Plant Archives Vol. 25, No. 2, 2025 pp. 1336-1340 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.192

EFFECT OF JAGGERY AS A SUBSTITUTE FOR REFINED SUGAR ON CHEMICAL AND SENSORY PROPERTIES OF MILK CHOCOLATES

N. Annapurna[1]*, M. Kalpana[2], V. Sudha Vani[3], R.V. Sujatha[4], K. Aruna Kumari[5] and V. Sekhar[6]

[1]Department of Dr.Y.S.R Horticultural University, COH- Venkataramannagudem, A.P., India

[2]Department of PSMA, College of Horticulture, Dr.Y.S.R Horticultural University, Venkataramannagudem, A.P., India

[3]Department of PHM, College of Horticulture, Dr.Y.S.R Horticultural University, Venkataramannagudem, A.P., India

[4]Department of Ag-Economics, College of Horticulture, Dr.Y.S.R Horticultural University, Venkataramannagudem, A.P., India

[5]Department of Biotech., College of Horticulture, Dr.Y.S.R Horticultural University, Venkataramannagudem, A.P., India

[6]Department of Statistics, College of Horticulture, Dr.Y.S.R Horticultural University, Venkataramannagudem, A.P., India

*Corresponding author E-mail: nunnaannapurna17@gmail.com

(Date of Receiving-22-07-2025; Date of Acceptance-27-09-2025)

ABSTRACT

Chocolate, valued for its antioxidant properties, has experienced a surge in global demand. However, its traditional formulation relies heavily on sugar—a key contributor to chronic degenerative diseases. So, in the present study sugar is substituted with other sweetening agents alone and in different combinations. The milk chocolates were prepared with ingredients *viz*. cocoa beans (18%), cocoa butter (13%), vegetable oil (8%), milk powder (22%), vanilla powder (1%) along with different sweetening agents *viz.*, sugar, palm jaggery, cane jaggery alone and in combination. Chocolates were analyzed for sensory attributes such as taste, texture, flavor, aroma, appearance, after mouth feel, overall acceptability and reducing sugars. Results revealed that statistically significant difference for sensory attributes was observed among all the treatments. Maximum mean score for flavour, aroma, texture and after mouth feel was recorded in T_6 (46%) palm jaggery whereas taste and appearance recorded highest mean score in T_9 (23% Cane jaggery +23% palm jaggery). While the mean score for overall acceptability of milk chocolates was recorded maximum (8.17) in T_9 23% Canejaggery with +23%palmjaggery, followed by T_1 (8.13) with 36% Sugar & T_6 (7.80) with 46% Palm jaggery whereas minimum of (6.70) was observed in T_7 (56% Palm jaggery). The highest reducing sugars of (7.81%) & (7.41) were recorded in T_{10} and T_7 respectively as against 4.03% in T_1 control. These findings highlight the potential of jaggery, especially in blended form, as a functional and consumer-preferred alternative to refined sugar in chocolate formulations.

***Key words*:** cane jaggery, palm jaggery, chemical characteristics, sensory attributes, jaggery-based milk chocolates.

Introduction

Chocolate is a highly valued food for its sensory and bioactive characteristics (Loncarevic *et al*., 2018), and its high energy content, texture, and flavour makes it a product with high consumer acceptance (Balcazar-Zumaeta *et al*., 2023; Tan & Balasubramanian, 2017). Nowadays, more conscious consumers are open to functional chocolates,

While chocolate is consumed worldwide as a confectionary, cocoa also offers health benefits, including reduced risks of cancer, heart stroke, and diabetes, and positive effects on cardiovascular health (Singh *et al*., 2017). These benefits are attributed to bioactive compounds, especially flavonoids, which function as antioxidants. Owing to the rising demand for healthier foods, the chocolate industry is increasingly focusing on "better-for-you" products such as low-fat, low-calorie, sugar-free, or nutrient-enriched chocolates (Norton *et al*., 2013; Kim & Jeon, 2020). Natural sweeteners like sugarcane jaggery and palm jaggery are being recognized as viable alternatives to refined sugar, particularly for managing lifestyle-related conditions such as obesity and diabetes.

Table 1: Different percentages of sweeteners in milk chocolate.

Treat-ments	Percentage of different sweeteners in milk chocolate			
	S	**CJ**	**PJ**	**CJ + PJ**
T1	36	0	0	0
T2	0	36	0	0
T3	0	46	0	0
T4	0	56	0	0
T5	0	0	36	0
T6	0	0	46	0
T7	0	0	56	0
T8	0	0	0	18+18
T9	0	0	0	23+23
T10	0	0	0	28+28
S: Sugars; **CJ:** Cane jaggery; **PJ:** Palm jaggery; **CJ + PJ:** Cane jaggery + Palm jaggery				
*18% cocoa nibs + 22% milk powder + 13% cocoa butter + 8% palm oil + 1%vanilla powder were added as common ingredients in milk chocolate.				

Jaggery is nutritionally superior to refined sugar, being rich in vitamins (provitamin A, B-complex, C, D_2, and E) and minerals (calcium, phosphorus, magnesium, and potassium). Its mineral content is about 50 times higher than refined sugar and five times higher than brown sugar, with 28 g/kg of mineral salts compared to just 0.3 g/kg in refined sugar (Gopalan *et al.*, 1991). This makes jaggery not only a sweetening agent but also a functional food ingredient.

Palm jaggery is a natural sweetener that enhances both the nutritional and sensory attributes of chocolates, being rich in minerals such as iron, calcium, magnesiumand antioxidants, offers added health benefits compared to refined sugar. Therefore, replacing refined sugar with jaggery in chocolate formulations represents an important step towards developing healthier & more nutritious products. Jaggery-based chocolates have the potential to provide a delicious yet wholesome alternative to conventional chocolates, catering to health-conscious consumers who seek natural and nutrient-rich ingredients. Such innovations align with current trends in functional foods and can significantly enhance the nutritional value, consumer appeal and marketability of chocolate.

Materials and Methods

Preparation process

First, the sugar, cane jaggery and palm jaggery were finely ground with a hand mill. Afterwards, hundred grams of milk chocolate was prepared with cocoa butter (13 gm), cocoa nibs (18gm) and sugar (36 gm), vegetable oil (8 gm) and vanilla (1 gm). For preparation of 100gm milk chocolate, cocoa nibs were first added to the melanger and ground for 3 hours to obtain cocoa liquor. Then, molten cocoa butter (13 gm) was added and grinded for an additional 3 hours. Milk powder, along with remaining cocoa butter, was added at 30-minutes intervals. The mixture was then conched for 7 hours until a smooth and silky consistency was obtained. The samples were transferred into the moulds and were refrigerated at a temperature of 4°C. After the samples were removed from the moulds, they were packed in aluminum sheets. Sweetening agents such as sugar, cane jaggery and palm jaggery added solely and in combination with each other (Table 1).

Table 2: Hedonic scale range.

Category	Sensory score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Organoleptic evaluation

Organoleptic evaluation was conducted by a panel consisting of diversified consumers to find the best treatments by following hedonic rating tests as described by Ranganna (1991). The product was evaluated for flavour, taste, texture, after mouthfeel, aroma, appearance and overall acceptability. The characters with mean scores of 5 or more out of 9 marks were considered acceptable. The score given by them was average.

Chemical Analysis

The reducing sugars in chocolate were estimated by the method described by Lane and Eynon (1923). Five grams of chocolate sample was weighed and transferred into a 250 ml volumetric flask. To this 2 ml of 45% lead acetate solution was added for the removal of colloidal matter, followed by the addition of 2 ml of 22% potassium oxalate solution to precipitate excess lead. The volume was then made up to 250 ml with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was tested with a drop of potassium oxalate to ensure it was lead-free. Then lead-free solution was titrated against 10 ml of standard Fehling's solution (A and B in 1:1 ratio) using methylene blue as an indicator. The titration was performed by boiling the Fehling's solution until the endpoint was indicated by the formation of a brick-red precipitate. The reducing sugar content was expressed

as percentage and calculated using the formula:

$$\text{Reducing sugars} = \frac{\text{Dilution factor} \times \text{Volume madeup}}{\text{Titre value} \times \text{Volume of sample taken}} \times 100$$

Statistical analysis

Chemical and sensory evaluation were carried out in a completely randomized design.The critical difference (CD) values were determined at 5% level of significance to assess statistical differences between treatments by using OPSTAT Software. It should be noted that all tests were replicated thrice.

Results and Discussion

The data pertaining to the sensory attributes were recorded in the milk chocolates with varied sweetening concentrations in the Table 3 and Fig. 1.

Taste

Among the different concentrations of sweetening agents in milk chocolates, the mean score of taste ranged from 6.70 to 8.13. The highest score for taste was obtained for T_9 with 23% cane jaggery + 23% palm jaggery (8.13) on par with T_1 control (8.10) followed by T_6 46% palm jaggery (7.80) and T_3 with 46% cane jaggery (7.70). Whereas, the lowest score was recorded in the T_5 (6.70) 36% palmjaggery.

Cane jaggery gave a mild and pleasant sweetness, while palm jaggery added a stronger flavor. Together, they balanced each other and reduced the strong taste that appeared when used alone in higher amounts, such as in T_5 (36% palm jaggery). This blend also matched well with cocoa and milk, resulting in a smoother and more acceptable taste. This findings were consistent with Shahanas (2019) who observed that using a combination of jaggery types enhanced flavor balance and overall acceptability in cocoa-based chocolates.

Flavour

The mean score for flavour ranged from 5.40 to 7.97 in the various concentration of sweetening agents of milk chocolates. Maximum score (7.97) for flavour was recorded in the T_6 with 46% palm jaggery, which is on par with T_9 (7.83) with 23% cane jaggery + 23% palm jaggery and T_3(7.63) with 46% cane jaggery, while minimum score (5.53) for flavour was observed in T_2 (36% cane jaggery).

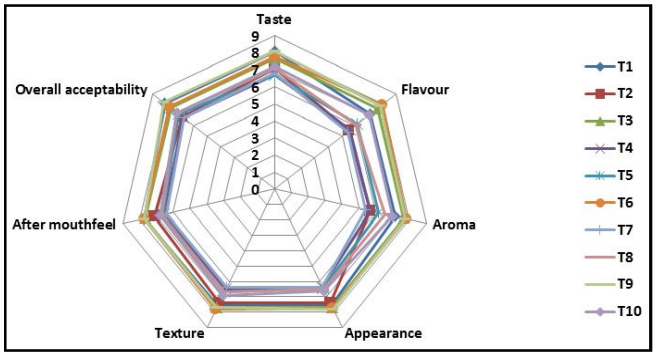

Fig. 1: Sensory evaluation of different sweetening agents incorporated in milk chocolates.

Table 3: Sensory evaluation of different sweetening agents incorporated in milk chocolates.

Treat-ments	T	F	Ar	App	Tex	Amf	Oa
T_1	8.10	7.10	7.13	7.60	7.60	7.70	8.13
T_2	7.10	5.53	5.67	7.40	7.40	7.13	6.83
T_3	7.70	7.63	7.63	7.67	7.70	7.67	7.67
T_4	6.73	5.60	5.67	6.40	6.53	6.57	6.77
T_5	6.70	6.10	6.17	6.47	6.70	6.63	7.10
T_6	7.80	7.97	7.80	7.73	7.80	7.73	7.80
T_7	6.80	5.40	5.40	6.40	6.40	6.40	6.70
T_8	7.10	6.03	6.57	6.53	6.70	6.67	7.20
T_9	8.13	7.83	7.77	7.80	7.70	7.70	8.17
T_{10}	7.17	7.03	6.97	6.63	6.90	6.80	7.20
Mean	**7.33**	**6.62**	**6.68**	**7.06**	**7.14**	**7.10**	**7.38**
SEm±	**0.112**	**0.102**	**0.140**	**0.188**	**0.149**	**0.109**	**0.160**
CD@ 5 %	**0.331**	**0.301**	**0.414**	**0.553**	**0.440**	**0.321**	**0.473**

T: Taste; **F:** Flavour; **Ar:** Aroma; **App:** Appearance; **Tex:** Texture; **Amf:** After mouth feel; **Oa:** Overall acceptability

T_6 (46% palm jaggery) scored the highest flovour because palm jaggery had a naturally strong and distinctive taste that blended well with cocoa in milk chocolate. Its flavor was more noticeable than that of cane jaggery, which provided a milder sweetness. This made the chocolate taste more appealing to the panelists. In contrast, chocolates with lower amounts of jaggery or only cane jaggery had weaker flavours, which were less preferred. These results agreed with Quadri *et al.*, (2022), who observed that the concentration and type of jaggery significantly influenced the flavor profile of jaggery-based chocolates.

Aroma

Aroma varied from 5.40 to 7.80. Among different sweetening agents, maximum score (7.80) was obtained in the T_6 with 46% palm jaggery which is on par (7.77) with T_9 23% cane jaggery+23% palm jaggery followed by T_3 (7.63) 46% cane jaggery and T_1(7.13) with 36% sugar. Minimum score (5.40) was reported in the T_7 with 56% palm jaggery.

T_6 scored the highest for aroma because palm jaggery had a naturally strong and pleasant aroma that blended well with cocoa in milk chocolate. Its aroma was more noticeable than that of cane jaggery or sugar, which provided a milder aroma. The combination in T_9 also performed well because the mix of cane and palm jaggery

provided a balanced and appealing aroma. In contrast, chocolates with very high amounts of palm jaggery, like T_7, had an overpowering aroma that was less preferred by the panelists. These results were consistent with Indiarto *et al.*, (2025), who highlighted that the strength and balance of aroma in plant-based white chocolate were influenced by both the type and concentration of added ingredients, such as encapsulated blueberry juice.

Appearance

The score for appearance ranged from 6.40 to 7.80 with a mean of 7.06 (Table 3). The significantly maximum score (7.80) of appearance was recorded in T_9 with 23% cane jaggery + 23% palm jaggery, on par (7.73) with T_6 46% palm jaggery followed by T_3 (7.67) 46% cane jaggery. While minimum score (6.40) was recorded in T_7 (56% palm jaggery).

The differences in appearance scores are due to the type and amount of jaggery used. T_9 (23% cane + 23% palm jaggery) and T_6 (46% palm jaggery) had the highest scores because the combination or moderate amount of jaggery gave a smooth, appealing color and texture. T_7 (56% palm jaggery) had the lowest score, likely because too much palm jaggery made the chocolate darker and less attractive. These results were consistent with Manisha *et al.*, (2022), who reported that the concentration and type of jaggery affected the visual quality of cane jaggery and palm jaggery chocolates.

Texture

Texture score varied from 6.40 to 7.80. Among different sweetening agents, highest score (7.80) was recorded in the T_6 (46% Palm jaggery), on par (7.70) with T_9 23% Cane jaggery + 23% palm jaggery, followed by T_3 (7.70) 46% cane jaggery. While lowest score (6.40) was observed in the T_7 (56% Palm jaggery).

The differences in texture scores were due to the type and amount of jaggery used. T_6, with 46% palm jaggery and T_9, with a balanced mix of cane and palm jaggery, received the highest scores because the jaggery blended well with other ingredients, resulting in a smooth and consistent texture. T_7, with 56% palm jaggery, received the lowest score, likely because the high amount of palm jaggery made the chocolate coarse and less smooth. Similar results were reported by Quadri *et al.*, (2022), who noted that both jaggery type and concentration played a key role in determining the textural quality of jaggery-based chocolates.

After mouthfeel

The score for after mouthfeel ranged from 6.40 to 7.73 with a mean of 7.10 (Table 3). The significantly maximum score maximum score (7.73) was recorded in the T_6 46% palm jaggery, which is on par with T_1 36% sugar and T_9 23% cane jaggery + 23% palm jaggery (7.70). Minimum score (6.40) was recorded in the T_7 56% palm jaggery.

The differences in after-mouthfeel scores were attributed to the type and amount of sweetening agent used. T_6 (46% palm jaggery), T_1 (36% sugar), and T_9 (23% cane + 23% palm jaggery) received the highest scores because these combinations produced a smooth, pleasant, and well-balanced mouthfeel. T_7 (56% palm jaggery) received the lowest score, as the high palm jaggery content caused a coarse and slightly gritty texture, resulting in a less pleasant after-mouthfeel. These results agreed with Indiarto *et al.*, (2025), who observed that both the type and concentration of ingredients significantly influenced the mouthfeel of plant-based white chocolate enriched with encapsulated blueberry juice.

Overall acceptability

The score for overall acceptability ranged from 6.70 to 8.17 with a mean of 7.38.(Table 3). The significantly maximum score (8.17) was recorded in the T_9 23% cane jaggery + 23% palm jaggery on par with T_1 36% sugar (8.13) and T_6 (46% palm jaggery) (7.80) whereas minimum score of 6.70 was recorded in the T_7 56% palm jaggery.

The overall acceptability scores were attributed to the type and amount of sweetening agent used. T_9 (23% cane + 23% palm jaggery), T_1 (36% sugar), and T_6 (46% palm jaggery) with other ingredients received the highest scores because these formulations provided a well-balanced taste, smooth texture, and appealing appearance. T_7 (56% palm jaggery) received the lowest score, as the high palm jaggery content resulted in a darker color, coarser texture, and less balanced sweetness, which reduced overall acceptability. These findings were consistent with Manisha *et al.*, (2022), who reported that the type and concentration of jaggery significantly affected the overall acceptability of cane jaggery and palm jaggery chocolates.

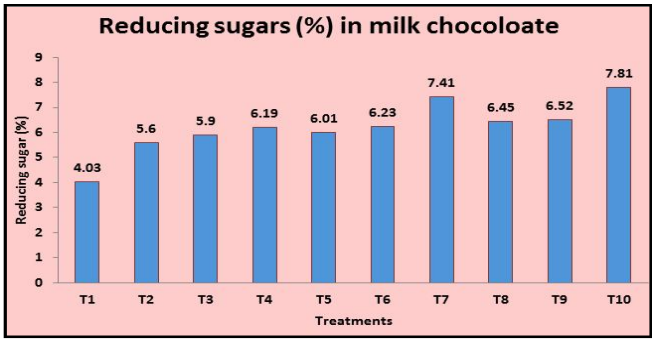

Fig. 2: Reducing sugars (%) in different sweetening agents incorporate in milk chocolate.

Reducing sugars (%)

The data indicated that significant difference was observed in reducing sugars of milk chocolate due to various concentration of sweetening agents in preparation of milk chocolate was presented in the Fig. 2.

Maximum reducing sugars content (7.81) was recorded in T_{10} 28% cane jaggery + 28% palm jaggery, followed by T_7 56% palm jaggery & T_9 23% cane jaggery + 23 % palm jaggery 7.41 & 6.52 respectively. While, minimum reducing sugars percent of 4.03 was observed in T_1 36% sugar.

Reducing sugars play a role in maintaining blood glucose levels and supporting normal metabolic activities. The differences in reducing sugar content was attributed to the type and proportion of sweetening agents used. T_{10} (28% cane + 28% palm jaggery), T_7 (56% palm jaggery), and T_9 (23% cane + 23% palm jaggery) recorded higher reducing sugars because jaggery naturally contained more reducing sugars along with minerals and antioxidants, which provided nutritional benefits. T_1 (36% sugar) recorded the lowest reducing sugars since refined sugar contained primarily sucrose with minimal nutrients. These results agreed with the findings of Nageswari (2019), who reported higher reducing sugars in milk chocolates prepared with palm sugar.

Conclusion

The study demonstrated that the type and proportion of sweetening agents significantly affected the sensory and nutritional quality of milk chocolates. Chocolates prepared with an equal blend of cane and palm jaggery achieved the highest score for taste, flavor, aroma, texture and overall acceptability indicating superior consumer preference. Jaggery based chocolates also contained higher reducing sugars along with beneficial minerals and antioxidants, offering sustained energy and added nutritional value compared to refined sugar chocolates. These findings revealed that incorporating cane and palm jaggery not only enhanced sensory appeal but also improves the health profile of milk chocolate, making it a suitable and potentially safer indulgence for diabetic patients when consumed in moderation.

References

Balcazar-Zumaeta, C.R., Pajuelo-Munoz A.J., Trigoso-Rojas D.F., Iliquin-Chavez A.F., Fernández-Romero E., Yoplac I., Muñoz-Astecker L.D., Rodríguez-Hamamura N., Maza Mejía I.M., Cayo-Colca I.S. and Chagas-Junior G.C. (2023). Reduction in the cocoa spontaneous and starter culture fermentation time based on the antioxidant profile characterization. *Foods*, **12(17)**, 3291.

Dokainish, H., Teo K., Zhu J., Roy A., AlHabib K.F., ElSayed A., Palileo-Villaneuva L., Lopez-Jaramillo P., Karaye K., Yusoff K. and Orlandini A. (2017). Global mortality variations in patients with heart failure: results from the International Congestive Heart Failure (INTER-CHF) prospective cohort study. *The Lancet Global Health*, **5(7)**, 665-672.

Indiarto, R., Putri N.W., Fetriyuna F., Subroto E., Irawan A.N., Muhammad D.R.A. and Lani M.N. (2025). Quality Improvement of Plant-Based White Chocolate Enriched with Encapsulated Blueberry Juice. *Food Chemistry Advances*. 100917.

Kim, S.H. and Jeon H.M. (2020). Chocolate choicemotives and attitudes in foodservice market: Fine store product vs. manufactured product consumers. *Journal Food service Business Research.* **23(2)**, 149-168.

Lane, J.H. and Eynon L. (1923). Determination of reducing sugars by means of Fehling's solution with methylene blue as internal indicator. *Journal of Society of Chemical Industry.* **42**, 32-36.

Loncarevic, I., Pajin B., Fistes A., Saponjac V.T., Petrovic J., Jovanovic P., Vulic J. and Zaric D. (2018). Enrichment of white chocolate with blackberry juice encapsulate: Impact on physical properties, sensory characteristics and polyphenol content. *Lwt.*, **92**, 458-464.

Manisha, J., Roja T., Saipriya S., Jayaprakash R., Rajender G. and Swamy R. (2022). Development of value added food products from palm jaggery. *The Pharma Innovation Journal*. **02**, 589-92.

Nageswari, G. (2019). Determination of total and reducing sugars of chocolate incorporated with palm sugar. *Journal Food Process Technology*. **10**, 782-783.

Norton, J., Fryer P. and Parkinson J. (2013). The effect of reduced-fat labelling on chocolate expectations. *Food Quality Preference.* **28(1)**, 101-105.

Quadri, H., Madhavi V., Navya A., Jayaprakash R., Rajender G. and Swamy R. (2022). Development of granular jaggery and jaggery based chocolates. *The Pharma Innovation Journal*. **11(5)**, 1951-56.

Singh, M., Chawla R., Khatkar S.K. and Singh S. (2017). Development of milk chocolate using Response Surface Methodology (RSM). *International Journal of Current Microbiology and Applied Sciences*. **6(6)**, 2881-94.

Shahanas, E., Panjikkaran S.T., Sharon C.L., Aneena E.R., Suma B., Minimol J.S. and Remya P.R. (2020). Physico Chemical Properties of Chocolates and its Variability with Process Conditions. *Indian Journal of Nutrition and Dietetics*. **57(1)**, 73.

Tan, J. and Balasubramanian B.M. (2017). Particle size measurements and scanning electron microscopy (SEM) of cocoa particles refined/conched by conical and cylindrical roller stone melangers. *Journal of food engineering*, **212**, 146-153.

Ranganna, S. (1991). Handbook of Analysis and Quality Control for Fruits and vegetable Products. Tata McGraw Hill Publishing Company Limited, New Delhi. 623-24.