Effect of sucrose replacement on nutritional parameters and sensory characteristics of the lollipops with isomaltulose

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Abstract. Lollipops are one of the most popular confectionary products among the consumers of all over the world. The main ingredient for their production is crystal sugar (sucrose). Its partial or complete replacement with suitable alternatives and sweeteners leads to change in sensory profile of lollipops and the overall perception by consumers. The use of isomaltulose may be consider as a revolution in confectionary industry due to its characteristics as a functional, digestible, non-cariogenic and just as important as a low glycaemic disaccharide. The aim of the present study was to evaluate the effect of isomaltulose as a sugar replacement in lollipops on main nutritional parameters and sensory characteristics as appearance (color and opacity), taste, aroma also the texture attribute perceived in a mouth. Results shown that isomaltulose can affect significantly the sensory and texture profile of the lollipops comparing the control products with sucrose. The data shows that samples have the same energy values of 388 kcal/g but sample obtained with isomaltulose has about 12% lower glycaemic indicator.

1 Introduction

Lollipops are one of the popular products among confectionery consumers worldwide. They are obtained after boiling sugar-glucose syrup to a candy mass with a dry matter of 97-98% [1]. The obtained candy mass is subjected to additional processing (cooling processes, flavoring, etc.) and is molding in the form of lollipops. The main ingredients for their production are crystal sucrose, glucose syrup and food additives (acids, colorings and flavorings). Lollipops come in a wide variety of shapes, sizes, aromas and flavors. There are also differences regarding their composition.

It has been established that excessive consumption of foods with a high sucrose content is one of the causes of the so-called "diseases of civilization" or „noncommunicable diseases“ [2]. Respectively the interest of producers and consumers in the so-called functional foods has increased in recent years. Functional foods are one of the new trends in nutrition science. They are intended either to improve the functions of some systems in the body, or to reduce the risk of disease [3]. Foods with sweet taste, accordingly sugar products, are a suitable medium as carriers of certain functional ingredients and suitable for the technological realization of certain functional concepts [4]. The variety of sweeteners and alternatives to sucrose allow the production of sugar-free sweet foods with certain functional claims. In this regard, isomaltulose is gaining wide popularity. It is a reducing disaccharide (an isomer of sucrose) that occurs naturally in honey and sugar beet juice [5]. Isomaltulose has about 50% less pronounced sweet taste compared to sucrose and a low glycaemic index (GI = 32), its energy value is similar to other sugars – 4 kcal/g [6, 7]. Several scientific studies have reported that isomaltulose does not induce the development of dental caries [7, 8].

Isomaltulose is currently used as an alternative to sucrose in foods and beverages - sports drinks, energy drinks, malt beverages, breakfast cereals, dairy products, bakery products and confectionery (e.g. chocolate products, jellies, ice cream, chewing gum) and others [7, 9].

The aim of the present study is to evaluate the influence of isomaltulose as an alternative to sucrose in the composition of lollipops recipes and the effect of this replacement on the sensory profile and some nutritional parameters.

2 Materials and methods

The lollipop samples were elaborated under confectionary production conditions in a candy company in Bulgaria. Two samples were developed and analyzed: 1) the control sample was produced according to the classic recipe with the addition of sucrose and glucose syrup – Control lollipops sample (CLS) and 2) the sample obtained with addition of 25% isomaltulose – Lollipops with isomaltulose LWI. Two samples were obtained according to the technological scheme presented in a Fig. 1. The candy mass is obtained using a vacuum apparatus. Boil to a temperature of 130°C, vacuum for 2 min. The candy mass is fed for cooling to a cooling mass to a temperature

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of 75°C. During the cooling process, the additional processing is carried out. The processed candy mass is hold out to form lollipops, which at the end of the process are cooled at a temperature of 20°C.

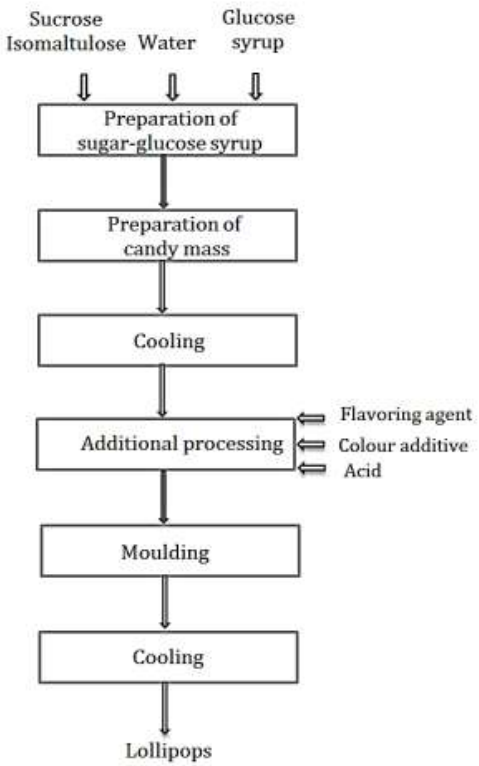

Fig. 1. Technological scheme for production of lollipops

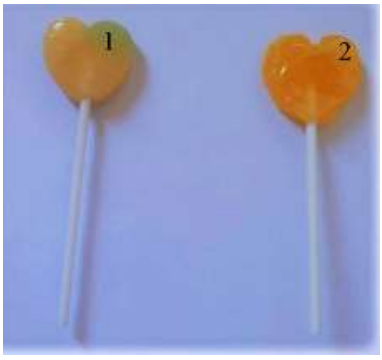

Fig. 2. Analyzed samples: 1-LWI and 2-CLS

Sensory evaluation of the hard lollipops was performed by using a Profile Attribute Analysis (ISO 13299:2016) and Texture Profile Method (ISO 11036:2020). The panel of assessors was composite by 12 trained panellists ages ranging from 30 to 65 years old, selected according to the guidelines of the ISO (female: n = 8; male: n = 4).

Before starting the sessions of sensory evaluation all panellists were trained and exposed to several screening tests. Appearance (color and opacity), taste, aroma and texture attribute perceived in a mouth were select and define in a preliminary session (Table 1). Lollipops samples were provided simultaneously in a single session. The assessors were asked to indicate and rate the intensity of their perceptions for each of sensory-texture attributes on a 9-point intensity scale according to Table 2.

Hedonic ranking test was performed for evaluation of the taste preferences according to the subjects' degree of liking from 5 = most preferred to 1 = least preferred [10].

Table 1. Sensory attributes and descriptions

Sensory attribute	Descriptions
Appearance:	
Color	Perceptions of the intensity of yellow hues from light to dark
Opacity	Perception of the lacking transparency or translucence in the hard candies
Taste:	
Sweetness	Perception of sweetness related to white sugar or browned sugar
Sourness	Perception of acidity related to citric or other fruit acids
Aroma:	
Citrusy	Total citrus aroma is composed of variety of the citrus fruits like orange, lemon, lime, grapefruit and others perceived through the nose and retronasal olfaction
Tropical	Total tropical aroma is composed of mainly of golden pineapple, coconut and mango perceived through the nose and retronasal olfaction
Mouthfeel	
Hardness	Perception of the force required to compress the food or ability to resist in a deformation
Fracturability	Perception of the force required to generate the first fracture and gives an indication of the brittleness of the product
Smoothness	Perception due to crystallization of the candies, that they don't feel grainy on the tongue, but smooth
Stickiness	Perception to be staying attached to any surface

The hardness of lollipops was measured using a Hoepler`s consistometer with a cone attachment with a tip angle of 53°68'. The cone sinks for 1 minute in the test sample under the influence of a weight of 0.5 kg

The color of lollipops was determined spectrophotometrically at $\lambda = 425$ nm on 10% solutions of the analysed samples.

The nutritional value of lollipops was calculated according to the macronutrient content [11]. The glycaemic indicator was calculated according to [12].

Statistical analysis was performed using MS Excel 2019. The data for the physico-chemical indicators are expressed as mean ± standard deviation, the difference was considered statistically significant when $p < 0.05$.

Table 2. Attribute intensity scale

Numerical value	Intensity
0	Absent perception of the assessed attribute
1	Small trace that may not be found if second tasting
2	Present in the sample but at low intensity
3 to 5	Clearly perception of the assessed attribute
6 to 8	Dominant perception of the assessed attribute
9	Maximum or over powers perceived for the assessed attribute

Table 3. Hedonic scale for assessing the consumer acceptability

Scale	Consumer acceptability
1	Dislike extremely
2	Dislike slightly
3	Neither like nor dislike
4	Like slightly
5	Like extremely

3 Results and discussion

It is known that the sugar replacement can be challenging for producing the hard candies and it is necessary to investigate how sugar alternatives (as isomaltulose in the current study) can affect some quality parameters of lollipops samples like the sensory characteristics, especially those concerning the texture profile. [13].

Additionally, was aimed to evaluate the hedonic response of this sugar replacement. Consumers preferences for the lollipops sensory characteristics can be a leading idea in the early stages of products development, moreover the sensory profiling can be helpful for definition of the necessary sensory characteristics which are leading to consumers acceptability. Target groups of consumers for the lollipop's consumption are stronger in childhood than in adulthood, for the reason that children exhibit a natural preference for a sweet taste [14].

In order to carry out a complete comparative evaluation of the lollipop samples and to check whether the obtained results from the sensory analysis will be confirmed by the physicochemical parameters like hardness and color. The results are shown in the Table 4. Data from the sensory evaluation of the lollipops samples shows that replacement of the sugar with isomaltulose in the current study affect significantly some characteristics.

Table 4. Physico-chemical indicators - hardness and color of the lollipops

Indicators	Sample	
	CLS	LWI
Hardness, kg/cm^2	58.9±0.18	52.64±0.14
Coloring, E (10% solution; λ = 425nm)	0.733±0.21	0.927±0.36

The changes in color reflects in opacity and deeper yellow hue in the sample with isomaltulose. This tendency is in a compliance with the spectrophotometric data from the physicochemical test of the color.

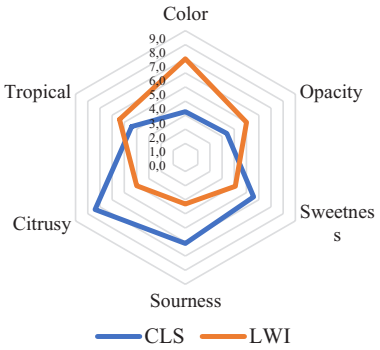

Fig. 3. Lollipops sensory profiles

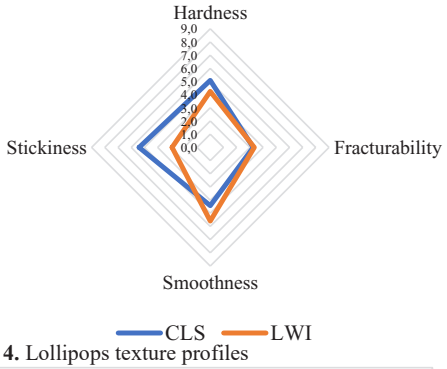

Fig. 4. Lollipops texture profiles

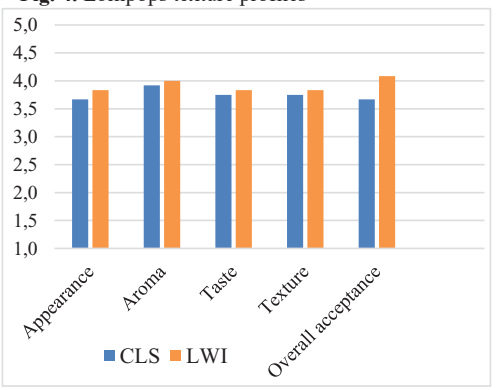

Fig. 5. Lollipops Hedonic acceptability

The changes in the sensory profile of the samples with isomaltulose were further manifested in an enhanced sensation of tropical aroma, at the same time it`s demonstrates a reduced perception of citrus aroma and sour taste. Sweet taste also scored lower, which may explain the different consumer acceptance regarding the isomaltulose lollipop sample.

Isomaltulose also provoked some differences in texture profile of the samples. Reduced intensity of the perceptions of the stickiness and hardness are noticeable.

It is possible that the different way of crystallization affecting the hardness of the candy mass leads to changes in smoothness sensory characteristic. Some of the consumers participating in the hedonic test expressed an opinion about a rougher surface as a mouthfeel.

The data shows that samples have the same energy values, because the energy value isomaltulose provides to the body is 4 kcal / g like other sugars. Differences are observed in the values of the calculated glycaemic indicator. The sample obtained with the participation of isomaltulose has about 12% lower glycaemic indicator than the CLS sample.

Table 5 shows the calculated energy value and glycaemic indicator of the analysed samples.

Table 5. Energy value and glycaemic indicator

Indicators	Sample	
	CLS	LWI
Energy value, kcal/g	388	388
Glycaemic indicator	80.54	71.56

4 Conclusion

The presented study demonstrated how replacement of the sugar with isomaltulose in the composition of the candy mass can affect some sensory and physicochemical characteristics of the lollipops comparing to the control samples. Lollipops with isomaltulose have lower glycaemic indicator about 12% comparing to the control samples. They have a deeper yellow hue and demonstrated significant level of opacity in appearance. This alternative to sugar can affect aroma-teste sensory profile, that why it is advisable to realize the hedonic test for consumer acceptability. The increased concentration of the isomaltulose in lollipops can be challenging for texture profile characteristics as hardness and smoothness.

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