Indian J Anim Health (2021), 60(2)-Special Issue: 272-276
DOI: https://doi.org/10.36062/ijah.2021.spl.00121

Short Communication

Substitution of sucrose in flavoured milk by tagatose

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Abstract

Excessive consumption of sucrose adversely affects human health. Reduction in sugar consumption by the people has, therefore, become the need of the hour. The uses of sugar substitutes as sweeteners have their own significance in foods. Of late, tagatose has emerged as a highly potential low-calorie sweetener for food applications. Studies were conducted to find out the suitability of tagatose as a sweetener in flavoured milk. Results suggested that 8 g sucrose can be fully substituted by 8.25 g tagatose and 0.75 g fructose per 100 mL of flavoured milk.

Key words: Flavoured milk, Fructose, Sucrose substitution, Tagatose

Highlights

- Tagatose, a low calorie (1.5 kcal/g) sweetener, has low glycemic index and can provide health benefits to consumers if used in the preparation of dairy products.
- Tagatose can replace sucrose fully in flavoured milk, if fructose is used as adjunct sweetener.
- Flavoured milk containing only tagatose scores less in overall acceptability as compared to that containing sucrose.
- Addition of 8.25 g tagatose and 0.25 g fructose can fully substitute 8 g of sucrose per 100 mL of flavoured milk.

Sucrose is the most widely used sweetener in food industry, but it contributes excessive calories leading to overweight and obesity, which in turn cause several health problems including type 2 diabetes, heart attack, kidney disease, some cancers and tooth decay (Levin, 2002; Oliveira *et al.*, 2015; VanLaar *et al.*, 2021). The World Health Organization has proposed to reduce the daily calorie intake through sugars for the health benefits of human beings to 5% from the earlier recommended level of 10% (Mooradian *et al.*, 2017). Reduction in sucrose consumption by the people is, therefore, the need of the hour, but none of the sugar substitutes has so far been found to be ideal to replace sucrose in foods (Mariotti and Lucisano, 2014; Luo *et al.*, 2019). Of late, tagatose has emerged as a promising sugar substitute for food applications due to its sucrose like sweetness, low caloric content, low glycemic index, desirable physicochemical properties and health benefits (Rouhi *et al.*, 2015). Keeping in view the popularity of flavoured milk among all age groups of people throughout the world, it was selected for substitution of sucrose by tagatose.

In acceptance or rejection of food products, primary determinants are appearance, color, odor, taste and texture (Izutsu *et al.*, 1981). Sensory properties are of prime importance for the market success of any food. The taste perception also plays a very vital role in the sensory evaluation process (Zargaraan *et al.*, 2016). Temperature and characteristics of food systems may affect the sensory profile of

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sweeteners (Fujimaru *et al.*, 2012). In the present study, work was carried out for optimizing sucrose substitution in flavoured milk using tagatose as an alternative sweetener, along with fructose as an adjunct sweetener.

Tagatose (purity 100%, brand: NuNatural), sucrose (purity 99.4%, brand: Madhur) and fructose (purity 99%, brand: Lobachemie) were purchased from the local market at Anand, Gujarat.

Flavoured milk was prepared using Amul brand standardized homogenized milk (4.5% fat and 8.5% SNF) as per the method of Aneja *et al.* (2002). Sucrose was added at the rate of 8 g/ 100 mL of flavoured milk (control sample) as per the existing commercial practice (De, 2001; Aneja *et al.*, 2002). For substitution of sucrose, either tagatose or tagatose along with fructose (adjunct sweetener) were used. All the samples of flavoured milk were filled in 200 mL capacity PET bottles and stored in the refrigerator overnight at 6±1°C before serving to sensory panel members. Sensory evaluation of flavoured milk was carried out for overall acceptability using 9 point hedonic scale as per Wichchukit and O'Mahony (2015) by a panel of eight semi-trained judges from the faculty of SMC College of Dairy Science, Anand. Data obtained from the experiments were subjected to statistical analysis using a completely randomized design (Steel and Torrie, 1980) as illustrated below:

$Yij = m + Ti + Eij$

Where,

Yij = Response due to j^{th} observation in the i^{th} treatment,

m = general mean,

Ti = effect of i^{th} treatment,

Eij = Error due to j^{th} observation in the i^{th} treatment.

For substitution of sucrose by tagatose as a sweetener in the flavoured milk, three different approaches were explored.

Considering the similar bulk properties of sucrose and tagatose, possibilities of complete substitution of sucrose by using different amounts of tagatose were explored in the first approach. Keeping in view the reported relative sweetness of tagatose as 0.9 (90% of that of sucrose), tagatose was added at the rate of 8.0, 9.0 and 10% (w/v) during the preparation of flavoured milk. Sample containing 8% (w/v) sucrose per 100 mL served as control. Results obtained from four replications of the experiment are presented in Table 1.

The overall acceptability score of flavoured milk significantly ($p<0.05$) increased upon increasing the level of tagatose from 8.0 g to 9.0 g per 100 mL of flavoured milk. Further increase in the tagatose level to 10 g/100 mL decreased the overall acceptability of the product, which might be due to increased sweetness contributed by tagatose. All the treated samples had significantly ($p<0.05$) lower overall acceptability scores than that of control. Patel and Aparnathi (2021) reported that the sweetness of 100 mL water containing 9 g tagatose was almost identical to that containing 8 g sucrose. The overall acceptability scores of lassi samples containing 12.0, 13.2 and 14.4% (w/v) tagatose were statistically at par with that prepared using 12% (w/v) sucrose (Patel *et al.*, 2021). However, the use of 9% (w/v) tagatose in the present study failed to give equivalent sweetness as that of control. Differences in performance of tagatose in different products might be due to the variation in the composition

Table 1. Overall acceptability scores of flavoured milk prepared by complete substitution of sucrose with tagatose (mean ± S.E.)

Amount of sweetener added (g/100 mL)	Overall acceptability score (out of 9)
Tagatose (8.0) + Sucrose (0.0)	6.79^{a}±0.17
Tagatose (9.0) + Sucrose (0.0)	7.35^{b}±0.10
Tagatose (10.0) + Sucrose (0.0)	7.00^{a}±0.12
Tagatose (0.0) + Sucrose (8.0)	8.54^{c}±0.14

Note: CD value 0.32, number of replicates 4, mean values differing significantly ($p<0.05$) have different superscripts

and other properties of the products such as acidity in case of lassi.

Taste quality and intensity are dependent not only on the structure of the compound but also on other taste reception parameters such as temperature, pH, viscosity and the presence of additional sweet or non-sweet compounds (Belitz *et al.*, 2009). The sensory profile of sweeteners may be affected by the temperature and characteristics of food systems (Fujimaru *et al.*, 2012; Paixão *et al.*, 2014). In soft drinks, tagatose in combination with intense sweeteners exhibited significant synergistic effects even at low doses (Bertelsen *et al.*, 2001). The present results could not be compared suitably due to non-availability of references of similar research works. Based on the results, a level of 9% (w/v) tagatose was selected for further study on flavoured milk.

Overall acceptability scores of the flavoured milk samples prepared by adding tagatose to partially replace sucrose along with control are presented in Table 2. The overall acceptability score of the flavoured milk increased with a decrease in the rate of sucrose substitution. Control sample which scored highest, had nonsignificant difference in the overall acceptability score with the sample containing 2.25 g tagatose and 6 g sucrose. The overall acceptability scores of all other samples differed significantly ($p<0.05$) from that of the control. Flavoured milk containing tagatose only scored lowest, which could be due to the inherent differences in sensory attributes of tagatose and sucrose. In general, substitution of sucrose with tagatose at different levels significantly ($p<0.05$) influenced the overall acceptability of flavoured milk. Results could not be compared satisfactorily due to non-availability of similar literature. It was evident that tagatose alone can not suitably replace more than 25% of the total sucrose in 100 mL of the product and therefore adjunct sweetener is necessary.

Fructose is commercially used as sweetener in foods and beverages due to its high relative sweetness which decreases total calorie intake (Hanover, 1982; Hanover and White, 1993). It has relatively low glycemic index i.e. 20 compared to 59 of sucrose (Jenkins *et al.*, 1981) and thus more suitable for diabetic people. Taste profile of fructose is similar to sucrose, but the former has slightly quicker onset and fall (Hanover and White, 1993).

In the third approach, tagatose along with a small concentration of fructose were added for complete substitution of sucrose. As aim of this study was to utilize tagatose as sucrose substitute, fructose was not added at high concentrations. It was theorized that fructose would provide more sucrose like taste even at relatively lower concentrations, thereby modifying the taste of the product in a favorable way.

Results obtained from the experiment in which out of 9 g of tagatose per 100 mL of flavoured milk, 0, 0.25, 0.50, 0.75 and 1.0 g tagatose (w/v) were replaced with fructose, are given in Table 3. Flavoured milk prepared by adding 8 g sucrose per 100 mL served as control. In general, the overall acceptability of the samples was significantly ($p<0.05$) influenced by the level of substitution of tagatose with fructose. Sensory score of the flavoured milk increased with an increase in substitution of tagatose by fructose. Control had highest overall

Table 2. Overall acceptability scores of flavoured milk prepared by partial substitution of sucrose with tagatose (mean ± S.E.)

Amount of sweetener added (g/100 mL)	Overall Acceptability score (out of 9)
Tagatose (9.00) + Sucrose (0.0)	$6.79^{a}\pm0.15$
Tagatose (6.75) + Sucrose (2.0)	$7.18^{a}\pm0.09$
Tagatose (4.50) + Sucrose (4.0)	$7.86^{b}\pm0.10$
Tagatose (2.25) + Sucrose (6.0)	$8.25^{bc}\pm0.07$
Tagatose (00.0) + Sucrose (8.0)	$8.54^{c}\pm0.12$

Note: CD value 0.48, number of replicates 4, mean values differing significantly ($p<0.05$) have different superscripts

Table 3. Overall acceptability scores of flavoured milk prepared by complete substitution of sucrose with blends of tagatose and fructose (mean ± S.E.)

Amount of sweetener added (g/100 mL)	Overall acceptability score (out of 9)
Tagatose 9.00 + Fructose 0.00	7.04^{a}±0.15
Tagatose 8.75 + Fructose 0.25	7.36^{ab}±0.15
Tagatose 8.50 + Fructose 0.50	7.75^{bc}±0.07
Tagatose 8.25 + Fructose 0.75	8.18^{cd}±0.09
Tagatose 8.00 + Fructose 1.00	8.25^{d}±0.11
Tagatose 0.00 + Sucrose 8.00	8.27^{d}±0.08

Note: CD value 0.48, number of replicates 4, mean values differing significantly ($p<0.05$) have different superscripts

acceptability score, but it was not significantly different from those samples containing 0.75% or 1% (w/v) fructose. Results indicated that fructose considerably improved the performance of tagatose in the flavoured milk and complete substitution of sucrose in the preparation of flavoured milk could be achieved by using either 0.75 g or 1 g fructose (Table 3).

The improvement in the overall acceptability of flavoured milk added with fructose as an adjunct sweetener and tagatose as major sweetening agent might be attributed to high relative sweetness (Shallenberger, 1993; Barclay *et al.*, 2012) and synergistic effects of fructose in improving the taste of the product (VanTornout *et al.*, 1985; Schiffman *et al.*, 1995; Barclay *et al.*, 2012; Reyes *et al.*, 2019). Results of the present study could not be compared as any literature on the use of fructose as an adjunct sweetener in flavoured milk was available.

Since the main aim of the study is to substitute sucrose with tagatose, addition of 0.75 g fructose along with 8.25 g tagatose in place of 8 g sucrose per 100 mL of flavoured milk was, therefore, receommended.

Conflict of interest: Authors have no conflict of interest in this study.

Author's contribution: AMP: Involved in conducting physical experiments, participating in planning of experiments and collaborative role in manuscript writing; SH: Contributed as advisor in planning experiments, reviewing and interpreting results and manuscript editing; BMM: Contributed as advisor in planning experiments, reviewing and interpreting results and manuscript editing; KDA: Contributed as advisor in planning experiments, reviewing and interpreting results and original manuscript writing.

ACKNOWLEDGEMENT

We are thankful to the Dean, College of FPT & BE, AAU, Anand and Principal, Dairy Science College, Anand for providing the facilities to do the experiments during PhD programme.

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Received – 07.08.2021, Accepted – 30.10.2021, Published – 01.12.2021
Section Editor: Prof. M. K. Sanyal, Member, Editorial Board