

RESEARCH ARTICLE

Development of sorghum millet incorporated reduced calorie flavoured milk

Supti Ojha¹ and Apurba Giri² (✉)

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Abstract: Sorghum millet is rich in nutrient profile including slow digestive starches, vitamins, minerals, protein, fiber that contribute to improve health outcomes like better digestion, controlled diabetes, and enhanced cardiovascular health. Stevia is a natural sweetener with zero calories and attracts individuals with diabetes and those who are health-conscious. This research aimed to optimize the level of sorghum and stevia in flavoured milk. In this study, the addition of millet in various batches were 1%, 2%, 3%, 4% and for the next step, the optimization of stevia level in various batches were 1%, 1.5% and 2%. Higher levels of sorghum millet addition increased moisture percentage, titratable acidity, total soluble solids of the products, similarly at higher levels of stevia addition increased moisture percentage, titratable acidity, but decreased total soluble solids. Flavoured milk was optimized with 3% of millet addition and sugar was completely replaced by 1.5% stevia based on sensory characteristics.

Keywords: Sorghum millet, Reduced calorie, Stevia, Functional food, Flavoured milk, Sensory analysis

Introduction

In today's fast-paced lifestyle, people are increasingly choosing ready-to-eat foods that are high in nutrients to maintain their health while managing their busy schedules. Among these, functional foods have gained popularity for their medicinal benefits, providing essential ingredients like vitamins, minerals and bioactive compounds (Giri et al. 2015; 2017).

Milk is a versatile food, renowned for its comprehensive nutritional profile that promotes strong bones, healthy teeth, and overall well-being. When it is combined with natural sweeteners, flavours and colours, it becomes flavoured milk, appealing to consumers of all ages and offering an enjoyable way to increase milk intake. Flavoured milk is a palatable, nutrient-rich, and affordable dairy-based beverage that appeals to individuals across all age groups and serves as an effective means of quenching thirst. It may incorporate a variety of ingredients such as edible flavours, nuts, food-grade colours, and sweeteners. To ensure microbiological safety and extended shelf life, flavoured milk is subjected to thermal processing methods such as pasteurization, sterilization, or boiling.

Millets or Nutri- cereals are a group of the cereal grain which associated to the family of *Poaceae* (grass family). It contain protein, carbohydrate, fat, vitamin, minerals, bio-active compound and essential amino acids, that maintain good health, diabetes, heart disease and may reduce lower blood pressure level (Mall and Tripathi 2016). Various types of millets are (sorghum, barnyard, little, proso, foxtail, browntop, pearl, *kodo* and finger millet) used for people's consumption in the mass developing countries.

Among different millets sorghum (*Sorghum bicolor*) is the fifth utmost accomplished grain in the world, than, wheat, corn, rice, barley (Rashwan et al. 2021). It is a good source of vitamins B and E, minerals (phosphorus, iron, zinc, calcium, potassium and magnesium), antioxidant (flavonoids, tannins and phenolic acids), β -carotene, bioactive compounds like anthocyanins and polyphenols (Ratnavathi et al. 2016; Tanwar et al. 2023). Sorghum millet contain high amount of fiber content that can help in weight

¹Food Technology, Nutrition and Management; E-mail: ojhasupti994@gmail.com

² Dept. of Nutrition, Mugberia Gangadhar Mahavidyalaya, Bhupatinagar, West Bengal, Pin-721425

(✉) Apurba Giri
Dept. of Nutrition, Mugberia Gangadhar Mahavidyalaya, Bhupatinagar, West Bengal, Pin-721425

E-mail: apurbandri@gmail.com; Mobile- 9513875903

management by reducing calorie intake (Ambati and Sucharitha 2019).

Additionally, stevia, a natural sweetener derived from the *Stevia rebaudiana* plant, offers a healthier alternative to sugar without adding calories (Giri et al. 2013; Giri and Rao 2025). Stevia not only provides sweetness but also supports cardiovascular health, reduces blood sugar levels, and assists in weight management, making it safe for diabetics and health-conscious individuals alike (Furlan et al. 2016; Abbas et al. 2017).

The present study was conducted with an objective of optimization of the level of sorghum millet and stevia addition in flavoured milk.

Materials and methods

Materials

Toned milk (Amul brand, manufactured by Indian Dairy Pvt. Ltd., Hooghly, WB); Sorghum millet flour (SIDDHAGIRI SWASTHYA brand, manufactured by The Ichalkaranji Co-op Industrial Estate Ltd, Kolhapur, Maharashtra); Sugar; Stevia (So Sweet brand, manufactured by KANHA BIOGENETIC); Kesar Atar (TRIPTI brand, packed by N.D. & CO, Rabindra Sarani, Kolkata); Kesar colour (Bush brand, manufactured by L.B.N. Industries, Chittor) were used in this study.

Methods

Manufacturing of control and functional flavoured milk

For making control flavoured milk, at first 200mL milk (Fat-3%, Solid not fat- 8.5%) was taken in a steel pan and sugar (14g), 0.025g kesar color (mixed in 5 mL water) were added and was heated (75 °C/15 s) for pasteurization. After cooling to ambient temperature, 2ppm kesar flavor was added and mixed thoroughly and filled in the bottle and stored at refrigerated condition (4±2°C)

For functional flavoured milk in the above process, sorghum millet (1, 2, 3 and 4% for different batches) was added before pasteurization and instead of sugar, stevia (1, 1.5, 2% for different batches) was added. Both control and sorghum millet added and stevia sweetened flavoured milk were mentioned in Fig. 1

Analysis

Physico-chemical analysis

For each samples moisture content was determined by gravimetric method according to the procedure described in ISI (1981). Titratable acidity of the control and functional flavoured milk was determined as per the procedure described in IS: 1479 (1960). The digital pH meter (Sartorius brand, manufactured by Hallmark Mechatronics, Kochi, Kerala) was used for pH test. Total soluble solids (TSS) of flavoured milk were measured by hand

refractrometer (ATAGO brand, manufactured by Atago India Instruments Pvt. Ltd., Mumbai) having range of 0-100°Brix range.

Sensory analysis

For sensory analysis a 9-point hedonic scale was used to convey the degree of likeness as dislike extremely-1, dislike very much-2, dislike moderately-3, dislike slightly-4, neither like nor dislike-5, like slightly-6, like moderately-7, like very much-8, like extremely-9. A group of six trained judges who were the faculty of Dept. of Nutrition, Mugberia Gangadhar Mahavidyalaya, evaluated product sensory evaluation. The samples (having temperature of 22-25°C) were properly coded with 3 digit number and given to the judges in a properly lighted room for sensory evaluation.

Results and Discussion

Initially, the percentage of sorghum millet was taken at levels of 1%, 2%, 3% and 4%. Subsequently, in the optimum level of sorghum millet added product the sucrose completely replaced with a natural sweetener stevia 1%, 1.5% and 2%.

Level of optimization of sorghum millet addition in milk

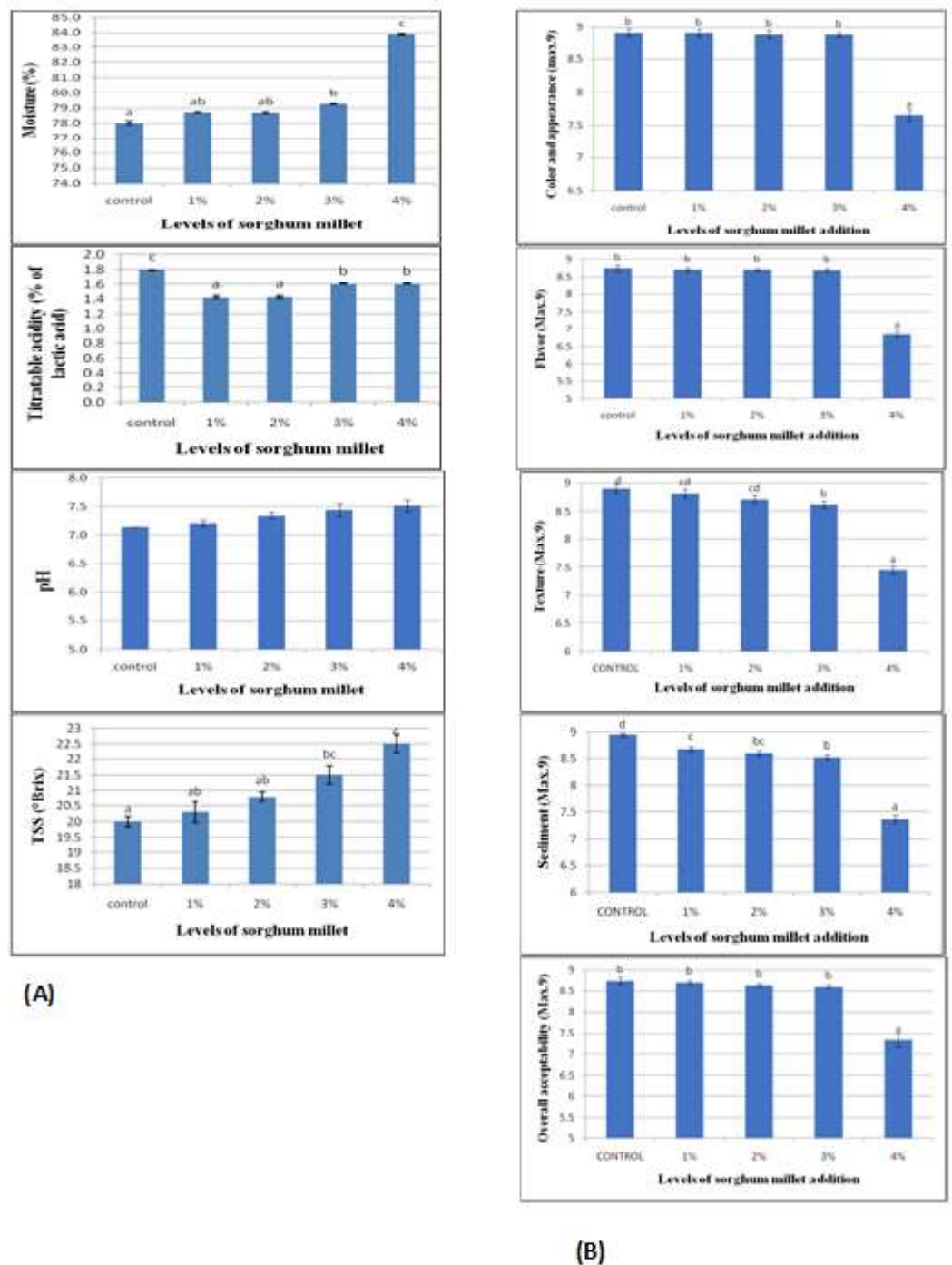
Fig. 2 illustrates the changes in physico-chemical attributes of flavoured milk resulting from the addition millet.

Physico-chemical attributes



Fig. 1 Control (left) and sorghum millet added and stevia sweetened flavoured milk (right)

Fig. 2 Effect on different physico-chemical (A) and sensory (B) properties due to different levels of sorghum millet addition in flavoured milk; $n=6$; Different small alphabets indicate significantly different ($p \leq 0.05$); Vertical bars indicate standard errors.



Moisture

In terms of moisture, it was observed that when sorghum millet addition at 1%, 2%, 3% and 4% were done, the moisture percentage significantly ($p \leq 0.05$) increased compare to control. Sorghum millet flour has high water retention capacity and adding more amount of millet that creates gel like consistency when mixed with milk (Tumwine et al. 2019; Akbari et al. 2023).

Titrateable acidity

In terms of acidity, it was observed that the addition of sorghum millet at 1%, 2%, 3% and 4% there was significant ($p \leq 0.05$) difference among control and treated samples. The addition of sorghum millet to flavoured milk decreased acidity up to a certain level because sorghum contained minerals like calcium, potassium, and magnesium, which acted as natural buffers,

neutralizing free acids in the milk (Rather et al. 2023). Additionally, sorghum's proteins helped to stabilize the pH by binding to hydrogen ions. However, when sorghum was added in excess, it introduced organic acids and phenolic compounds, which contributed to the overall acidity (Przybylska-Balcerek et al. 2019; Xie et al. 2021). Moreover, higher concentrations of sorghum provided more carbohydrates for lactic acid bacteria, which could ferment the sugars and produced more lactic acid, further increasing the milk's acidity (Banwo et al. 2021). Additionally, at high levels, sorghum could destabilize milk proteins, releasing acidic by-products and exacerbating the sourness (Köten and Gül 2024).

pH

In this study pH value were observed to be ranging from 7.1 to 7.5 for different levels of sorghum millet addition 0% (control), 1%, 2%, 3% and 4%. Result showed that there were no significant ($p > 0.05$) difference among control and treated samples.

Total soluble solids (TSS)

It was observed that increase in sorghum millet addition at 1%, 2%, 3% and 4% level, the TSS percentage significantly ($p \leq 0.05$) increased at 3% and 4% levels. This was due to sorghum millet contribute increase in soluble solids in the flavoured milk (Bunphan et al. 2015).

Sensory analysis

Color and Appearance

Color and appearance is an important characteristic of any food product and it helps in consumer acceptance. In present study color and appearance score between control and treated sample ranged from 7.65 to 8.91. Up to 3% level of sorghum millet addition there was no significant ($p > 0.05$) change of colour and appearance score compare to control. After that level significant decreased in color and appearance score was observed. Color and appearance score increased due to natural pigments (anthocyanins, carotenoids and tannins) present in sorghum millet, but when the level of sorghum increased, the milk became cloudy and dull resulting decrease in color and appearance quality (Srikao 2023).

Flavor

Flavor is a combination of taste, smell and mouth feel. In this study, flavor score among control and treated samples range from 6.85 to 8.75. Up to 3% level of sorghum millet addition there was no significant ($p > 0.05$) changes of flavour score as compared to control. After that level significant ($p \leq 0.05$) decrease in flavour score was observed. Flavor score was decreased when the levels of sorghum millet increased due to the presence of astringent

compounds (polyphenols and tannins), and earthy flavours that negatively affect the flavour profile (Mitharwal et al. 2021).

Texture

Texture is a key attributes of food, which helps to define food quality and acceptability. In this study texture score between control and treated samples ranged from 7.45 to 8.90. Up to 2% level of sorghum millet addition there was no significant ($p > 0.05$) change of texture scores as compare to control. After that level, significant ($p \leq 0.05$) decrease in texture score was observed. The decrease in texture score of sorghum millet added flavoured milk was due to thick and grainy texture due to the high content of fibers, starches and insoluble particles (Hema et al. 2022).

Sediment

The sediment may affect the appearance, texture of the flavoured milk. In this study sediment score of control and treated samples was from 7.36 to 8.95. There was significant ($p \leq 0.05$) difference between control and all treated samples. The decrease in sedimentation score of sorghum millet in flavoured milk was due to the insoluble fibers, particles aggregation, interactions between millet polyphenols and milk protein (Pandey and Singh 2024).

Overall acceptability

In the present study the score of overall acceptability between control and treated samples ranged from 7.33 to 8.95. Up to a 3% addition of sorghum millet, the sensory panelists rated the flavoured milk on par with the control sample in terms of overall acceptability. Beyond that level significant ($p \leq 0.05$) decrease in overall acceptability was observed. Therefore, a 3% addition of sorghum millet was determined to be the optimal level in this study.

Optimization of stevia addition in sorghum millet incorporated flavoured milk

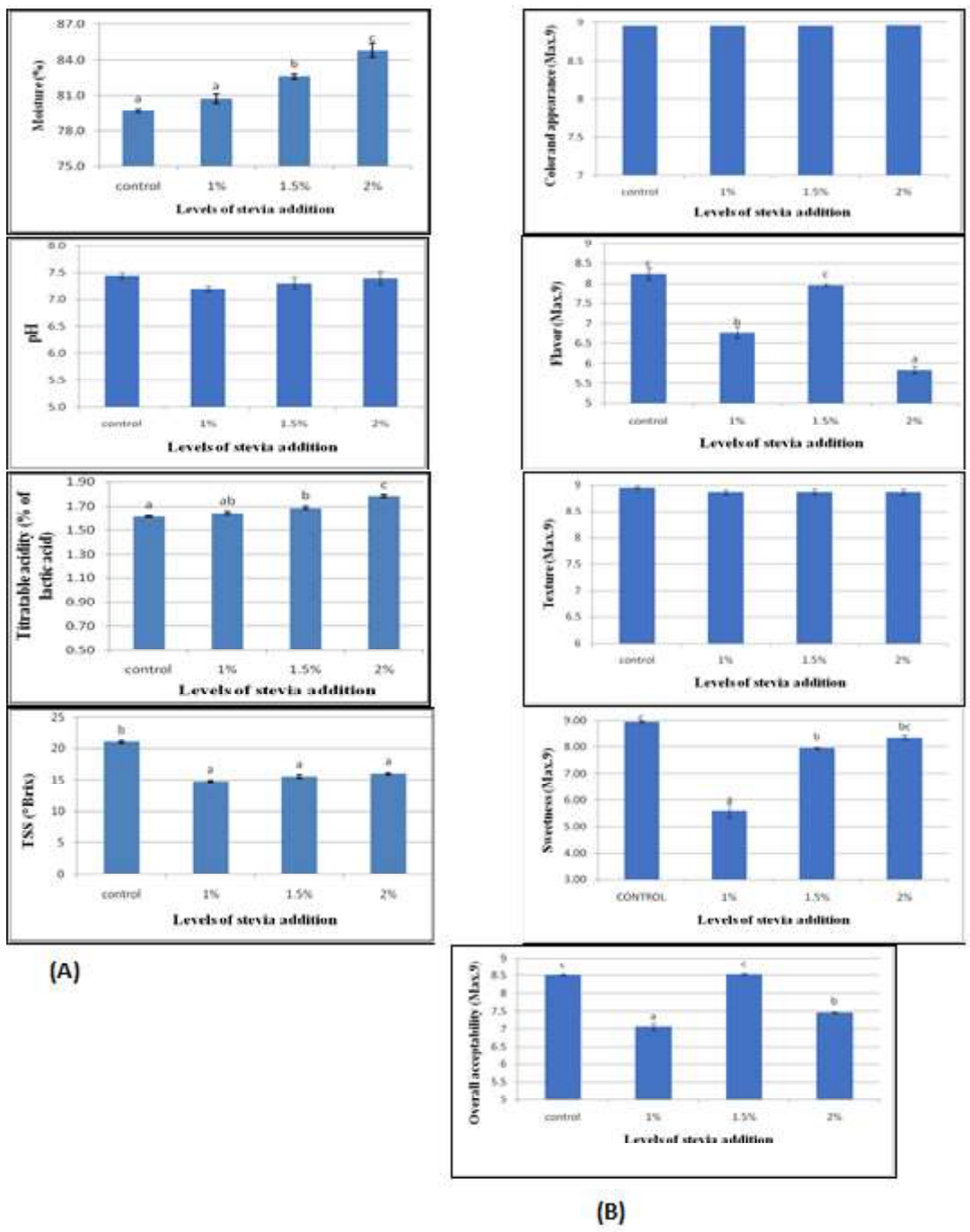
Fig. 3 presents the changes in physico-chemical and sensory attributes of sorghum millet-incorporated flavoured milk due to the addition of stevia.

Physico-chemical attributes

Moisture

In terms of moisture, it was observed that when stevia addition at 1%, 1.5% and 2% the moisture percentage ranged from 79.7 to 84.8. There was no difference between control and 1% level of stevia addition, after that at 1.5 and 2% level of stevia addition a significant ($p \leq 0.05$) increase in moisture percentage was observed. In this case, sugar was replaced by stevia so total solid percentage decreased as well as moisture percentage increased.

Fig. 3: Effect of different physico-chemical (A) and sensory attributes (B) due to different levels of stevia addition in sorghum millet added flavoured milk; n=6, Different small alphabets indicate significantly different ($p < 0.05$); Vertical bars indicate standard errors.



Giri et al. (2014) observed that the moisture percentage of control was 59.80%, as against 64.90%, 66.0%, 67.0% for 50%, 60% and 70% sugar reduction through 0.05%, 0.06% and 0.07% stevia addition, respectively in *Kulfi*. The moisture percentage of control *Kulfi* were significantly ($p \leq 0.05$) lower than the all-treated samples. When stevia percentage increased, the moisture percentage increased significantly ($p \leq 0.05$).

In terms of moisture content, it was observed that with stevia addition at 1%, 1.5%, and 2%, the moisture percentage ranged from 79.7% to 84.8%. There was no significant difference between the control and the 1% stevia level; however, a significant ($p \leq 0.05$) increase in moisture content was observed at 1.5% and 2% levels. This increase can be attributed to the replacement of sugar with stevia, which led to a reduction in total solids and a corresponding rise in moisture content.

Similar findings were reported by Giri et al. (2014), where the moisture content of control *Kulfi* (59.80%) was significantly ($p \leq 0.05$) lower than that of the treated samples, which showed moisture percentages of 64.90%, 66.00%, and 67.00% for 50%, 60%, and 70 sugar reductions through the addition of 0.05%, 0.06%, and 0.07% stevia, respectively. Their study also confirmed that increasing stevia levels resulted in a significant ($p \leq 0.05$) increase in moisture content. These findings are in agreement with the current study, indicating that partial or full replacement of sugar with stevia tends to increase moisture levels due to reduced total solids.

pH

In this study pH value ranged from 7.2 to 7.4 for different levels of stevia addition at 1%, 1.5% and 2%. Result showed that there were no significant ($p > 0.05$) differences among control and treated samples.

Titratable acidity

It was observed that titratable acidity score of control and all treated samples ranged from 1.61% to 1.78%. There was significant ($p \leq 0.05$) difference between control and 1% stevia added flavoured milk but at 1.5 and 2% titratable acid score was increased when the levels of stevia increased. Stevia itself is generally neutral, but stevia based sweetener sometimes create acid forming compounds that contributed overall titratable acidity of milk. By replacing sugar with adding stevia might increase the microbial activity in milk, potentially encouraging the growth of bacteria that produce lactic acid or other acids, leading to higher titratable acidity. Sorghum millet contains tannins which interacts with stevia and produce acid (Mahato et al. 2020; Tanwar et al. 2023).

Total soluble solids

In this study it was observed that due to addition of stevia (1%, 1.5% and 2%), the total soluble solids percentage were decreased as compare to control. 1% sugar solution contained approximately 10°Brix (100 g/L) and contributes around 10-12% to TSS in flavored milk. 1% stevia solution contains approximately 0.2-0.5°Brix (2-5 g/L). It contributed around 0.2-0.5% to TSS in flavored milk. This means that sugar contributed significantly more TSS than stevia, mainly due to use of stevia in lower quantity (Nourmohammadi et al. 2021).

Sensory analysis

Color and appearance

In the present study, the color and appearance scores of the control and stevia-treated flavoured milk samples ranged from 8.95 to 9.00. There were no significant differences ($p > 0.05$) observed among the control and treated samples, indicating that

stevia addition did not affect the visual attributes of the product. This can be attributed to stevia's inherent stability and non-reactivity with other ingredients, which prevents it from altering the color or appearance of the final product.

These findings are consistent with the observations of Arora et al. (2015), who reported no significant changes in color and appearance scores during the preparation of milkshake using 12 mg/100 g and 24 mg/100 g stevia powder. Their study, like the current one, confirms that stevia can be effectively used as a sweetener without compromising the visual quality of dairy-based beverages.

Flavor

In this study the score of flavor between control and stevia treated samples ranged from 5.83 to 8.23. There was significant ($p \leq 0.05$) decrease in flavor score at 1% level of stevia addition, because the sweetness of 1% stevia added flavored milk was lower than control. There was no significant ($p > 0.05$) difference between control and 1.5% stevia added flavored milk, because the sweetness of 1.5% stevia was similar to control. But at 2% stevia added flavored milk excessive sweetness and mild bitter aftertaste was observed. So flavor score decreased.

Giri et al. (2014) observed that the flavor score did not change significantly at 50% sugar replacement by 0.05% stevia in *Kulfi*. But at higher level of sugar replacement (60% and 70% of sugar replacement by 0.06% and 0.07% stevia, respectively) flavor score decreased significantly due to bitter taste of stevia.

In the present study, the flavor scores of control and stevia-treated samples ranged from 5.83 to 8.23. A significant ($p \leq 0.05$) decrease in flavor score was observed at the 1% stevia level because the sweetness of the 1% stevia-added flavoured milk was lower than that of the control. In contrast, there was no significant ($p > 0.05$) difference between the control and the 1.5% stevia-treated sample. However, at the 2% stevia level, the flavoured milk exhibited excessive sweetness combined with a mild bitter aftertaste, resulting in a decline in the overall flavor score.

These findings are in line with the observations of Giri et al. (2014), who reported that the flavor score remained relatively unchanged with a 50% sugar replacement using 0.05% stevia in *kulfi*. However, at higher levels of sugar replacement—specifically 60% and 70% through the addition of 0.06% and 0.07% stevia respectively—the flavor score decreased significantly due to the development of a bitter taste. Both studies highlight the importance of optimizing stevia levels to maintain an acceptable flavor profile while replacing sugar as higher levels of stevia introduce a bitter aftertaste that adversely affects flavor.

Texture

In this study the texture score between control and stevia treated samples ranged from 8.95 to 8.97. There was no significant ($p > 0.05$) difference among control and treated samples. Arora et al. (2015) observed that texture score did not change significantly in the preparation of *Kheer* using 20mg/100g and 40mg/100g stevia powder.

Sweetness

In this study the score of sweetness among control and stevia treated samples ranged from 5.60 to 8.95. Stevia addition at 1% the sweetness properties was significantly ($p \leq 0.05$) decreased due to insufficient sweetness, but the addition of stevia at 1.5% the sweetness perception was similar to control. After that level it gave excessive sweetness and bitterness.

Overall acceptability

The overall acceptability scores for the control and stevia-treated samples ranged from 7.07 to 8.53. At a 1.5% stevia addition level in flavoured milk, sensory panelists rated the product comparable to the control. However, increasing the stevia concentration beyond this level led to a significant ($p \leq 0.05$) decline in overall acceptability. Therefore, a 1.5% stevia level was determined to be optimal in this study.

Conclusion

The study focused on the preparation of sorghum millet incorporated reduced calorie flavoured milk. It was found that as the levels of sorghum millet and stevia addition were increased, some physico-chemical and sensory attributes changed significantly ($p \leq 0.05$). At higher level of sorghum millet and stevia addition decreased over all acceptability sensory score. Flavoured milk with 3% sorghum millet and 1.5% stevia was optimized in the study.

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