Research Article

Therapeutic Evaluation and Development of Nutrient-Rich Value-Added Products Utilizing Marayoor Jaggery

Divya Raichu Jacob*, Sneha NM, Tessy Mol James

Department of Clinical Nutrition and Dietetics, St. Teresa's College (Autonomous), Affiliated to Mahatma Gandhi University, Ernakulam, Kerala, INDIA.

Submission Date: 15-10-2024; Revision Date: 24-11-2024; Accepted Date: 14-12-2024.

ABSTRACT

Aim/Background: Marayoor jaggery (*Saccharum officinarum* L.), a traditional sweetener from Kerala, India, is produced using methods that retain its rich nutrient profile. This study aimed to evaluate its nutritional composition, phytochemical properties, antioxidant capacity and to develop standardized food products incorporating this sweetener. **Materials and Methods:** The nutritional composition of Marayoor jaggery was determined using the standard operating procedures by FSSAI and AOAC methods. The qualitative and quantitative phytochemical analysis was determined by Folin-Ciocalteau method and Aluminium chloride colorimetric method. Food products incorporating marayoor jaggery, such as amla marble cake (T1), amla ragi laddu (T2) and amla nutty cookies (T3) was standardized and subjected to sensory evaluation. **Results:** Nutritional composition of marayoor jaggery revealed higher levels of fructose, glucose, vitamins B1, B5, B6 and iron compared to conventional jaggery. Phytochemical screening indicated the presence of phytochemicals like terpenoids and glycosides. The antioxidant activity, measured through DPPH assay, showed a concentration-dependent increase with maximum DPPH˙ radical scavenging activity (35.37±0.62%) at 30 µg/mL. Sensory evaluation by an untrained panel demonstrated a preference for these products made with Marayoor jaggery over controls. **Conclusion:** The study highlights the potential of Marayoor jaggery as a nutritious sweetener that can contribute to addressing iron deficiency anemia and improving public health.

Keywords: Antioxidant, Nutritional analysis, Phytochemicals, Sensory evaluation.

Correspondence:
Dr. Divya Raichu Jacob
Faculty, Department of Clinical Nutrition and Dietetics, St. Teresa's College (Autonomous), Affiliated to Mahatma Gandhi University, Ernakulam-682011, Kerala, INDIA.

Email: divyaraichu@gmail.com

INTRODUCTION

Jaggery is a non-centrifugal sugar and traditional sweetener prepared from the sap of palm trees or sugarcane juice. When jaggery is prepared differently from sugarcane juice, it retains more of its nutrients. Various researches have underscored the nutrient rich profile of jaggery, mainly because of its iron content, which can be helpful in treating iron deficiency anemia.[1] Jaggery's micronutrients have a variety of nutritional and therapeutic uses. Studies have shown that jaggery is superior to white sugar.[2]

Marayoor, a region in the Idikki district of Kerala is mostly noted for its enormous sugarcane production, which is the main crop of both Marayoor and Kanthalloor, aside from its natural sandal forests. Traditional methods are used in the homesteads to create Marayoor jaggery. The uniqueness of marayoor jaggery is that it does not contain any artificial sweeteners nor natural or synthetic colouring.[3] The nutritional composition and therapeutic qualities can vary according to the place of cultivation. Marayoor jaggery from Kerala, India has recently gained popularity these days because of the traditional methods of cultivation.

The need for the study arises from the limited existing research on marayoor jaggery, particularly with regard

SCAN QR CODE TO VIEW ONLINE

www.ajbls.com

DOI: 10.5530/ajbls.2024.13.79

to its nutritional content. Despite its use as a traditional sweetener, there is a lack of comprehensive studies assessing its nutrient profile**.** Marayoor jaggery, being locally available and culturally accepted, presents a promising opportunity to develop such products and integrate them into community-based nutrition programs. However, the absence of scientific evidence regarding its nutritional value hinders the effective utilization of marayoor jaggery in addressing iron deficiency anemia. The study is important because it could provide important information about how to treat iron deficiency anemia by using products made from locally accessible marayoor jaggery. The findings from this research could potentially suggest the importance of the development of innovative and culturally appropriate strategies for promoting iron-rich diets, particularly in regions where marayoor jaggery is readily accessible. Additionally, exploring the bioavailability of iron in marayoor jaggery could shed light on its effectiveness as a natural iron source.

The objectives of the study were to estimate the nutritional composition of marayoor jaggery; determine the phenolic and flavonoid content quantitatively and alkaloids, cardiac glycosides, tannins, saponins and terpenoids qualitatively; estimate the *in vitro* antioxidant property of marayoor jaggery and develop standardized products using marayoor jaggery incorporated with vitamin C rich amla powder and sprouted ragi powder.

MATERIALS AND METHODS

Procurement and preparation of the sample

Traditionally cultivated marayoor jaggery was procured from 'Marayoor GR spice', GI certified marayoor jaggery makers from Marayoor, Idukki. Five grams of the sample in powdered form was dissolved and macerated in distilled water (25 mL). It was filtered using Whatman filter paper no.1 and 1 mg/mL of stock solution in distilled water was prepared from it. This was used for the *in vitro* tests in the study.

Nutritional composition of Marayoor jaggery

There are limited studies on the nutritional composition of marayoor jaggery, which is cultivated by traditional methods of farming. Previous studies have found that the main sugars present in the conventional jaggery are sucrose, fructose and glucose.[4] The vitamins present in jaggery are vitamin A, vitamin D2, vitamin E, vitamin C, vitamin B1 vitamin B6 and vitamin B5 respectively.[1] The nutritional composition in marayoor jaggery was determined by the standard operating procedures of FSSAI and AOAC methods.

Quantitative determination of phenols and flavonoids

A modified version of the Folin Ciocalteau method was used to estimate the phenolics of marayoor jaggery. The Folin-Ciocalteu Reagent (FCR) is reduced in the presence of phenolics, producing molybdenum-tungsten blue complex. This is detected spectrophotometrically at 760 nm. The intensity of the reaction increases linearly with the concentration of phenolics in the reaction medium.[6] Important naturally occurring bioactive substances are flavanoids.[5,6] Total Flavonoid Content (TFC) is commonly measured by the aluminium chloride colorimetric technique, which assumes that all flavonoids would respond equally when compared to a flavonoid standard. Aluminium Chloride ($AlCl_3$) colorimetric method runs on the basis of $AlCl_3$ forming acid stable complexes with either the C-3 or C-5 hydroxyl group of flavones and flavonols, as well as the C-4 keto groups.[7]

Qualitative determination of alkaloids, cardiac glycosides, tannins, terpenoids and saponins

The qualitative analysis of phytochemicals including alkaloids, cardiac glycosides, tannins, terpenoids and saponins were determined.[8]

Estimation of *In vitro* antioxidant property of Marayoor jaggery

The 1,1-Diphenyl-2-Picrylhydrazyl (DPPH) radical was used to assess the potential of marayoor jaggery extract to neutralize free radicals generated (DPPH ions). The stable free radical's capacity to react with hydrogen donors provides the basis for the DPPH test. The free radical DPPH, which is stable at room temperature, reacts with methanol to form a violet solution. The free radical's ability to function as a free radical is destroyed via chain breaking when it interacts with an antioxidant and its colour turns pale yellow.[9]

Development of standardized products using Marayoor jaggery

Food products using ingredients incorporating marayoor jaggery, sprouted ragi powder and dry amla powder were developed and standardized. The products include amla marble cake (T1), amla ragi laddu (T2) and amla nutty cookies (T3), each prepared in three different proportions denoted as A, B and C. Each proportion indicates 60:25:15, 50:35:15 and 40:45:15 of sprouted ragi powder, marayoor jaggery and dried amla powder respectively.

Sprouted ragi powder is utilized due to its enriched nutrient profile resulting from germination, making it superior to other germinated grains like sorghum

and maize.[10] Ragi is a rich source of iron and sprouting makes the nutrients bioavailable in our body.[11] Additionally, the incorporation of dried amla powder is significant as gooseberries contain vitamin C, known to enhance iron absorption, thus potentially addressing iron deficiency anemia. Organoleptic analysis combines a number of disciplines to provide a deeper understanding of products' sensory attributes and consumer reactions. The different parameters like appearance, colour, flavour, texture, taste, overall acceptability for the developed products (T1, T2 and T3) were scored by 25 untrained panel judges using 9 hedonic rating scale.

Statistical analysis

The percent radical scavenging activity of marayoor jaggery at different concentrations of the sample in triplicates was estimated. One way ANOVA followed by Tukey HSD was conducted to determine the statistical difference in radical scavenging per cent at different concentrations of the sample. After the sensory evaluation, the mean score, mean rank and kruskal-wallis value was evaluated using 'Scistatcalc'. The mean score represents the average rating or score given to each treatment group across different parameters such as appearance, color, flavor, texture, taste and overall acceptability.

RESULTS

Nutritional composition of Marayoor jaggery

The main sugars present in jaggery are sucrose (72-78%), fructose (1.5-7%) and glucose (1.5-7%). In this study, the main sugars in conventional jaggery were estimated to be sucrose (63%), fructose (8%) and glucose (10%) respectively.[12] It can be noted that the fructose and glucose content is higher in marayoor jaggery. Table 1 shows the vitamin content in marayoor jaggery per 100 g.

Table 1: Vitamin content in marayoor jaggery.

Vitamins	Quantity (per 100 g)
Vitamin A	140 IU
Vitamin D2	20 mg
Vitamin E	90 mg
Vitamin C	7 mg
Vitamin B1	130 mg
Vitamin B5	80 mg
Vitamin B6	50 mg

The vitamins present in jaggery are vitamin A (3.8 mg), vitaminD2(6.5mg),vitaminE(111.3mg),vitaminC(7mg), vitamin B1 (0.01 mg), vitamin B5 (0.01 mg) and vitamin B6 (0.01 mg).[1] It can be noted that marayoor jaggery contains higher amount of vitamin B1, B_5 and B_6 and equal amounts of vitamin C.

The minerals present in jaggery are calcium, magnesium, phosphorous, sodium, iron, manganese, zinc, chloride, copper and potassium respectively.[4] Table 2 represents the mineral content in marayoor jaggery per 100 g.

Table 2: Mineral content in marayoor jaggery.

Minerals	Quantity (mg per 100 g)
Calcium	80 mg
Magnesium	152 mg
Phosphorous	32 mg
Sodium	26 mg
Iron	13 mg
Manganeese	174 mg
Zinc	3 mg
Chloride	60 mg
Copper	8 mg
Potassium	253 mg

Calcium (40-100 mg), magnesium (70-90 mg), phosphorous (20-90 mg), sodium (19-30 mg), iron (10-13 mg), manganese (0.2-0.5 mg), zinc (0.2-0.4 mg), chloride (5.3 mg), copper (0.1-0.9 mg) and potassium (1056 mg) are the minerals found in regular jaggery, respectively.[12] It can be noted that magnesium, manganese, zinc and chloride are slightly greater than usual jaggery. It is noticeable that it contains high amount of iron content, i.e., 13 mg.

Quantitative and qualitative determination of phytochemicals

The total phenolic and flavonoid content were calculated to be 0.336±0.56 mg/mL and 2.19±1.2 mg/mL respectively. The results of the qualitative analysis showed the presence of glycosides and terpenoids and the absence of alkaloids, tannins, saponins.

Estimation of *In vitro* antioxidant property of Marayoor jaggery

Percent radical scavenging activity of Marayoor jaggery at different concentration using DPPH assay is given in Table 3. One way ANOVA followed by Tukey HSD was conducted to determine the statistical difference in radical scavenging per cent at different concentration of the sample.

From the Table 3, it is evident that the percent radical scavenging activity of marayoor jaggery increased with

increasing concentration of sample. The maximum DPPH˙ radical scavenging activity was 35.37±0.62% at 30 µg/mL concentration. The IC_{50} value was estimated to be 42 µg/mL concentrations. This shows that Marayoor jaggery has a good antioxidant capacity against free radical formation.

Table 3: Percent radical scavenging activity of Marayoor jaggery (*Saccharum Officinarum L.)* at different concentration using DPPH assay.

Concentration (µg/mL)	Per cent radical scavenging activity in DPPH Assay
Control	0
10	11.73±0.12[a]
20	26.95±0.42[b]
30	35.37±0.62[c]

[a-d]Mean values with different subscript within a column shows that statistically significant difference ($p<0.05$).

One Way ANOVA followed by Tukey HSD showed that there was statistically significant difference in per cent radical scavenging activity between different concentration of sample *($p<0.05$)*. In a previous study, the IC_{50} values of lyophilized sugarcane products which were determined using DPPH assay were found to be low, ranging from 0.073 and 2.81 µg/mL.[13] Lyophilized form used in the study may have yielded a better antioxidant capacity.

Development of standardized products using marayoor jaggery

Table 4 illustrates the average values for the organoleptic assessment of amla marble cake (T1) with Marayoor jaggery. The mean score denotes the average rating assigned to each treatment group based on various criteria, including appearance, color, flavor, texture, taste and overall acceptability. The mean rank value denotes the ranks allocated to each treatment group across several criteria. MRV stands for the mean rank values which come from an approach that assigns ranks to the observations. Nonparametric methods like Kruskal Wallis test was used in the study which compares the mean rank value between different proportions of amla marble cake (T1) with that of control.

Table 4 indicates that T1C (with 40:45:15 proportion for sprouted ragi powder, marayoor jaggery and dried amla powder) achieved the highest mean scores for appearance, color, flavor, texture, taste and overall acceptability. This had highest proportion of marayoor jaggery among all the proportions. The mean score was the lowest for the control group across all factors. Consequently, it can be inferred that amla marble cake is more visually appealing, palatable, flavorful and possesses superior texture and taste compared to the control. Table 5 presents the average values for the organoleptic assessment of amla marble laddu (T2).

Table 4: Mean values for organoleptic evaluation of "Amla marble cake" prepared with Marayoor jaggery.

Treatment	Appearance		Colour		Flavour		Texture		Taste		OAA	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T1A	54.62	8.2	56.60	8.0	42.48	6.8	35.98	6.6	37.90	6.9	43.36	7.3
T1B	55.69	8.3	56.72	8.1	54.92	7.5	54.62	7.5	48.23	7.3	54.46	7.8
T1C	59.84	8.4	63.33	8.3	79.84	8.3	80.21	8.3	83.32	8.4	77.82	8.5
Control	23.62	7.1	25.32	6.8	28.48	6.4	36.58	6.8	32.54	7.1	31.12	7.0
KW Value	28.62		28.33		43.65		41.25		52.6		37.62	
λ^2 (0.05)	7.81											

(MS-Mean score, MRV-Mean rank value).

Table 5: Mean scores for organoleptic evaluation of "Amla ragi laddu" prepared with Marayoor jaggery.

Treatment	Appearance		Colour		Flavour		Texture		Taste		OAA	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T2A	53.70	8.2	59.92	8.4	58.19	7.7	57.20	7.7	56.34	7.7	59.50	7.9
T2B	67.02	8.7	63.35	8.4	57.29	7.6	61.48	7.9	58.02	7.8	59.56	7.9
T2C	56.66	8.3	58.41	8.3	57.66	7.7	54.4	7.6	64.46	8.0	58.16	7.8
Control	23.35	7.0	20.34	6.8	19.27	7.5	25.9	6.5	19.97	6.2	16.83	6.5
KW Value	35.78		40.78		37.64		24.93		38.53		23.67	
λ^2 (0.05)	7.81											

(MS-Mean score, MRV-Mean rank value).

Table 6: Mean scores for organoleptic evaluation of "Amla nutty cookies" prepared with Marayoor jaggery.

Treatment	Appearance		Colour		Flavour		Texture		Taste		OAA	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T3A	64.46	7.6	58.66	7.9	58.63	7.8	52.36	7.6	58.96	7.8	61.28	6.9
T3B	66.38	8.4	64.24	8.1	60.96	7.9	52.15	7.6	61.86	7.9	63.64	7.8
T3C	57.84	8.0	60.30	7.9	61.57	7.9	55.83	7.0	58.94	7.8	62.62	7.8
Control	16.75	6.3	18.80	7.1	25.82	7.3	47.51	6.7	27.30	6.6	19.34	6.1
KW Value	53.19		44.49		27.12		10.71		24.49		22.46	
λ^2 (0.05)	7.81											

(MS-Mean score, MRV-Mean rank value).

Table 5 indicates that the mean score was highest for T2B (50:35:15 proportion for sprouted ragi powder, marayoor jaggery and dried amla powder) in appearance and texture and for T2C (40:45:15 proportion for sprouted ragi powder, marayoor jaggery and dried amla powder) in taste. The color and overall acceptability were highest for T2A and T2B. The flavor was more pronounced in T2A and T2C. The mean score was the lowest for the control group across all factors. Consequently, it may be inferred that amla ragi laddu more effectively meets the sensory criteria compared to the control. Table 6 presents the average values for the organoleptic assessment of amla nutty cookies.

Table 6 indicates that T3B achieved the highest mean scores for appearance, color, flavor, texture, taste and overall acceptability. The mean score was the lowest for the control group across all factors. The flavor was highest for T3B and T3C in terms of both flavor and overall acceptance. It may be inferred that amla ragi laddu more effectively meets the sensory criteria compared to the control. Overall, it can be noted that all the products made by incorporating marayoor jaggery had high acceptability.

CONCLUSION

There are limited studies on marayoor jaggery and this study explored the nutritional composition, phytochemical properties and antioxidant capacity of marayoor jaggery. The analysis revealed that it contains higher amounts of fructose, glucose, vitamins B1, B5, B6 and significant quantities of iron compared to conventional jaggery. It also demonstrated a notable presence of terpenoids and glycosides, though alkaloids, tannins and saponins were absent. The antioxidant properties of marayoor jaggery, assessed through DPPH radical scavenging activity, indicated a dose-dependent increase in antioxidant capacity. However, the antioxidant capacities were lower when compared with other studies. The nature of the sample used may have contributed to this effect.

Additionally, the study successfully developed and standardized three innovative food products incorporating marayoor jaggery, sprouted ragi powder and dried amla powder: amla marble cake, amla ragi laddu and amla nutty cookies. Sensory evaluation by an untrained panel highlighted the superior organoleptic qualities of these products incorporating marayoor jaggery compared to controls. It was also noted that the organoleptic evaluation parameters were high for the proportion with higher amount of marayoor jaggery, which was used in preparing amla ragi laddu.

The findings underscore the potential of marayoor jaggery as a nutrient-rich, natural sweetener with significant health benefits. Its integration into community-based nutrition programs and initiatives such as Anemia Mukt Bharat initiatives could address iron deficiency anemia effectively, especially in regions where marayoor jaggery is readily accessible. Furthermore, this research provides a basis for future studies to explore the bioavailability of iron and other micronutrients in marayoor jaggery.

ACKNOWLEDGEMENT

The authors are grateful for the funding received from Management Assisted Research Grant (MARG) from St. Teresa's College (Autonomous), Ernakulam for the successful completion of the project.

FUNDING

The authors are grateful for the funding received from Management Assisted Research Grant (MARG) from St. Teresa's College (Autonomous), Ernakulam for the successful completion of the project.

CONFLICT OF INTERESTS

The authors declare that there are no conflicting interests.

ABBREVIATIONS

DPPH: 2,2-diphenyl-1-picrylhydrazyl.

REFERENCES

1. Hirpara P, Thakare N, Kele V, Patel D. Jaggery: A natural sweetner. *J Pharmacogn Phytochem*. 2020;9(5):3145-8.
2. Lamdande AG, Khabeer ST, Kulathooran R, Dasappa I. Effect of replacement of sugar with jaggery on pasting properties of wheat flour, physico-sensory and storage characteristics of muffins. *J Food Sci Technol*. 2018;55(8):3144-53. doi:10.1007/s13197-018-3242-7.
3. Government of India. *Geographical Indications Journal*.; 2018;113.https://ipindia.gov.in/writereaddata/Portal/IPOJournal/1_2680_1/Journal_113.pdf.
4. Jaswant S., Solomon S, Kumar, D. Manufacturing Jaggery, a product of sugarcane, as health food. *Agrotechnology*. 2013, S11.
5. Tungmunnithum D, Thongboonyou A, Pholboon A, Yangsabai A. Flavonoids and Other Phenolic Compounds from Medicinal Plants for Pharmaceutical and Medical Aspects: An Overview. *Medicines (Basel)*. 2018;5(3):93. Published 2018 Aug 25. doi:10.3390/medicines5030093.
6. Lawag IL, Nolden ES, Schaper AAM, Lim LY, Locher C. A Modified Folin-Ciocalteu Assay for the Determination of Total Phenolics Content in Honey. *Applied Sciences*. 2023;13(4):2135. https://doi.org/10.3390/app13042135.
7. Bag, GC, Devi PG., Bhaigyabati, T. Assessment of Total Flavonoid Content and Antioxidant Activity of Methanolic Rhizome Extract of Three Hedychium Species of Manipur Valley. *Int J Appl Biol Pharm*. 2015;30:154-9.
8. Kancherla N, Dhakshinamoothi A, Chitra K, Komaram RB. Preliminary Analysis of Phytoconstituents and Evaluation of Anthelminthic Property of Cayratia auriculata (In Vitro). *Maedica*. 2019;14(4):350-6. https://doi.org/10.26574/maedica.2019.14.4.350.
9. Dontha S. A review on antioxidant methods. *Asian J Pharm Clin Res* [Internet]. 2016 Oct. 1 [cited 2024 Jul. 10];9(8):14-32. Available from: https://journals.innovareacademics.in/index.php/ajpcr/article/view/13092.
10. Singh P, Raghuvanshi RS. Finger millet for food and nutritional security. *Indian Journal of Food Science*, 2012;6(4):77-84.
11. Anitha S, Kane-Potaka J, Botha R, *et al*. Millets Can Have a Major Impact on Improving Iron Status, Hemoglobin Level and in Reducing Iron Deficiency Anemia-A Systematic Review and Meta-Analysis. *Front Nutr*. 2021;8:725529. Published 2021 Oct 14. doi:10.3389/fnut.2021.725529.
12. Singh J, Solomon S, Kumar Dilip. Manufacturing jaggery, a product of sugarcane, as health food. *Agrotechnology*. 2013;11. doi: 10.4172/2168-9881.S110.
13. Ahmed M.S.H, Nayaka H.M.A, Almulaiky Y.Q, Dalali S.A. Evaluation of phytochemical screening and biological activity of lyophoilized sugarcane juice, vacuum and open pan jaggery for aqeous extracts.2021;12(1):81-91.

Cite this article: Jacob DR, Sneha NM, Tessy mol James. Therapeutic Evaluation and Development of Nutrient-Rich Value-Added Products Utilizing Marayoor Jaggery. Asian J Biol Life Sci. 2024;13(3):652-7.