

EVALUATION OF CARBONATED PROBIOTIC HIBISCUS SODA BEVERAGES USING GINGER BUG

Omowumi Hannah Ukah, Adeola Taiwo Muniru and Kassim Sadiq Abubakar

Department of Food Science and Technology, Polytechnic, Bida, Niger State, Nigeria

Corresponding email; info.adeola@gmail.com

ABSTRACT

The benefits of probiotic beverages they serve as micro-biomes for normal metabolic activity. This study investigated the mineral composition, microbial and sensory properties of carbonated probiotic hibiscus soda beverages produced using ginger bug as a natural source of carbonation. Standard procedures were used to prepare the hibiscus extract, activate the ginger bug, and ferment the beverage. The resulting samples were analyzed for mineral composition (calcium, iron, and potassium) and subjected to sensory evaluation by a trained panel. The data obtained were statistically analyzed using analysis of variance (ANOVA). Calcium levels ranged from 14.23-17.27 mg/100 g, iron from 0.38-0.45 mg/100 g, and potassium from 29.09–30.84 mg/100 g, with significant differences ($P < 0.05$) among samples. These values confirm the nutritional relevance of the beverage, particularly in supporting bone health, oxygen transport, and electrolyte balance. Sensory evaluation indicated high consumer acceptability on a nine-point hedonic scale, with mean scores for color (7.50-8.00), taste (7.20-7.85), flavor (6.75-7.60), mouth feel (7.35-7.55), appearance (7.55–8.00), and overall acceptability (7.05-7.80). Statistically significant differences ($P > 0.05$) were observed among samples, the microbial result range from 1.0×10^3 to 1.4×10^3 and 1.0×10^3 to 1.1×10^3 respectively, indicating consistent quality and palatability. The carbonated probiotic hibiscus soda produced with ginger bug demonstrated both nutritional and sensory appeal, offering a functional alternative to conventional carbonated soft drinks. The findings suggest that the beverage holds promise for consumer marketability, health promotion, and the functional beverage industry.

Keywords: mineral, microbial sensory, probiotic, Hibiscus, ginger

INTRODUCTION

Probiotics carbonated beverages have become a popular choice for many consumers worldwide, with a growing interest in functional drinks that not only provide refreshment but also offer health benefits (Saxelinet *al.*, 2013). Probiotic beverages, particularly those containing live microorganisms that provide health benefits when consumed in adequate amounts, have gained significant attention due to their potential to improve gut health and enhance the immune system. Hibiscus, a flowering plant known for its vibrant color and tart flavor, has been used traditionally for its medicinal properties, including its ability to lower blood pressure and support heart health Hopkins (et al., 2013)

In recent years, there has been a surge in consumer interest for functional beverages, particularly those offering health benefits beyond basic nutrition. Among these, probiotic drinks have gained significant attention for their positive effects on gut health, immunity, and overall well-being (Saxelinet *al.*, 2013). Probiotics, which are live microorganisms that confer health benefits to the host when consumed in adequate amounts, have been incorporated into a variety of food and beverage products. These beneficial organisms primarily species of *Lactobacillus*, *Bifidobacterium*, and certain yeasts such as

Saccharomyces boulardii have been widely incorporated into a variety of food and beverage products, including yogurt, fermented milk drinks, dietary supplements, and functional foods.. Carbonated beverages, a popular category of drinks, are often artificially carbonated with carbon dioxide (CO₂) to provide effervescence and refreshing qualities. However, there is a growing trend toward exploring natural carbonation methods, such as using ginger bug, a fermented mixture of ginger, sugar, and water, to create naturally carbonated beverages (Yap *et al.*, 2015).

This study explores the potential of creating a carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation. The sensory properties of this beverage, including its flavor, appearance, texture, and overall acceptability, are key to determining its potential success in the market.

A ginger bug is a natural, homemade starter culture that uses the process of fermentation to create a base for homemade probiotic drinks like ginger ale or other fizzy, fermented beverages. It is made from a mixture of fresh ginger, sugar, and water, which encourages the growth of wild yeasts and bacteria, providing natural carbonation and beneficial probiotics.

The benefits of probiotics and natural fermentation methods are well-documented; there is limited research on the sensory evaluation and consumer acceptance of carbonated probiotic hibiscus soda produced using ginger bug as the natural carbonation source. Hibiscus has been explored for its health benefits, but its application in a carbonated probiotic beverage, especially one using natural carbonation, remains under-researched. It is unclear how the carbonation process through ginger bug affects the sensory characteristics of the hibiscus soda, such as its taste, mouthfeel, and overall consumer preference. Given the growing consumer demand for functional and naturally carbonated drinks, it is crucial to investigate how these factors interact and how they influence consumer acceptance.

MATERIALS AND METHODS

Fresh ginger, hibiscus, sugar, honey, water kefir, probiotic powder, bottle etc.

Sample Collection: Fresh ginger, hibiscus, honey, sugar, water kefir, probiotic, and bottles used for this study were purchased from Modern Market, Bida, Niger State.

The AAS used for chemical analysis were of analytical grade. The mineral analysis (Calcium, Iron and potassium) was carried out in triplicates using standard AOAC (2023) Sensory evaluation was carried out using a 9-point hedonic scale. The results obtained were subjected to one way ANOVA and means were separated using Duncan Multiple Range Test (DMRT)

Table 1: Mineral Composition (mg/100g) of Carbonated Probiotic Hibiscus Soda Using Ginger Bug as a Natural Source of Carbonation.

Samples	Calcium (mg/100g)	Iron (mg/100g)	Potassium (mg/100g)
A	14.23 ^b ±0.02	0.44 ^a ±0.00	29.09 ^c ±0.04
B	10.84 ^c ±0.23	0.38 ^b ±0.02	30.84 ^a ±0.04
C	17.27 ^a ±0.07	0.45 ^a ±0.03	30.26 ^b ±0.05

Values are means ± standard deviation of duplicate determination. Values in the same column with different superscripts are significantly different (p<0.05). A = 48 Hours fermentation time, B = 72 Hours fermentation time, C = 96 Hours fermentation time

Table 2: Microbial evaluation of Carbonated Probiotic Hibiscus Soda Using Ginger Bug as a Natural Source of Carbonation.

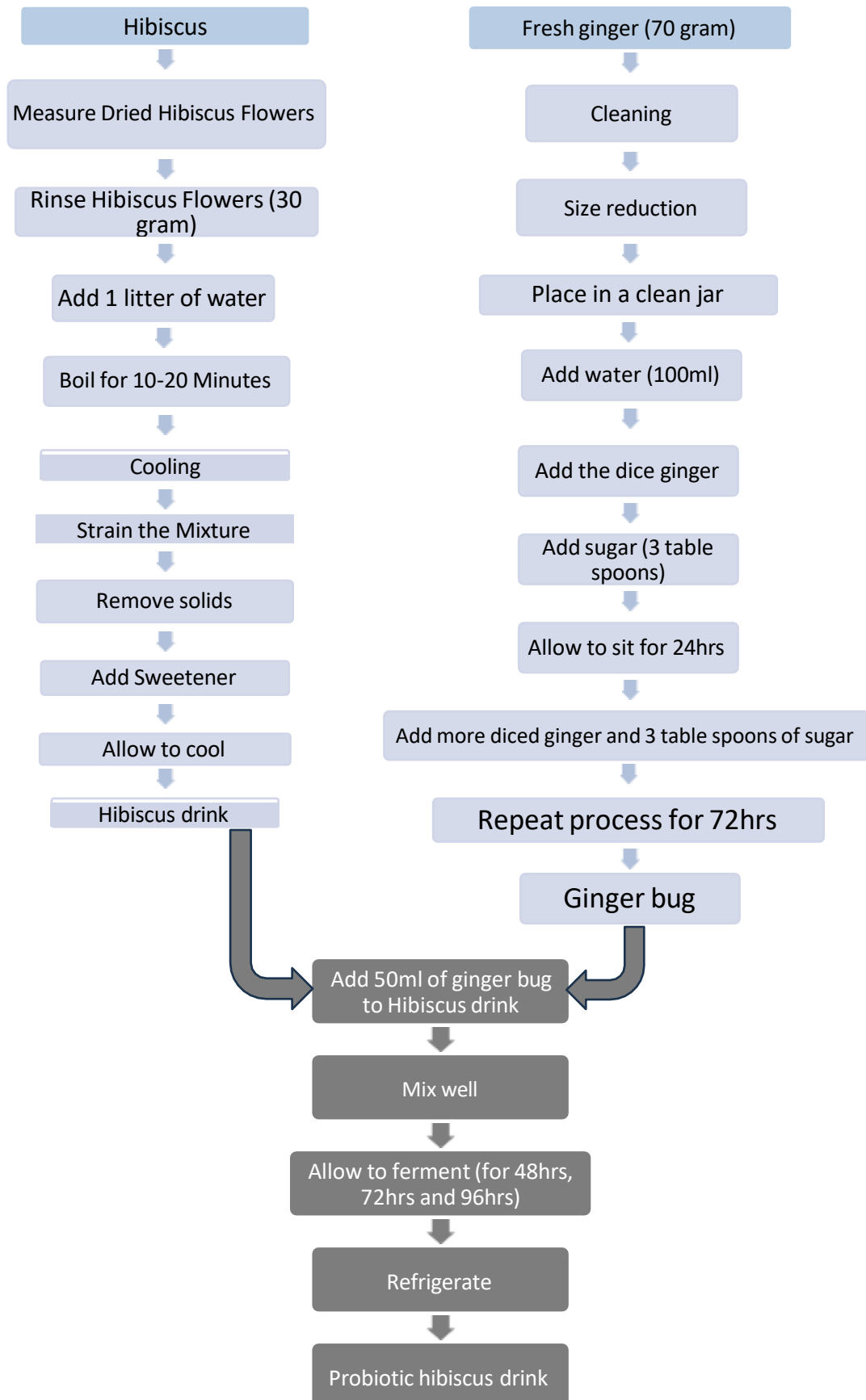
Sample	Total plate count cfu/mL	Fungi count cfu/ml
A	1.0 x 10 ³ ± 0.0 ^b	NP
B	1.2 x 10 ³ ± 0.00 ^a	1.0 x 10 ³ ± 0.09
C	1.4 x 10 ³ ± 0.10 ^a	1.1 x 10 ³ ± 0.50 ^a

Values are means ± standard deviation of duplicate determination. Values in the same column with different superscripts are significantly different (p < 0.05). A = 48 Hours fermentation time, B = 72 Hours fermentation time, C = 96 Hours fermentation time. NA = Not present

Table 3: Sensory evaluation of Carbonated Probiotic Hibiscus Soda Using Ginger Bug as a Natural Source of Carbonation.

Samples	Colour	Taste	Flavor	Mouthfeel	Appearance	Overall acceptability
A	8.00 ^a ±1.08	7.85 ^a ±1.04	7.60 ^a ±1.10	7.55 ^a ±1.10	7.85 ^a ±1.18	7.80 ^a ±0.77
B	7.75 ^a ±1.64	7.50 ^a ±1.57	6.75 ^a ±1.59	7.35 ^a ±2.01	8.00 ^a ±1.21	7.05 ^b ±0.95
C	7.50 ^a ±1.70	7.20 ^a ±1.36	7.30 ^a ±1.45	7.45 ^a ±1.43	7.55 ^a ±1.10	7.10 ^b ±0.72

Values are means ± standard deviation of duplicate determination. Values in the same column with different superscripts are significantly different (p < 0.05). A = 48 Hours fermentation time, B = 72 Hours fermentation time, C = 96 Hours fermentation time



Source: (Adeyemi *et al.*, 2022)

Fig: 1 Modified flow chart showing the preparation of hibiscus drinks and fresh ginger

DISCUSSION

The mineral composition of carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation was investigated. The calcium, iron, and potassium contents of the formulated samples were determined, and significant differences ($P < 0.05$) were observed among them. Mineral composition is an important parameter in functional beverages, as it contributes not only to nutritional quality but also to physiological functions such as bone health, oxygen transport, and electrolyte balance (Oludemiet *et al.*, 2023). The calcium content of the samples ranged from 14.23–17.27 mg/100 g, with sample A recording the least value and sample C the highest. The increase in calcium levels in sample C may be attributed to the higher concentration of hibiscus extract and the fermentation activities of the ginger bug, which may have enhanced mineral solubilization. This trend is similar to the report of Abubakar *et al.* (2022), who observed an increase in calcium levels in fermented sorghum-based beverages. However, the values recorded in this study were slightly lower than those reported by Adeleye and Osundahunsi (2023) for calcium-rich fortified probiotic drinks, suggesting that dilution during preparation might have influenced the final concentration.

The iron content of the samples ranged from 0.38–0.45 mg/100 g, with sample B having the least value and sample C the highest. There was no significant difference ($P > 0.05$) between sample A and C. Iron is an essential mineral for hemoglobin formation and energy metabolism. The relatively low levels observed in this study align with findings by Ezeochaet *et al.* (2023), who also reported reduced iron content in hibiscus-based beverages compared to the raw calyces. This reduction may be due to the solubility and binding of iron during fermentation. Conversely, Ibrahim *et al.* (2022) reported higher iron retention in spontaneously fermented sorghum beverages, suggesting that the type of fermentation starter (ginger bug vs. microbial inoculant) could influence mineral preservation. The potassium content of the samples ranged from 29.09–30.84 mg/100 g, with sample A recording the least and sample B the highest value. Potassium is vital for electrolyte balance and cardiovascular health, and hibiscus is widely reported as a rich source of this mineral. The significant differences ($P < 0.05$) observed among the samples may be due to variations in fermentation activity and raw material composition. The findings are in agreement with those of Mahadevan *et al.* (2019), who

reported potassium as the predominant mineral in hibiscus drinks. However, the potassium levels recorded in this study were lower than those reported by Adeyemi *et al.* (2022) for hibiscus-based probiotic beverages, possibly due to differences in ingredient concentration and fermentation conditions.

Overall, the results suggest that probiotic hibiscus soda produced with ginger bug retained appreciable levels of calcium, iron, and potassium, making it a functional beverage with nutritional relevance. While supporting studies (Mahadevan *et al.*, 2019; Abubakar *et al.*, 2022) confirm hibiscus drinks as mineral-rich, opposing findings (Ezeochaet *et al.*, 2023; Adeleye and Osundahunsi, 2023) highlight possible reductions in mineral retention due to dilution or fermentation type. This indicates that further optimization in formulation and fermentation control could enhance mineral bioavailability and overall nutritional value.

The microbial result also revealed statistically that 72 hours and 96 hours of fermentation of the hibiscus beverages matrix significantly ($p < 0.05$) higher than 48 hours of fermentation with values ranges from 1.0×10^3 – 1.4×10^3 cfu/ml. These differences could be associated to handling process and variation exist in the fermentation time as Izah and Ohimaih (2016) reported that some microbes have a short-time proliferation in favourable condition. The fungi count recorded less count in 72hrs and 96hrs fermentation of the hibiscus beverages. However, 48hrs of the fermentation indicate fungi growth. It was observed that the result shows safe level of the beverage consumption for way exceeding the WHO level within specific ranges in different food samples for microorganism.

The sensory evaluation of carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation was carried out to determine consumer acceptance in terms of colour, taste, flavour, mouthfeel, appearance, and overall acceptability. Results showed that there were no significant differences ($P > 0.05$) among the samples for all sensory attributes. Sensory evaluation is a key factor in determining market success of functional beverages, as consumers often judge product quality by sensory appeal rather than nutritional value (Small and Prescott, 2005). The colour scores ranged from 7.50–8.00, with sample C recording the least score and sample A the

highest. The high colour ratings across all samples confirm hibiscus as a rich natural source of anthocyanins, responsible for its deep red colour. This finding agrees with Mahadevan *et al.* (2019), who reported strong consumer preference for hibiscus-based drinks due to their attractive pigmentation. Similar trends were observed by Abubakar *et al.* (2022) in hibiscus-sorghum probiotic beverages. The taste attribute ranged from 7.20–7.85, with sample C having the lowest score and sample A the highest. The relatively high taste scores across samples suggest good flavour balance between the hibiscus base, sweeteners, and carbonation from the ginger bug. This agrees with Adeyemi *et al.* (2022), who noted that controlled fermentation improved taste quality of hibiscus probiotic beverages. However, Ezeochaet *et al.* (2023) reported that excessive fermentation could lead to increased sourness, thereby lowering taste acceptance highlighting the need for careful fermentation control.

The flavour scores ranged from 6.75–7.60, with sample B having the least and sample A the highest value. Though not significantly different ($P>0.05$), the slight variations may be linked to differences in fermentation activity and residual ginger compounds. Similar flavour improvements from ginger-based fermentation were reported by Ibrahim *et al.* (2022), who found that bioactive compounds from ginger enhanced aroma profiles in fermented drinks.

Mouth feels scores ranged from 7.35–7.55, with sample B recording the lowest and sample A the highest. The consistency in scores indicates that carbonation produced by the ginger bug was uniform across all samples. This is consistent with the findings of Oludemiet *et al.* (2023), who emphasized that carbonation enhances sensory perception of mouth feel in probiotic sodas.

The appearance scores ranged from 7.55–8.00, with sample C having the lowest and sample B the highest. The high appearance ratings align with consumer expectations of hibiscus drinks as visually appealing. This agrees with Mahadevan *et al.* (2019), who noted that bright red hues positively influence consumer preferences in hibiscus beverages. Overall acceptability scores ranged from 7.05–7.80, with sample B recording the least and sample A the highest. The high acceptability across all samples suggests that carbonated probiotic hibiscus soda made with ginger bug is well-received, showing potential for consumer marketability. These findings agree with Adeyemi *et al.*

(2022), who reported positive consumer acceptance of hibiscus probiotic beverages, but differ slightly from Ezeochaet *et al.* (2023), who observed moderate consumer response when sourness was pronounced. In general, the results demonstrate that all samples were well accepted by the panelists, showing no significant differences among sensory attributes. This indicates that ginger bug carbonation successfully produced a probiotic hibiscus soda with appealing sensory qualities comparable to commercial soft drinks but with added health benefits.

CONCLUSION

This study investigated the mineral composition, microbial and sensory properties of carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation. The findings revealed that the beverage contained appreciable amounts of essential minerals such as calcium, iron, and potassium, which are important for bone development, oxygen transport, and electrolyte balance. Although variations were observed among samples, the values obtained indicate that the product can contribute to dietary mineral intake. However, the count of microbial recorded were low. The sensory evaluation showed that all samples were well accepted by panelists in terms of color, taste, flavor, mouth feel, appearance, and overall acceptability, with no significant differences ($P>0.05$) among the samples. This suggests that ginger bug fermentation provided consistent carbonation and improved palatability, making the probiotic hibiscus soda comparable in sensory appeal to conventional carbonated soft drinks while offering additional health benefits. The study therefore concludes that carbonated probiotic hibiscus soda produced with ginger bug is not only nutritionally relevant but also acceptable to consumers. It represents a promising functional beverage that can promote health, enhance dietary diversity, and serve as a natural alternative to sugar-laden commercial soft drinks.

RECOMMENDATIONS

Based on the findings of this research, the following recommendations are made:

- i. The production of carbonated probiotic hibiscus soda using ginger bug should be scaled up for commercial purposes, as it combines nutritional benefits with high consumer acceptance.
- ii. Further research should be carried out on the storage stability, and shelf-life of the probiotic hibiscus soda

under different preservation and packaging conditions.

- iii. Public health campaigns and nutrition education should promote hibiscus-based probiotic beverages as healthier alternatives to conventional soft drinks, especially among young consumers who are heavy soda drinkers.
- iv. Food industries and government agencies should support local innovations in probiotic beverages through funding, training, and policy incentives to boost small-scale production and encourage the use of natural fermentation starters like ginger bug.

REFERENCES

- Abubakar, M. A., Lawal, M. T., & Mohammed, A. S. (2022). Effect of fermentation on mineral composition and sensory properties of sorghum-based probiotic beverages. *Journal of Food Science and Nutrition*, 10(4), 215–223.
- Adeleye, O. O., & Osundahunsi, O. F. (2023). Nutritional quality and mineral composition of fortified probiotic beverages produced from plant sources. *Food Chemistry Advances*, 2, 100104.
- Adeyemi, I. A., Olayinka, A. O., & Ojo, O. A. (2022). Development and evaluation of probiotic beverages from fermented hibiscus extracts. *Journal of Food Processing and Preservation*, 46(5), e16423.
- AOAC. (2023). *Official methods of analysis of AOAC International* (22nd ed.). Association of Official Analytical Chemists.
- Ezeocha, V. C., Nwosu, J. N., & Onuegbu, N. C. (2023). Influence of fermentation on the nutritional and sensory qualities of hibiscus-based beverages. *African Journal of Food Science*, 17(2), 45–54.
- Hopkins, A. L., Lamm, M. G., Funk, J. L., & Ritenbaugh, C. (2013). Hibiscus sabdariffa L. in the treatment of hypertension and hyperlipidemia: A comprehensive review. *Fitoterapia*, 85, 84–94.
- Ibrahim, S. A., Abdullahi, B. A., & Musa, H. (2022). Fermentation effects on the quality and sensory attributes of traditional cereal-based beverages. *International Journal of Food Science and Technology*, 57(3), 1556–1564.
- Izah S. C. and Ohimaih E.L. (2016) Microbiological quality of palm oil used in Nigeria microbiology research 2:1:037-045
- Mahadevan, N., Shivali, & Kamboj, P. (2019). Hibiscus sabdariffa Linn.—An overview of its phytochemistry and therapeutic uses. *Natural Product Research*, 23(3), 123–135.
- Oludemi, T. O., Adeola, A. A., & Ogunleye, O. O. (2023). Mineral composition and .nutritional importance of fermented functional beverages. *Journal of Food Composition and Analysis*, 115, 104861.
- Saxelin, M., Tynkkynen, S., Mattila-Sandholm, T., & de Vos, W. M. (2013). Probiotic and other functional microbes: From markets to mechanisms. *Current Opinion in Biotechnology*, 24(2), 204–211.
- Siti, H. N., Kamisah, Y., & Kamsiah, J. (2013). The role of oxidative stress, antioxidants and vascular inflammation in cardiovascular disease. *Vascular Pharmacology*, 71, 40–56.
- Yap, Y. L., Tan, J. S., & Tan, B. C. (2015). Fermentation technology for the production of functional beverages using natural microbial cultures. *Journal of Food Science and Technology*, 52(7), 3985–3996.