metabolism of insulin (Kinghorn, 2002) and therefore is recommended to diabetics. Scientific researchers have shown that stevia, used as a sweetener in human nutrition, doesn't damage genetic material (Brusick, 2008). Stevia help's in weight loss because the glycosides can not be degraded in the human body and they are not transferred into the bloodstream and doesn't produce any calories. Since stevia sweetened products have lower calorific value there is a great possibility of its use in the food industry.

The aim of this work was to investigate the differences in sweetness profile and viscosity of strawberry flavored yogurt with the addition of different concentrations of sucrose, stevia and equal portions of sucrose and stevia as well as at first day and after seven days of cold storage.

MATERIALS AND METHODS

Materials

Pasteurized and homogenized milk with 3.2% milk fat and DVS (Direct Vat Set) cultures for direct inoculation of the milk were used for fermentation. ABT 5 (Christian Hanse'n A/S, Horsholm, Denmark) culture is composed of bacterial strains *Lactobacillus acidophilus, Streptococcus thermophilus and Bifidobacterium* spp. Yogurts were sweetened by the addition of sucrose (Viro, Virovitica, Croatia) and stevia (Naturex, Avignon, France) containing 90% stevioside. Prior to addition, stevia powder was diluted according to producer's instructions which matches sucrose sweetness and added as a 2% aqueous solution. For flavoring of produced yoghurts, aroma identical to natural strawberry flavor, which contains cochineal (carmine) red A (E124) and tartrazine (E102) was used (Döhler, Darmstadt, Germany).

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Table 1. *Sweetener amounts added in yoghurt samples.*

Sweetener amount (%)	**A Samples 3%**	**B Samples 4.5%**	**C Samples 5%**
1- sucrose	*A1*: 3 g sucrose	*B1*: 4.5 g sucrose	*C1*: 5 g sucrose
2 – stevia	*A2*: 0.9* mL 2% stevia solution	*B2*: 1.35* mL 2% stevia solution	*C2*: 1.5* mL 2% stevia solution
3 – equal portion's of sucrose and stevia	*A3*: 1.5 g sucrose + 0.45 mL stevia	*B3*: 2.25 g sucrose + 0.675 mL stevia	*C3*: 2.5 g sucrose + 0.75 mL stevia

*According to calculation: 0.9 mL of 2% stevia solution matches 3 g of sucrose
1.35 mL of 2% stevia solution matches 4.5 g of sucrose
1.5 mL of 2% stevia solution matches 5 g of sucrose

Methods

The inoculum was prepared by dissolving 1 g of microbial culture in 100 mL of tempered milk (40 °C) and activated for 30 minutes at 40 °C. Tempered milk samples were inoculated with 2.5% (v/v) of inoculum. Fermentation was carried out at 40 °C until the pH was decreased to around 4.6 from an initial pH approximately 6.6. At the end of fermentation the samples were cooled, sweetened, and stored in a refrigerator (+4 °C) for 24 hours until analysis. In all yoghurt samples 0.2 mL/100 g of aroma was added. Samples were sweetened by addition of 1) sucrose, 2) stevia, and 3) an equal portions of sucrose and stevia (table 1). Each sweetener (sucrose, stevia or combination of sucrose and stevia) was added in quantities of 3, 4.5 and 5 % (usual sweeteners quantities for flavoured yoghurts). In this way 9 different samples were obtained. Flavored yoghurts were produced and its pH values are presented in table 1.

Table 2. *Sweetness scale*

NOT SWEET	**LIGHTLY SWEET**	**MEDIUM SWEET**	**VERY SWEET**	**EXTREMELY SWEET**
0	1	2	3	4

The sensory properties were evaluated by a panel group of 5 sensory analysts by ranking test and the 20 – point scoring system of weighted factors. The sweetness between the samples, sweetened with sucrose, stevia or mixture of sucrose and stevia in different concentrations (3, 4.5 and 5%) was compared. The samples were presented to sensory analysts in a series, and each sample was ranked according to an appropriate scale (table 2).

According to the 20 – point scoring system with weighted factors the taste, odor, consistency and color of produced flavored yoghurts were evaluated. The following weighted factors (Fv) were used: 1.4 for taste; 1 for odor; 1 for consistency and 0.6 for color. Maximum score of weighted factors was 20, and scores for each property were in the range from 1 to 5. Rheological properties were measured by rotation rheometer; Rheometric Scientific RM 180 (inc. Piscataway, USA), using a measuring system with a cylindrical spindle. Shear stress and apparent viscosity at different shear rates were determined by rheometer. From the dependency of the logarithm of shear rate and the logarithm of the shear stress linear regression equation was obtained from which certain parameters were determinate: consistency coefficient (mPas), flow index and the regression coefficient for each sample. Regression coefficient (R2) represents the method accuracy (Režek - Jambrak et al., 2008).

All experiments were performed in triplicate expect after seventh day of cold storage where analyses were performed once. Average values and standard deviations were calculated and curves were fitted using Microsoft Excel for Windows®. Data were tested for significance by the one-way analysis of variance (ANOVA) at $p < 0.05$.

RESULTS AND DISCUSSION

Fermentation

Fermentation of milk with ABT 5 culture was carried out to achieve pH value of around 4.6, from initial 6.6 and it lasted in average about 5 hours at 40 °C. pH value of flavored yoghurt was measured after first, second and seventh day of storage. In the first two days there wasn't significant change in pH value, while between the second and seventh day of storage, pH decreased approximately for 0.11 units. Decrease of pH value could be a result of the postacidification due preserved ABT 5 metabolic activity during the

Table 3. *Average pH values of flavoured yoghurts after first, second (n=3) and seventh (n=1) day of cold storage and corresponding standard deviations.*

Sweetener amount	**Sample**	**1. day ($\bar{x}\pm\delta$)**	**2. day ($\bar{x}\pm\delta$)**	**7. day (x)**
3%	**A1**	4.25 ± 0.04	4.26 ± 0.04	4.10
	A2	4.30 ± 0.11	4.23 ± 0.02	4.13
	A3	4.31 ± 0.10	4.29 ± 0.10	4.11
4.5%	**B1**	4.29 ± 0.09	4.28 ± 0.08	4.11
	B2	4.26 ± 0.07	4.23 ± 0.04	4.13
	B3	4.21 ± 0.03	4.21 ± 0.08	4.14
5%	**C1**	4.21 ± 0.02	4.24 ± 0.05	4.13
	C2	4.20 ± 0.03	4.23 ± 0.05	4.10
	C3	4.20 ± 0.02	4.20 ± 0.04	4.11

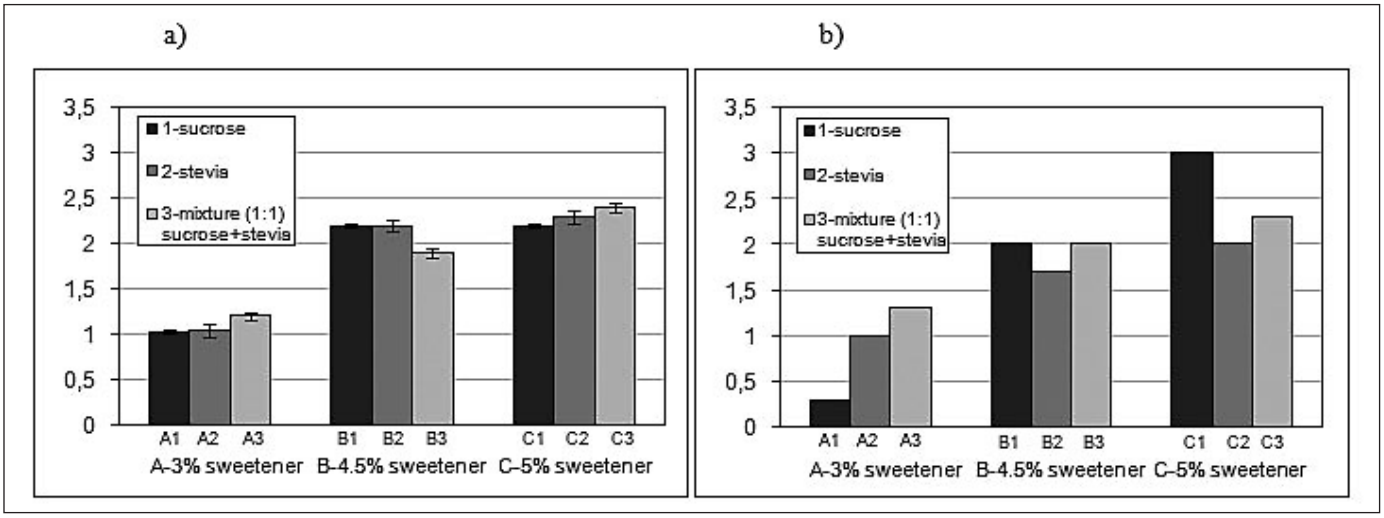

Figure 1. *Sweetness ranking rated by sensory analysts according to sweetness scale after a) first and b) seventh day of cold storage.*

cold storage (Božanić and Tratnik, 2001). It can be concluded that the addition of sweeteners (sucrose, stevia or combinations of sucrose and stevia) had no influence on the change of pH values (table 3). In the research of Matijević (2004) during 21 days of cold storage of yoghurts produced also by ABT 5 culture no significant ($p>0.05$) change in pH values were detected.

Sensory analysis

Samples were presented to sensory analysts in a series and they were ranked according to the sweetness scale (table 2). First, the samples with the lowest (3%) amount of added sweetener were presented, followed by medium (4.5%) and the highest (5%) amount of sweetener. After the first day of storage samples with the same amount of sweeteners, regardless of the type of added sweetener were equally sweet (figure 1. a). Increase of the sweeteners amount contributed to the increase in sweetness of all samples regardless of the type of added sweetener (figure 1. a). After seven days of cold storage sweetness was reduced (for ~ 0.37) in samples in which only sucrose or only stevia were added (3% and 4.5%) compared with the first day. In samples in which combination of sucrose and stevia was added no greater drop of sweetness was determined (figure 1. b). The drop of sweetness was probably due to decrease of pH for 0.1 pH units. The research presented by Gašpar (2010) showed that the amount of 3.3 g of stevia was not equivalent to the sweetness of 1000 g sucrose as manufacturer indicated. Therefore, in presented paper, the sensory panel found that the 6 g of stevia was equivalent to the 1000 g of sucrose.

After ranking test classical sensory analysis (20 – point scoring system with weighted factors) was performed. Since equal strawberry flavor was added to all yoghurt samples, thus scores for the odor and color were equal (table 4). Samples in which only sucrose was added, regardless of amount, were slightly sparsely compared to the other samples and the evaluation of the consistency of these samples was lower (~ 3.75) compared to the other samples (table 4). Scores for taste were ranged between 4.08 and 5.99 of a maximum of 7 points (table 4). The taste was scored as the best in yogurts with the addition of mixture sucrose and stevia in the highest concentration (5%), while the lowest score for the taste had yoghurts with the addition of stevia in the lowest concentration (3%) (table 4). The highest overall score had the samples with the addition of an equal share of stevia and sucrose (17.59 of total 20) in concentration 4.5% while the lowest had the samples with the addition of sucrose in concentration 3% (table 4). The lowest scores had the yoghurts sweetened with stevia. This can be attributed to the taste of artificial sweeteners remains in the mouth after yogurt consumption. In general, we can conclude that the optimal amount of sweeteners in yogurt was 4.5% regardless of the sweetener type. The taste property was the best scored when sucrose and stevia were added and the lowest scored were samples sweetened with stevia. In all sweetness concentrations the samples with the addition of an equal portion of stevia and

Table 4. *Average weighted scores for certain properties of strawberry flavoured yoghurts and associate standard deviations (n = 3).*

Sweetener amount	Sample	Taste (7)	Odor (5)	Consistency (5)	Color (3)	Total (20)
3%	A1	4.52±0.93	3.78±0.03	3.75±0.43	2.79±0.13	14.84±1.31
	A2	4.08±0.35	3.65±0.09	4.70±0.17	2.84±0.14	15.27±0.32
	A3	4.76±0.74	4.00±0.00	4.43±0.06	2.79±0.05	15.98±0.67
4.5%	B1	5.76±0.47	4.18±0.38	4.13±0.12	2.82±0.10	16.90±1.05
	B2	4.71±0.21	3.96±0.40	4.27±0.23	2.74±0.03	15.69±0.53
	B3	5.93±0.35	4.35±0.09	4.48±0.20	2.83±0.06	17.59±0.20
5%	C1	5.76±0.47	4.22±0.03	3.92±0.14	2.88±0.12	16.78±0.50
	C2	4.32±0.20	4.27±0.23	4.27±0.23	2.79±0.05	15.64±0.21
	C3	5.99±0.15	4.13±0.12	4.35±0.09	2.83±0.06	17.30±0.24

sucrose had better scores than the samples sweetened with pure sucrose. Samples sweetened with stevia in concentration 3% and 5% were less sweet than the samples sweetened with combination of sucrose and stevia as well as sweeter than the samples which were sweetened with sucrose. According to the sensory results the scores for consistency of yoghurt samples with the addition of sucrose were lower compared with other samples. Scores for the consistency in samples with the stevia were slightly lower than the scores for samples sweetened with an equal portion of sucrose and stevia in the concentration 4.5% and 5%. Contrary, scores for consistency at the concentration 3% in samples sweetened by stevia were higher than scores of the samples sweetened with equal portions of sucrose and stevia (table 4). The overall scores showed that the best evaluated samples were with the addition of sucrose and stevia in any concentration. The lowest evaluated samples were yogurts supplemented with stevia in concentration 3%.

Sensory scores for odor and color after 7 days of cold storage of all yoghurts were equal as first day and there were no significant differences ($p>0.05$). There were also no differences between consistency for the first and seventh day of storage. Scores for taste were ranged from 3.5 to 6.3 of a maximum 7 points which was similar to the scores after the first day of storage (4.08 to 5.99). In samples with 4.5% of sucrose and stevia mixture the taste was scored the best of all yoghurt samples, same like after first day of storage. The highest and lowest overall scoring of samples after 7 days of storage coincided with the scores after the first day of analysis (figure 2).

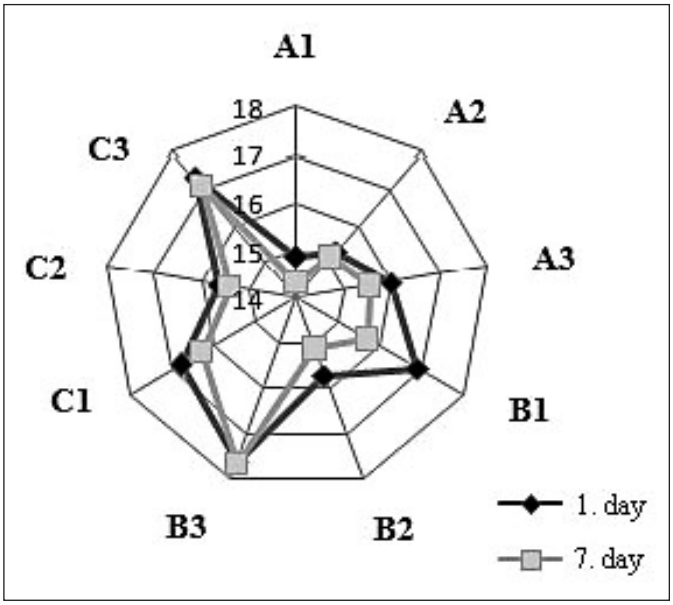

Figure 2. *Total sensory evaluation of flavoured yoghurts with the addition of: 1-sucrose, 2-stevia and 3-an equal share of sucrose and stevia in the amount of 3% (A), 4.5% (B) and 5% (C) after first (♦) and seventh (■) day of cold storage.*

Rheological properties

Apparent viscosity of flavored yogurts was measured to determined the effect on consistency of sweeteners sucrose or stevia water solution. The apparent viscosity of samples in which only sucrose was added and the apparent viscosity of samples with the addition of stevia or a combination of sucrose and stevia were similar. The obtained results by rheometer weren't coincide with the results of sensory analysts who gave (table 5) the lowest scores for consistency for samples sweetened with sucrose, while the best scores got the samples sweetened by combination of sucrose and stevia except for the minimum concentration (3%) where the highest score for consistency obtained stevia sweetened samples. Addition of any kind of sweeteners had no effect on samples viscosity. Average flow index for all samples was around 0.23. Regression coefficients for all samples were high (over 0.90) and that implies the accuracy of the calculated rheological properties of yoghurt using linear regression.

After seven days of storage the decrease in the apparent viscosity and consistency coefficient of all samples occurred (table 6). The largest decrease in the consistency coefficient was observed in samples with the addition of stevia in the lowest concentration (3%) from 6.225 mPas (first day) to 2.172 mPas (seventh day). In samples with the addition of sucrose in the highest concentration (5%) the least decrease of the apparent viscosity occurred from 4.998 mPas (first day) to 4.385 mPas (seventh day). The average flow index was 0.297 and that indicates an increase compared to the average flow index after the first day of storage (0.23). Regression coefficients for all samples were higher than after the first day of analysis (0.97) (table 6).

Table 5. *Average values with its standard deviations of flavoured yogurts rheological properties (n = 3).*

Sweetener amount	Sample	Apparent viscosity/mPas ($\bar{x}\pm\delta$)	Consistency coefficient/mPas ($\bar{x}\pm\delta$)	Flow index ($\bar{x}\pm\delta$)	Regression coefficient R^2
3%	A1	22.0±0.00	5.391±0.46	0.237±0.01	0.909
	A2	21.0±0.00	6.225±1.35	0.214±0.03	0.900
	A3	22.0±0.00	5.823±0.46	0.224±0.01	0.911
4.5%	B1	21.5±0.71	6.524±2.27	0.212±0.04	0.896
	B2	21.5±0.71	5.476±0.52	0.230±0.00	0.913
	B3	21.5±0.71	5.603±0.52	0.229±0.02	0.908
5%	C1	22.0±0.00	4.998±0.30	0.248±0.00	0.911
	C2	21.0±0.00	5.026±0.64	0.242±0.01	0.909
	C3	21.5±0.71	5.187±0.86	0.241±0.02	0.908

CONCLUSIONS

According to obtained results 6 g of sweetener stevia was equivalent to 1000 g of sucrose. Generally, the best scored samples were with addition of an equal portion of sucrose and stevia while the least scored were with stevia addition no

matter of sweetness concentration. The sweetest samples were with the addition of an equal portion of sucrose and stevia in the highest concentration (5%) and the least sweet were with the sucrose addition at the lowest concentration (3%). Yoghurts sweetened with addition of 4.5 g/100 g equal portion of sucrose and stevia were the best sensory evaluated. After 7 days of cold storage sweetness drop occurred if compared with the first day in samples with sucrose as well as in samples with stevia addition. Addition of sweeteners weren't influenced the apparent viscosity.

Table 6. *Rheological properties of flavoured yoghurts after 7 days of cold storage.*

Sweetener amount	Sample	Apparent viscosity/mPas (x)	Consistency coefficient/mPas (x)	Flow index (x)	Regression coefficient R^2
3%	**A1**	20	3.006	0.303	0.970
	A2	19	2.172	0.344	0.975
	A3	20	3.507	0.285	0.972
4.5%	**B1**	21	3.380	0.296	0.974
	B2	21	3.639	0.282	0.972
	B3	20	2.978	0.307	0.970
5%	**C1**	22	4.385	0.264	0.968
	C2	21	3.863	0.275	0.973
	C3	20	2.760	0.319	0.974

LITERATURE

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