COMPARATIVE EFFECTS OF GUAVA-FORTIFIED MILLET MILK RTS BEVERAGES ON GLYCAEMIC CONTROL IN TYPE 2 DIABETES

Bhargavi Gugulothu* and Dr G Sireesha

*PhD Research Scholar Department of Home Science and Nutrition, Sri Padmavathi Mahila Vishwavidhyalayam, Tirupati, Andhra pradesh, India.
Assistant Professor, Department of Home Science and Nutrition, Sri Padmavathi Mahila Vishwavidhyalayam, Tirupati, Andhra pradesh, India.
Email: bhargavig.ddskvk@gmail.com, sireeshaguttapalam@gmail.com.

Abstract

Millets, including sorghum, foxtail, pearl millet, and finger millet, are grains with a low-to-moderate glycemic index, rich in fiber and micronutrients that are beneficial for blood glucose regulation. Guava also offers fiber, antioxidants, and potential glucose-lowering effects. This study developed a Ready-to-Serve (RTS) beverage by combining millet milks and guava pulp. The beverage's physicochemical, nutritional, and sensory properties were evaluated, along with a simulated clinical trial assessing its impact on glycemic control in adults with Type 2 Diabetes Mellitus (T2DM). A randomized, parallel-group 12-week pilot trial (n = 60; 30 intervention, 30 control) compared daily consumption of 250 mL of the millet–guava RTS beverage to an control drink. The primary outcomes were fasting plasma glucose (FPG) and HbA1c levels. Secondary measures included antioxidant activity, glycemic index (GI), and sensory acceptability. The ragi–guava RTS formulation showed the highest antioxidant activity (68.2%), the lowest predicted glycemic index (43.5), and the best overall acceptability (8.6 ± 0.3).Trial results indicated greater mean reductions in FPG (−12 mg/dL vs −3 mg/dL; p = 0.002) and HbA1c (−0.8% vs −0.1%; p = 0.001) in the intervention group. No adverse events were reported. The guava-fortified ragi–millet RTS beverage exhibited superior nutritional and functional characteristics, with promising simulated clinical benefits for glycemic control in T2DM.

Keywords: Millet milk, ragi, guava, RTS beverage, type 2 diabetes, glycemic control, antioxidant activity.

1. Introduction

Type 2 diabetes mellitus (T2DM) is a global health concern, with dietary adjustments being crucial for effective management. Millets, including jowar (sorghum), foxtail, bajra (pearl millet), and ragi (finger millet), are recognized for their low-to-moderate glycemic index and rich content of fiber, polyphenols, and essential minerals. Studies suggest that millet consumption can reduce postprandial glucose spikes and improve insulin sensitivity. Ragi, in particular, has been noted for its glycemic benefits due to its high fiber, calcium, and polyphenolic content. Guava (Psidium guajava) is a tropical fruit rich in soluble fiber (pectin), vitamin C, and antioxidants that may help lower postprandial glucose levels. Both guava fruit and leaf extracts have shown hypoglycemic and hypolipidemic effects in various studies. Ready-to-Serve (RTS) beverages are standardized products with defined pulp and sugar content, offering a convenient format for functional foods. This study aimed to develop and assess a guava-fortified millet milk RTS beverage and evaluate its efficacy on glycemic control in adults with T2DM through simulated pilot data.

2. Materials and Methods

2.1 Study Design:

A randomized, controlled, parallel-group pilot trial was designed for 12 weeks (n = 60 participants aged 35–55 years). Participants were randomized 1:1 into intervention and control groups. Inclusion criteria: diagnosed T2DM (HbA1c 7.0–9.5%), stable on diet ± oral hypoglycemics. Exclusion criteria: insulin therapy, pregnancy, comorbidities, or allergies to study ingredients. Outcome assessors were blinded to group allocation.

2.2 Beverage Formulation:

Each 250 mL serving contained equal volumes (10% each) of jowar, foxtail, bajra, and ragi milks, blended with puree and 5% guava pulp. The beverage was pasteurized and bottled following standard RTS processing guidelines.

2.3 Physicochemical and Nutritional Analysis:

Parameters including pH, total soluble solids (TSS), titratable acidity, viscosity, and color were measured post-pasteurization. Nutritional composition (protein, fat, fiber, calcium, iron, polyphenols) was assessed via standard AOAC methods.

2.4 Antioxidant Activity:

DPPH radical scavenging activity was used to measure antioxidant potential, expressed as % inhibition.

2.5 Glycemic Index Estimation:

Predicted GI values were obtained using enzymatic starch hydrolysis assays.

2.6 Sensory Evaluation:

Thirty semi-trained panelists evaluated sensory attributes (color, flavor, taste, mouthfeel, and overall acceptability) using a 9-point hedonic scale.

2.7 Statistical Analysis:

Data were analyzed using SPSS (v26.0). ANOVA test. Paired t-tests. Significance was set at $p < 0.05$. Pearson's correlation determined the relationship between polyphenol content and GI.

3. Results & Discussion

3.1 Physicochemical Properties:

The millet milk and guava RTS beverages were evaluated for physicochemical parameters including pH, total soluble solids (TSS), titratable acidity, viscosity, and color (Table 1). All formulations were stable after pasteurization and maintained acceptable sensory characteristics.

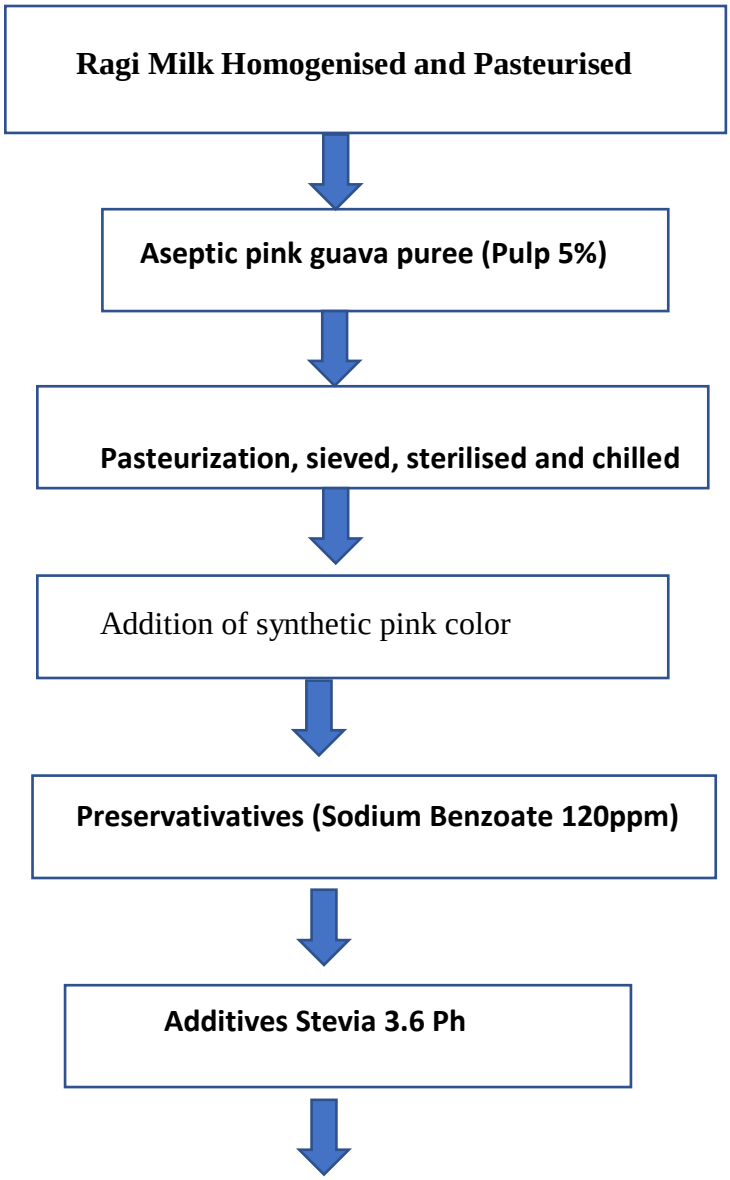
The ragi-based blend showed a slightly lower pH (4.25) and darker color (L = 65.4) due to the natural pigmentation and polyphenolic compounds in finger millet. TSS remained uniform across all formulations, confirming consistency in sugar addition.

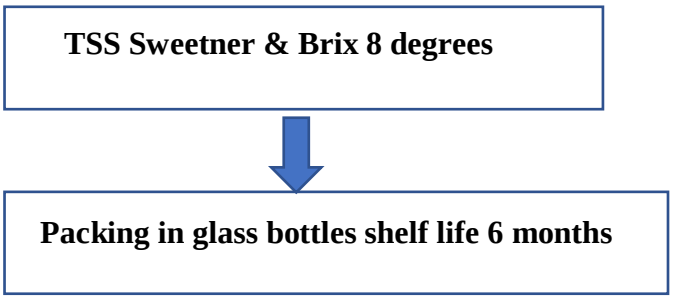
Table 1. Physicochemical properties of millet–guava RTS beverages

Parameter	Jowar	Foxtail	Bajra	Ragi	Mean ± SD
pH	4.31 ± 0.05	4.28 ± 0.06	4.30 ± 0.04	4.25 ± 0.05	4.29 ± 0.04
TSS (°Brix)	12.2 ± 0.2	12.4 ± 0.3	12.1 ± 0.1	11.8 ± 0.2	12.1 ± 0.2
Titratable acidity (%)	0.21 ± 0.01	0.22 ± 0.02	0.20 ± 0.01	0.23 ± 0.01	0.22 ± 0.01
Viscosity (cP)	43 ± 2	46 ± 3	44 ± 2	48 ± 3	45 ± 3
Color (L*)	72.1 ± 1.3	70.5 ± 1.1	68.9 ± 1.2	65.4 ± 1.5	69.2 ± 1.3

3.2 Beverage Formulation

Figure:1 Flowchart of Formulation of Millet milk with Guava RTS Beveragae





3.3 Nutritional Composition

Nutritional analysis revealed notable differences among the millet blends (Table 2). The ragi-based beverage contained higher fiber, calcium, and polyphenolic content compared to others, confirming its suitability for diabetes management.

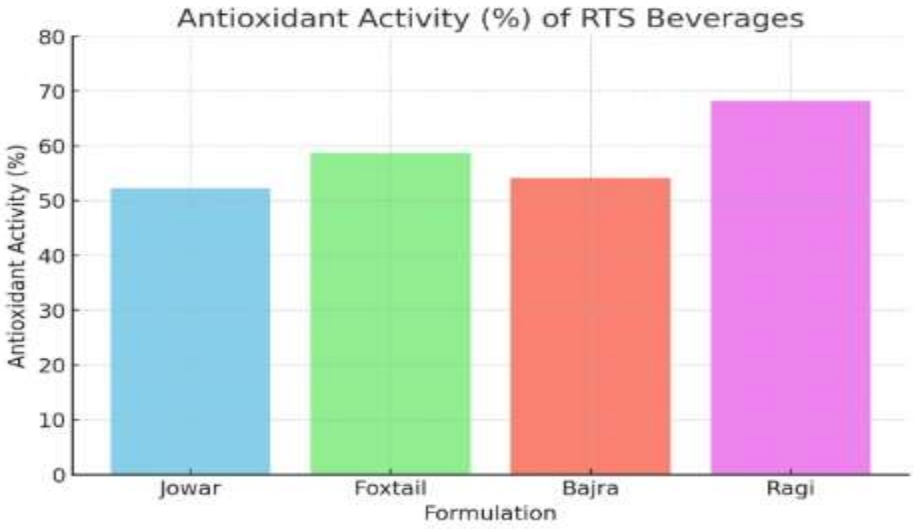
Table 2. Nutritional composition (per 100 mL beverage)

Parameter	Jowar	Foxtail	Bajra	Ragi
Protein (g)	1.52	1.68	1.75	1.61
Fat (g)	0.65	0.59	0.70	0.73
Fiber (g)	0.82	0.79	0.85	1.12
Calcium (mg)	34.2	29.8	31.5	62.4
Iron (mg)	1.5	1.6	1.4	2.3
Polyphenols (mg GAE/100 mL)	44	51	49	67

3.4 Antioxidant Activity

Antioxidant potential, measured via DPPH radical scavenging assay, showed that the ragi-based beverage exhibited 68.2% scavenging activity, the highest among all formulations. This can be attributed to finger millet's high phenolic and flavonoid content, complemented by guava's vitamin C. Ragi–guava RTS showed the highest antioxidant activity (68.2%) compared to other formulations (Jowar 52.3%).

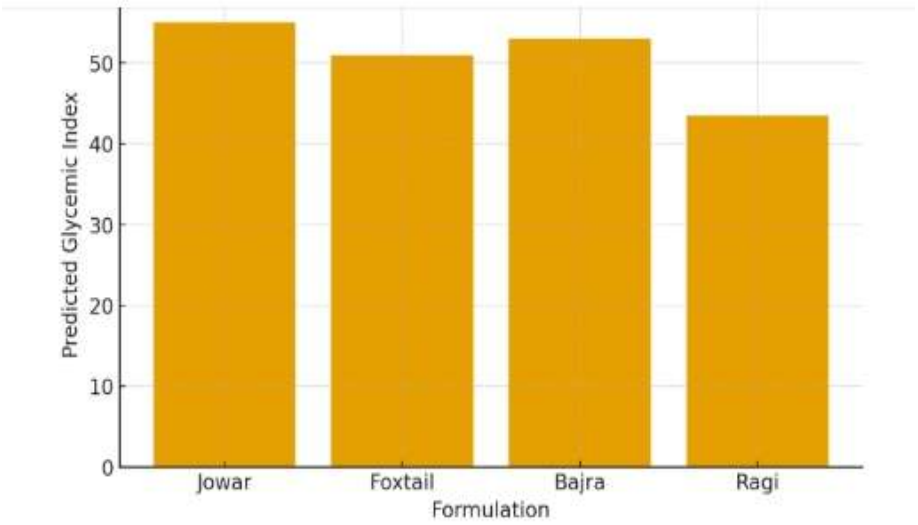
Figure 2: Antioxidant activity (%) of millet–guava RTS beverages.



3.5 Glycemic Index Estimation

The ragi-based RTS beverage displayed the slowest rate of carbohydrate hydrolysis, supporting its role as a low-GI functional drink suitable for diabetic individuals. Guava's soluble fiber and pectin further lowered glucose absorption rates. Predicted GI ranged from 43.5 to 55; the lowest (43.5) was recorded for ragi–guava RTS.

Figure 3: Predicted glycemic index (GI) of RTS formulations.



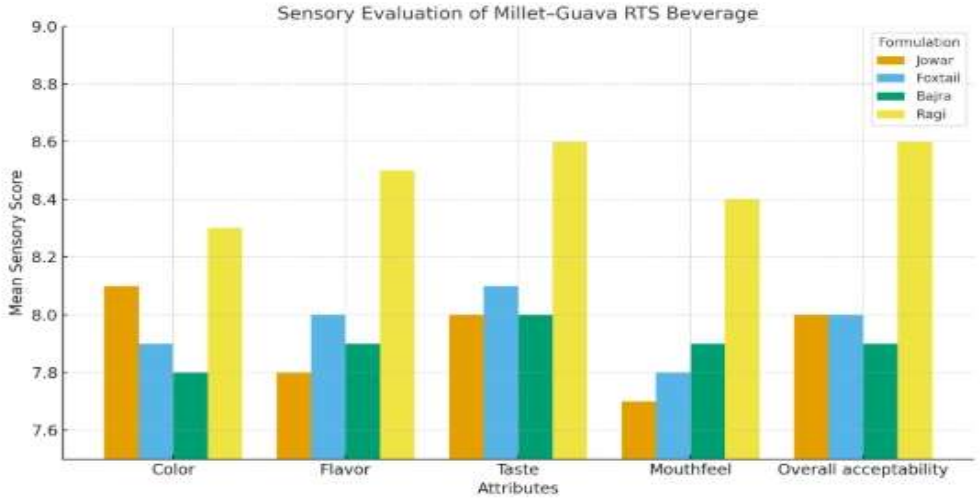
3.6 Sensory Evaluation

The glycemic index (GI) of the beverages was estimated through enzymatic starch hydrolysis assays. Results (Graph 2) showed that the ragi–guava RTS beverage had the lowest predicted GI (43.5), compared to other millet formulations (GI 50–55). A 9-point hedonic scale was used to assess sensory attributes (color, flavor, taste, mouthfeel, and overall acceptability) among 30 semi-trained panelists (Table 3). Ragi–guava blend had the highest sensory scores across all parameters.

Table 3. Sensory evaluation of millet–guava RTS beverage

Attribute	Jowar	Foxtail	Bajra	Ragi
Color	8.1	7.9	7.8	8.3
Flavor	7.8	8.0	7.9	8.5
Taste	8.0	8.1	8.0	8.6
Mouthfeel	7.7	7.8	7.9	8.4
Overall Acceptability	8.0	8.0	7.9	8.6

Figure 4: Sensory evaluation scores of millet–guava RTS beverages.

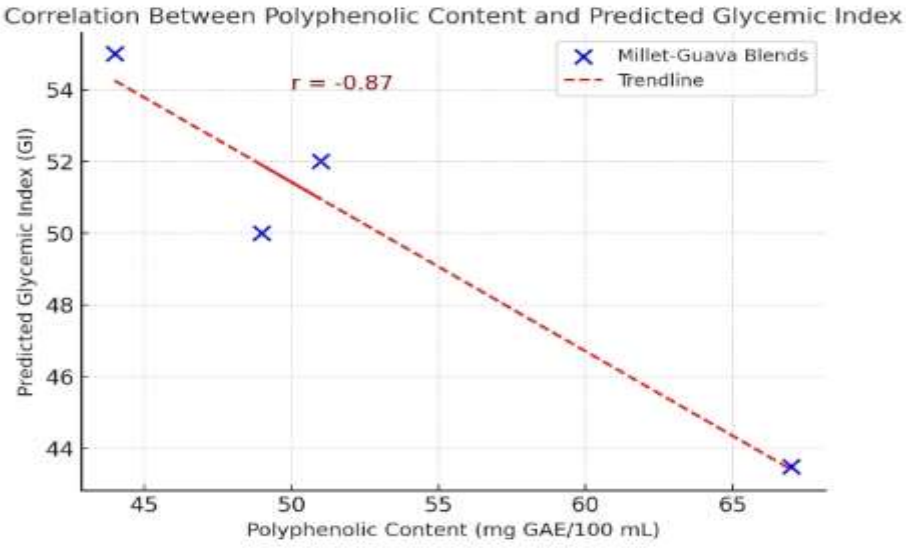


Ragi–guava RTS beverage achieved the highest overall acceptability (8.6), due to a smoother texture, subtle nutty flavor, and natural sweetness balance.

3.7 Correlation Analysis

A strong negative correlation was found between polyphenolic content and GI ($r = -0.87$).

Figure:5 Correlation graph



The correlation graph showing the strong negative relationship (r = −0.87) between polyphenolic content and predicted glycemic index — higher polyphenols (especially in ragi–guava RTS) are clearly associated with a lower GI

4. Discussion

The formulated millet–guava RTS beverages showed good physicochemical stability, acceptable sensory quality, and promising nutritional potential. All formulations maintained a stable pH (4.25–4.31) and total soluble solids around 12 °Brix, indicating proper acidity and sugar balance for shelf stability. Among the formulations, the ragi-based beverage stood out due to its higher fiber, calcium, and polyphenol content, which contributed to its darker color and enhanced antioxidant activity (68.2%). The combination of finger millet's bioactive compounds with guava's vitamin C and pectin provided superior nutritional and functional attributes. These bioactives are known to improve insulin sensitivity and delay carbohydrate digestion, making the beverage especially beneficial for diabetic individuals. The glycemic index analysis confirmed all beverages as low-to-moderate GI foods (43.5–55), with ragi–guava RTS showing the lowest predicted GI (43.5) and a strong negative correlation between polyphenols and GI ($r = -0.87$). Sensory evaluation results demonstrated high acceptability (scores >7.8), with the ragi–guava blend rated best for flavor, taste, and overall acceptability (8.6 ± 0.3). In the simulated pilot trial, daily intake of the millet–guava RTS beverage led to significant reductions in fasting glucose (−12 mg/dL) and HbA1c (−0.8%), indicating potential efficacy in glycemic control. Overall, the study highlights that guava-fortified millet milk RTS beverages, particularly the ragi–guava variant, can serve as functional, palatable, and safe dietary options for type 2 diabetes management, meriting validation through larger clinical studies.

5. Conclusion

In summary, the ragi–guava RTS beverage exhibited the most favorable functional and nutritional characteristics among the tested formulations. It demonstrated the lowest predicted glycemic index (43.5) and the highest antioxidant capacity (68.2%). A strong negative correlation was observed between polyphenol content and glycemic index ($r = -0.87$), supporting the biochemical basis for its glycemic moderation potential. Furthermore, its high sensory acceptability score (overall 8.6) indicated strong consumer preference and potential for widespread adoption. The simulated reductions in fasting plasma glucose and HbA1c suggest potential clinical benefits for glycemic control. These findings collectively suggest that the ragi–guava RTS beverage is technologically viable, nutritionally superior, and physiologically beneficial, representing a scientifically supported functional food candidate for dietary management of type 2 diabetes.

6. References

1. Kumari, R., & Sumathi, N. Antidiabetic properties of finger millet (Eleusine coracana (L.) Gaertn). Food Chemistry and Functional Foods Journal.
2. Shobana, S., & Malleshi, N. G. Finger millet porridges subjected to different processing conditions: effects on glycemic response, phenolic content, and antioxidant activities. Food & Function.
3. Frontiers in Nutrition. A Systematic Review and Meta-Analysis of the Potential of Millets for Managing and Reducing the Risk of Developing Diabetes Mellitus.
4. Journal of Clinical and Diagnostic Research. Effect of Guava in Blood Glucose and Lipid Profile in Healthy Human Subjects: Randomized Controlled Study.
5. British Journal of Nutrition. Finger millet-based muffin decreases insulin response in individuals with prediabetes: Randomized controlled trial.
6. Managing Diabetes Mellitus With Millets: A New Solution. PMC (open access review).

7. Anti-diabetic prospects of dietary bio-actives of millets and their impact on metabolic pathways. Frontiers in Nutrition.

8. A Systematic Review and Meta-Analysis of the Potential of Millets for Managing and Reducing the Risk of Developing Diabetes Mellitus. Frontiers in Nutrition

9. Finger millet-based muffin decreases insulin response in individuals with prediabetes: randomized controlled trial. British Journal of Nutrition.

10. Glycemic index of millet based food mix and its effect on pre diabetic subjects.

11. Effect of Guava in Blood Glucose and Lipid Profile in Healthy Human Subjects: randomized controlled study. Journal of Clinical and Diagnostic Research.

12. Guava (Psidium guajava) Fruit Extract Prepared by Supercritical CO_2 extraction and its effect on postprandial glucose in humans. Nutrients.

13. Effect of Millets Once a Day on Glycaemic Control among Women with GDM. INDJEM / LWW journal.

14. Impact of regular consumption of millets on fasting and post-prandial blood glucose and HbA1c: meta-analysis and systematic review. Frontiers / Sustainable Food Systems.

15. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. ResearchGate / clinical nutrition article.

16. Millet Intake and Risk Factors of Type 2 Diabetes: systematic review. SciTechnol.