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Possibility of using sweeteners in the prevention of obesity development

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Abstract:

Background. The problem of the 21st century both in Poland and around the world is overweight and obesity, and diabetes. Due to the increased incidence of these diseases, the consumption of intense sweeteners, which are used as substitutes for sucrose, has increased. The purpose of this study was to evaluate the sweet taste intensity of selected sweeteners in comparison with the benchmark - beet sugar. **Methods.** The material for the study consisted of four sweeteners: sugar, xylitol, stevia, and cane sugar. The substances were subjected to dilution in an infusion of black tea. This tea was then divided into 4 portions and each portion was sweetened with a different sweetener at a rate of 20g per 1l of infusion. The samples were coded with 3-digit codes, and the paired method was used for sensory evaluation. A total of 78 people participated in the study. **Results.** Differences in the intensity of sweet taste between beet sugar and the substitutes used were confirmed. Cane sugar and xylitol were characterized by a lower intensity of sweet taste, but these substitutes were preferred compared to beet sugar. Stevia is characterized by greater sweetness than beet sugar, while survey respondents strongly preferred beet sugar. **Conclusions.** Consumers, participating in the survey, prefer products with a less intensely sweet taste. Learning about consumers' preferences for sweet taste will allow the use of appropriately preferred substances in the production of food and dishes. This will have a positive effect on the sugar content of the daily ration and its overall consumption.

Key Words: *sugar, sweeteners, obesity, consumer preferences, taste*

Introduction

A problem of the 21st century both in Poland and around the world is overweight and obesity, and diabetes. Due to the increased incidence of these diseases, there has been an increase in the consumption of intense sweeteners, which are used as replacements for sucrose [1].

The main purpose of using sweeteners is to give products a sweet taste with a parallel low supply of

energy to the body [2,3]. Sweeteners are largely used in "light" products, which are often used by people who are losing weight or those who want to live a healthy lifestyle. People with diabetes also use strong sweeteners in large doses, without paying attention to the consequences of the effects on the body [4,5]. Strong sweeteners not only differ in their properties but also in the intensity of their sweet taste. Most of them are sweeter than ordinary white sugar, so they can be used in much smaller quantities than sucrose [2,6]. In some strong sweeteners, not only the sweet taste is sensed, but can also be sensed, for example, bitter taste, or other undesirable types of taste [2,3,7].

The primary sweetener that has long been used is beet sugar. The main carbohydrate that occurs in sugar beets is sucrose [1]. Sucrose is also found in sugar cane and even maple syrup. This compound has a wide range of uses [8]. In addition to its sweetening properties, it is also high in calories, so it is often substituted for other sweeteners [11,12,13].

Sweeteners are those substances that are used to give products a sweet taste, but also to reduce the number of calories delivered by about 30% [20]. Sweeteners are classified as food additives, and in addition to the above-described use, they are also intended to improve the organoleptic characteristics of the product [21]. The standard to which sweet taste refers is a 10% aqueous solution of sucrose, and the unit of the sweetness of such a solution is 1 [3,10,22].

Sweeteners found on the market can be divided into natural, semi-synthetic, and synthetic. This division is illustrated in Figure 2.

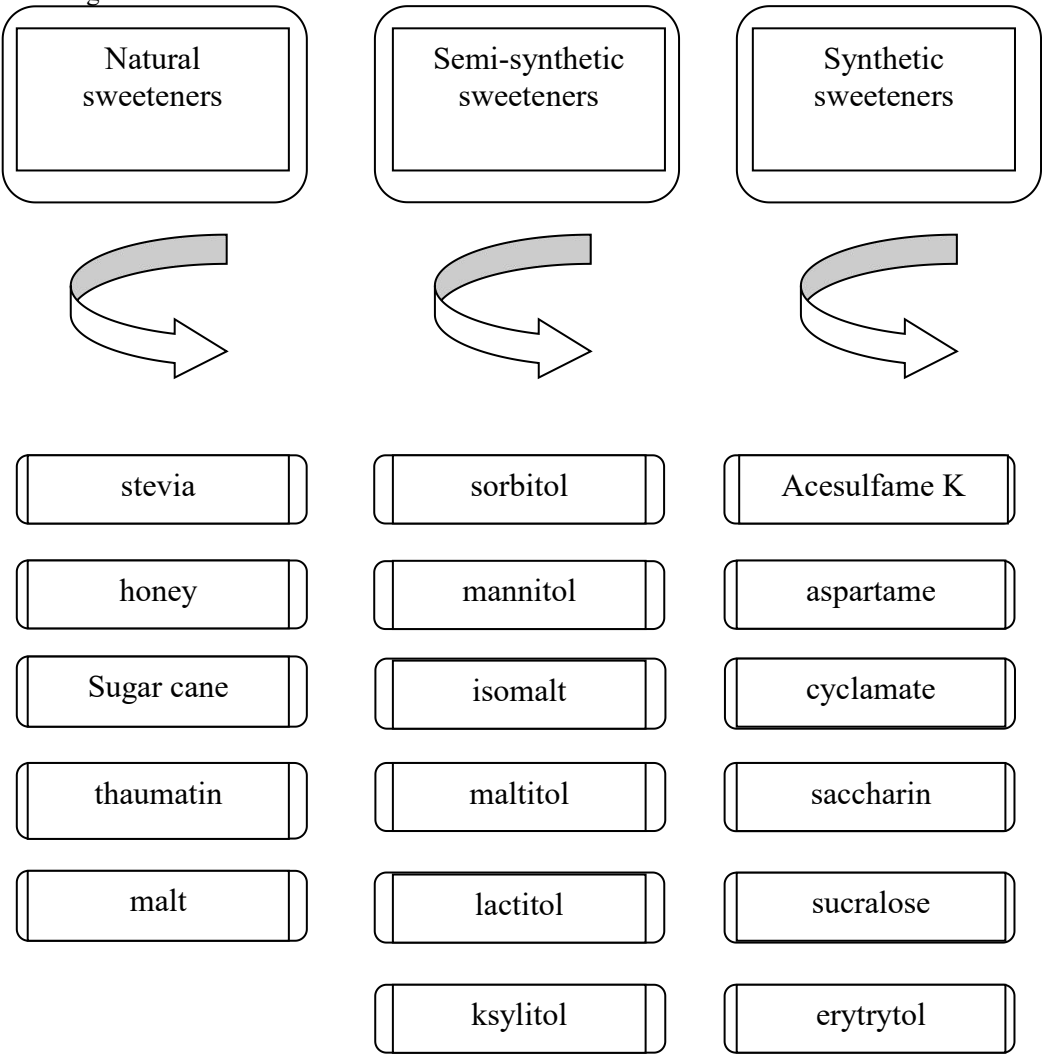


Fig. 1. Division of sweeteners.

Each sweetener is characterized by different intensity of sweet taste, with sucrose being the benchmark. Table I compares selected polyalcohols for which the intensity range is 0.3 - 1 [2,20].

Table 1. Sweet taste intensity of selected chemical compounds [20]

Chemical compound	Sweetness compared to the standard - sucrose
Lactitol	0,3 – 0,5
Isomalt	0,4 – 0,5
Sorbitol	0,5 – 0,6
Mannitol	0,4 – 0,6
Xylitol	1
Maltitol	0,6 – 0,9
Erythritol	0,6 – 0,8

The **aim** of this study was to evaluate the intensity of the sweet taste of selected sweeteners in comparison with the standard - beet sugar.

Material & methods

Procedure. The study consisted of assessing the intensity of sweet taste. The test material consisted of four sweeteners:

1. White sugar "Słodka łyżeczka" produced for Jeronimo Martins Polska S.A. by Krajowa Spółka Cukrowa S.A.
2. Xylitol "Treasures of the Earth" - a natural sweetener derived from birch bark. Manufacturer: SANTE. Best-before date: 10. 2022.
3. Stevia "green leaf" - Powdered substance. Manufacturer: Domos Polska Sp. z o. o. Best-before date: 04/10/2021.
4. Unrefined cane sugar "Demerara" - Manufacturer: SANTE.

All sweeteners were stored under appropriate conditions in accordance with the manufacturer's guidelines.

The substances were subjected to dilution in black tea infusion, which was prepared in accordance with PN-EN ISO 3103:1996 [26]. Water for brewing the tea was obtained from a public water supply, located in the building of the Silesian Medical University in Zabrze Rokitnica. The tea used for the brew was black express tea from the company "Saga". The tea bag, according to the instructions, was brewed in 200 ml of freshly boiled water for 2- 3 minutes. This tea was then divided into 4 portions and each portion was sweetened with a different sweetener at a rate of 20g per 1l of infusion. The samples were coded with 3-digit codes.

Sensory testing using the paired method was carried out in an adapted sensory laboratory, located in the Department of Dietetics of the Department of Food Technology and Quality Assessment at the Silesian Medical University. This laboratory met the requirements of PN-EN ISO 8589:2010 [27].

The study involved 78 people who were specially trained to do so in accordance with PN-EN ISO 8586:2014 [28]. The subjects were given three pairs of samples of 20 ml each in colorless, odorless containers suitable for food contact for evaluation. One sample in a pair was always tea with sugar. Respondents marked their answers on the author's questionnaire.

The evaluation involved two aspects. First, the evaluator marked on the card the sample that, in his opinion, was more intense in sweet taste. Meanwhile, the second task was to mark which sample of the pair was more preferred by the respondent.

The results were analyzed using statistical tables.

Results

Figure 2 illustrates a summary of the results collected on xylitol. Respondents were more likely to indicate xylitol as the preferred substance in terms of taste. According to the respondents, sugar was a substance characterized by greater intensity, as many as 75 people gave this answer.

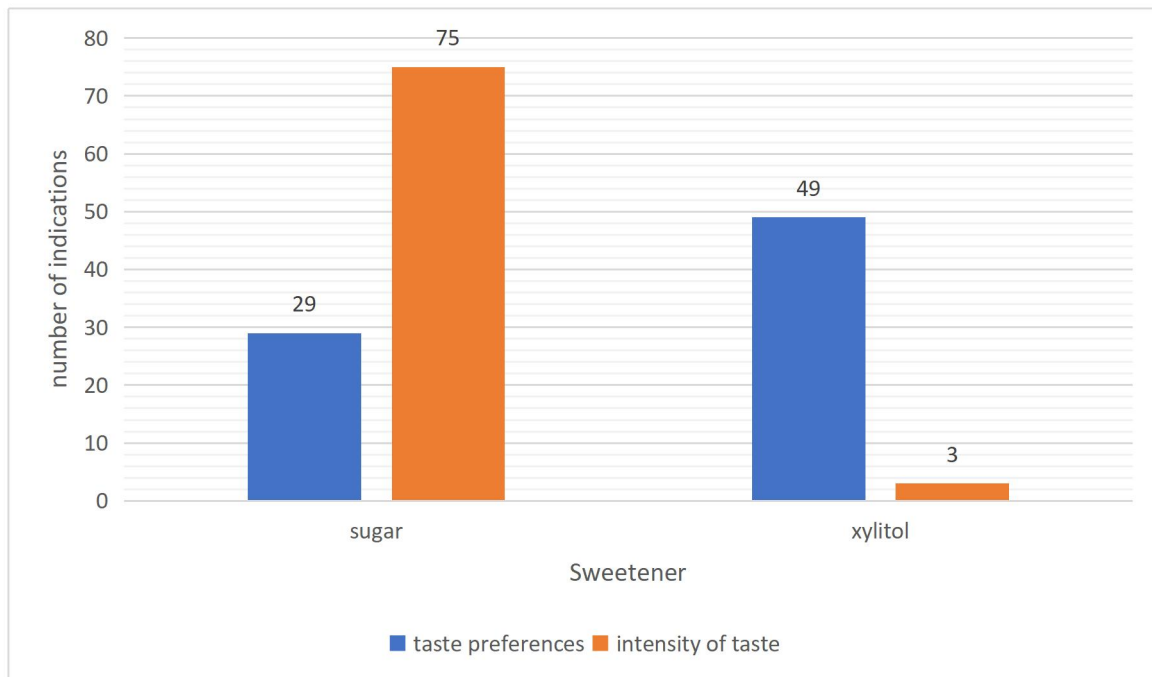


Fig. 2. Results comparing taste preference and sweet taste intensity between sugar and xylitol (N=78).

In the sensory test conducted, 78 responses to the question "which of the samples received have a more intense sweet taste?" were obtained using the paired method. Statistical analysis was performed using statistical tables for the binomial distribution. The marginal value for the 78 responses is 48 for a significance level of $\alpha = 0.05$. Respondents gave 75 affirmative responses for the answer "sugar", which means that the results obtained are statistically significant. Only 3 people marked xylitol as a sweeter sweetener than sugar.

In the sensory test conducted, 78 responses to the question "which of the samples do you think are tastier?" were obtained using the paired method. Statistical analysis was performed using statistical tables for the binomial distribution. The marginal value for the 78 responses is 48 for a significance level of $\alpha = 0.05$. Respondents gave 49 affirmative answers for the answer "xylitol," which means that the results obtained are statistically significant. 29 respondents marked sugar as the more preferred sweetener in taste.

Figure 3 shows the collected results on stevia. It illustrates both the respondents' perception of sweet taste and their taste preferences.

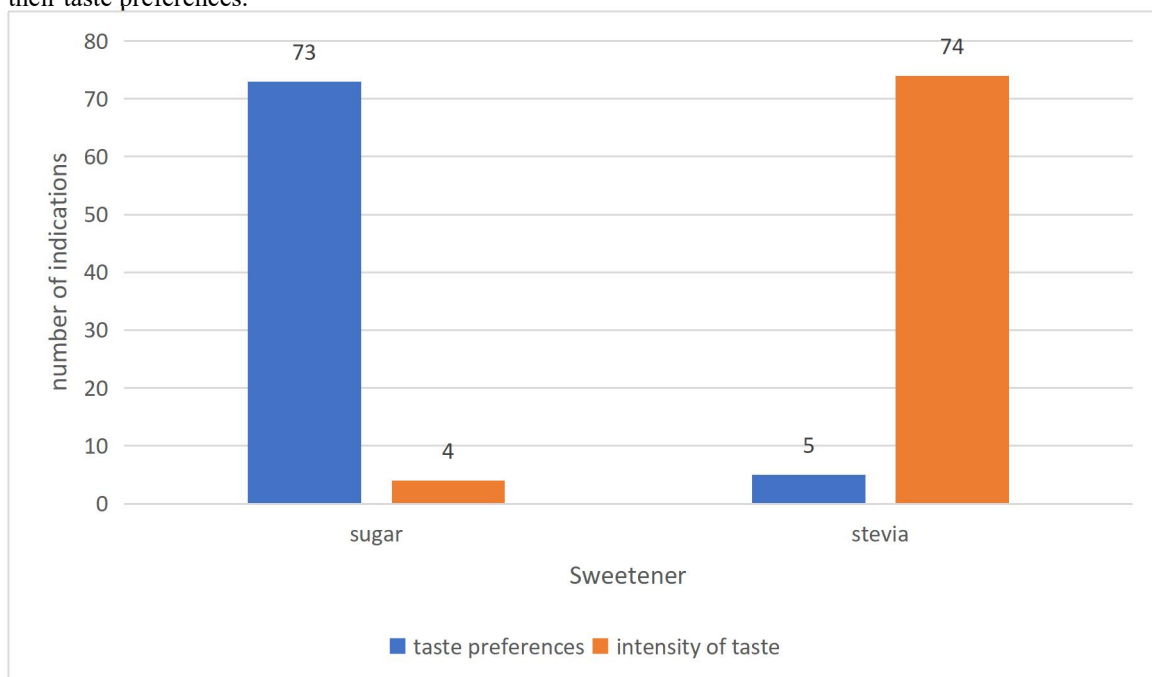


Fig. 3. Results comparing taste preferences and sweet taste intensity between sugar and stevia (N=78).

In the sensory test conducted, 78 responses to the question "which of the samples received have a more intense sweet taste?" were obtained using the paired method. Statistical analysis was performed using statistical tables for the binomial distribution. The marginal value for the 78 responses is 48 for a significance level of $\alpha=0.05$. Respondents gave 74 affirmative responses for the answer "stevia", which means that the results obtained are statistically significant. Only 4 respondents marked sugar, as a more intense taste, and sweetener.

In the sensory survey conducted, 78 responses to the question "which of the samples do you think are tastier?" were obtained using the paired method. Statistical analysis was performed using statistical tables for the binomial distribution. The marginal value for the 78 responses is 48 for a significance level of $\alpha=0.05$. The respondents gave 73 affirmative answers for the answer "sugar," which means that the results obtained are statistically significant. 5 respondents marked sugar as the preferred sweetener in taste.

Figure 4 shows the results of the comparison between sugar and cane sugar. The graph illustrates the type of taste preference of the students, as well as the intensity of their perception of sweet taste.

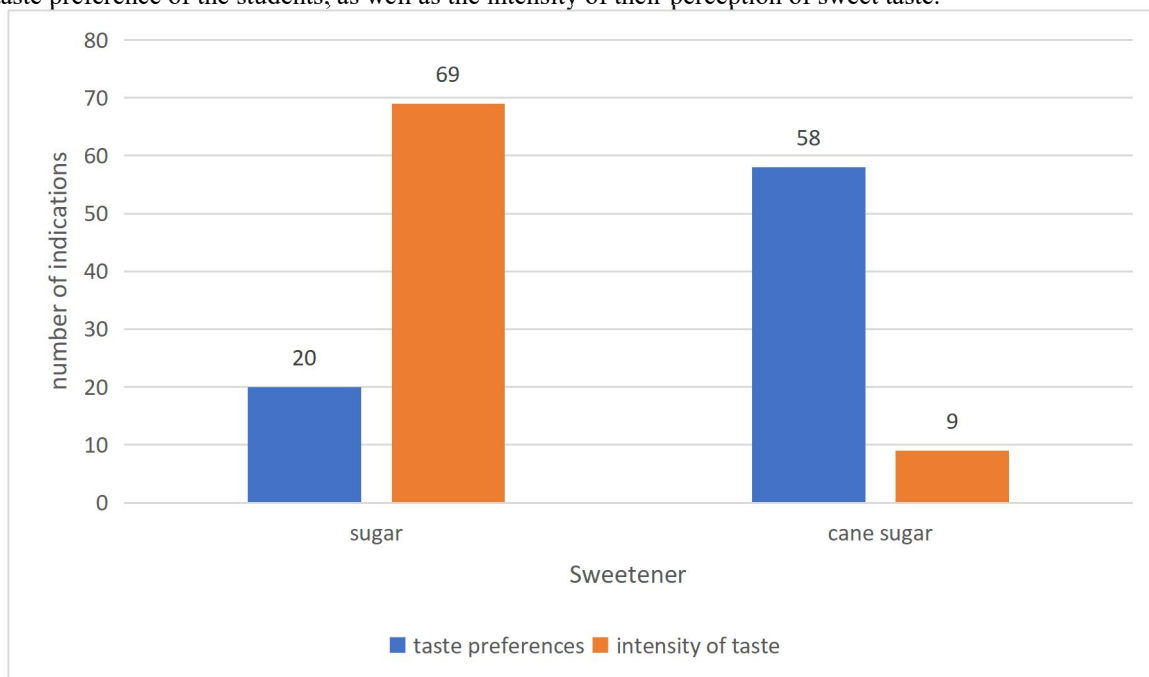


Fig. 4. Results comparing taste preferences and sweet taste intensity between sugar and cane sugar (N=78).

In the sensory test conducted, 78 responses to the question "which of the samples received have a more intense sweet taste?" were obtained using the paired method. Statistical analysis was performed using statistical tables for the binomial distribution. The marginal value for the 78 responses is 48 for a significance level of $\alpha=0.05$. Respondents gave 69 affirmative responses for the answer "sugar", which means that the results obtained are statistically significant. Only 9 respondents marked cane sugar, as a more intense taste, and sweetener.

In the sensory survey conducted, 78 responses to the question "which of the samples do you think are tastier?" were obtained using the paired method. Statistical analysis was performed using statistical tables for the binomial distribution. The marginal value for the 78 responses is 48 for a significance level of $\alpha=0.05$. Respondents gave 58 affirmative responses for the "cane sugar" response, which means that the results obtained are statistically significant. 20 respondents marked sugar as the preferred sweetener in taste.

Discussion

The consumption of sucrose is nutritionally unfavorable, and its excessive amount in the diet can lead to the development of diseases of civilization, such as diabetes, cardiovascular disease, obesity, and dental caries [29]. This fact causes sugar substitutes to be increasingly used in food technology [3].

The aim of the study by Swiader and Waszkiewicz-Robak was to determine the sweetening properties of selected sweeteners - aspartame, acesulfame K, cyclamate, and sodium saccharinate. The study material consisted of the aforementioned synthetic sweeteners; sucrose was used as a standard for sweet taste. It was found that the perception of sweet taste intensity of sweeteners decreases with the increase of their concentration in solution. At perennially high concentrations of sweeteners in aqueous solutions, the intensity of perceived sweetness decreased, and at the same time, a lower precision of the obtained evaluations was observed. A relationship was found between the concentration of sucrose and the concentrations of the sweeteners tested,

equivalent in terms of sweetness intensity, which can be useful for quick and simple conversion of the amounts of these sweeteners when used as sucrose substitutes [20].

The study, conducted by Marjanska and Szpakowska, aimed to analyze the attitude of young consumers aged 21-30 toward foods containing low-calorie sweeteners. The study group consisted of 97 respondents. Almost half of the respondents declared a negative attitude toward foods containing low-calorie sweeteners. Eight tonics available on the Polish market were examined through quantitative descriptive analysis. The results were compiled using principal component analysis and a hierarchical clustering method. Sensory perceptible differences were detected between tonics sweetened only with sucrose and a mixture of different substances [30].

The aim of the study by Galkowska et al. was to evaluate the effect of partial or complete replacement of sucrose with steviol glycosides on the rheological characteristics of milk-starch desserts. The test material consisted of desserts made from Superior Standard potato starch or acetylated potato starch, skimmed milk powder, sucrose, and/or steviol glycosides with the addition of curcumin as a coloring agent and vanilla flavoring. The amount of sucrose substituted with steviol glycosides, taking into account their sweetening potential, was [%] in each sample: 0, 33.5, 66.5, and 100. By determining the characteristics of stickiness, viscosity curves, and mechanical spectra, the rheological properties of the desserts were evaluated. It was found that the substitution of sucrose with steviol glycosides in the recipes of starchy desserts led to the production of gels and gels with significantly modified rheological characteristics. The direction of the induced changes depended on the type of starch used. In terms of the rheological properties of a starch-based dessert, sucrose can play the role of both a viscosity-enhancing agent and a factor that impedes the swelling of starch grains and limits interactions between starch polymers and other dessert components [31].

Kurasinskaya and Wawryniuk's study was aimed at evaluating the shelf-life of jellies obtained using agar as a gelling agent, as well as sugar and various sweeteners used as its substitutes. The following sweeteners were used in the study: sucrose, fructose, dextrose monohydrate, xylitol, sorbitol, and sodium saccharinate. The jellies were subjected to measurements of mechanical and physicochemical properties. Sensory evaluation of jellies was also carried out according to a five-point scale. Such qualitative characteristics of jellies as shape, color, breakthrough, surface, texture, and palatability were evaluated. The results showed that the use of sweeteners has a significant effect on the mechanical properties studied. Above that, jellies with sugar and sorbitol have the highest consumer acceptance [32].

Conclusion

Based on the results, the following conclusions can be proposed. Evaluators perceived differences in the intensity of sweet taste depending on the sweetener used. Differences in the intensity of sweet taste between beet sugar and the substitutes used were confirmed: cane sugar and xylitol were characterized by a lower intensity of sweet taste, but these substitutes were preferred compared to beet sugar. Stevia is characterized by greater sweetness than beet sugar, while survey respondents strongly preferred beet sugar. Consumers participating in the survey prefer products with a less intensely sweet taste.

According to the latest WHO recommendations, sugar intake during the day should be limited to 10% of energy needs and the goal is 5%. Knowing consumers' preferences for sweet taste will allow the use of appropriately preferred substances in the production of food and dishes. This will have a positive impact on the sugar content of the daily ration and its overall consumption.

Conflicts of interest - The authors declare no conflict of interest.

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