

Development of an Antioxidant Functional Beverage from Soursop Leaves (*Annona muricata*) and Stevia Leaves (*Stevia rebaudiana*) for Diabetes Prevention

Jojor Indriani Samosir¹, Hotnida Sinaga^{1*}, Eko Kornelius²

¹Program Studi Magister Ilmu Pangan, Fakultas Pertanian, Universitas Sumatera Utara, Medan, Indonesia

²Departemen Kimia, Fakultas Matematika dan Ilmu Pengetahuan, Universitas Sumatera Utara, Medan Indonesia

Received: January 07, 2026

Revised: February 26, 2026

Accepted: March 25, 2026

Published: March 31, 2026

Corresponding Author:

Hotnida Sinaga

hotnida.sinaga@usu.ac.id

DOI: [10.29303/jppipa.v12i3.14199](https://doi.org/10.29303/jppipa.v12i3.14199)

 Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)



Abstract: Diabetes mellitus is a degenerative disease closely associated with oxidative stress, with a high prevalence in Indonesia reaching 19.5 million cases in 2021. Stevia leaves and soursop leaves have an antioxidant composition with the ability to protect humans from free radicals and prevent oxidation. Soursop leaves and stevia leaves are one contain bioactive compounds with antioxidant and antihyperglycemic properties, making them potential ingredients for functional beverages. This study aimed to formulate a herbal tea combining soursop and stevia leaves and to evaluate its bioactive content, product quality, toxicity, and antihyperglycemic effectiveness. Three formulation ratios (75%:25%, 50%:50%, and 25%:75%) and brewing times of 3, 5, and 7 minutes were investigated. The evaluated parameters included total soluble solids, color intensity, pH, total phenolic content, antioxidant activity, sensory characteristics, and heavy metal contamination analyzed using ICP-OES. The best formulation was obtained at a 25%:75% ratio with a brewing time of 7 minutes. The selected product was further assessed for toxicity using the Brine Shrimp Lethality Test (BSLT) and for antihyperglycemic activity in alloxan-induced male mice, with ethical approval No. 1306/KEPK/USU/2025. Data were analyzed using two-way ANOVA followed by Tukey's test ($\alpha = 0.05$). The BSLT results showed an LC_{50} value of 562 ppm, indicating low toxicity. In the antihyperglycemic test, a dose of 5.6 mg/kg body weight resulted in the greatest reduction in blood glucose levels (46.15%). Overall, the herbal tea combining soursop and stevia leaves was found to be safe and demonstrated potential as a functional beverage for diabetes prevention.

Keywords: Antioxidant; Diabetes; Functional beverages; Soursop and stevia leaves

Introduction

Modern lifestyle changes, especially unbalanced diets, contribute to the rise of degenerative diseases closely linked to oxidative stress. Oxidative stress plays a key role in diabetes mellitus pathogenesis through cell damage, chronic inflammation, and metabolic disorders (Yuslianti, 2018); (Kurniasih, 2019)). Type 2 diabetes mellitus is a degenerative disease with high prevalence, including in Indonesia with about 19.5 million sufferers in 2021 (IDF, 2021). Chronic hyperglycemia in diabetes

risks serious complications, requiring preventive approaches via increased natural antioxidant intake (Terauchi, 2023).

Many natural ingredients from Indonesia have high antioxidant content and contain various active compounds. The use of these natural ingredients is very important for improving public health at a lower cost (Yahaya Gavamukulya, 2014). Herbal teas as natural-based functional drinks are widely developed due to ease of consumption and bioactive content. Soursop leaves (*Annona muricata*) contain high-antioxidant

How to Cite:

Samosir, J. I., Sinaga, H., & Kornelius, E. (2026). Development of an Antioxidant Functional Beverage from Soursop Leaves (*Annona muricata*) and Stevia Leaves (*Stevia rebaudiana*) for Diabetes Prevention. *Jurnal Penelitian Pendidikan IPA*, 12(3), 430-437. <https://doi.org/10.29303/jppipa.v12i3.14199>

flavonoids and polyphenols (Shibula, 2015). Stevia leaves (*Stevia rebaudiana* Bertoni) act as non-caloric natural sweeteners with antihyperglycemic activity by enhancing insulin sensitivity and inhibiting glucose metabolism. Stevia contains many phytochemicals that are beneficial for lowering blood sugar levels.

The glycosides in stevia have high antihyperglycemic activity and serve as a substitute for sucrose in diabetic patients. The hypoglycemic effect is achieved thru the reduction of glycogenolysis and gluconeogenesis processes, and the absorption of glucose in the duodenum (Jan, 2021); (Sulastri, 2022). Combining antioxidant sources may yield better synergistic effects than single ingredients (Lingga, 2014)(Lingga, 2014). However, studies on soursop-stevia herbal tea formulations, especially effects of ratios and brewing time on quality, safety, and antihyperglycemic efficacy, remain limited. Based on that background, the researcher is interested in creating a tea bag formulation from soursop leaves and stevia leaves This is because both leaves have high antioxidant activity and prevent diabetes. Based on the above problem, the researcher is interested in conducting a study titled "Development of Antioxidant Functional Beverages from Soursop Leaves (*Annona muricata*) and Stevia Leaves (*Stevia Rebaudiana*) in Diabetes Prevention.

Method

Materials: Main materials: soursop leaves (*Annona muricata* L.) and stevia leaves (*Stevia rebaudiana* Bertoni). Chemicals: ethanol, methanol, n-hexane, DPPH reagent, Folin-Ciocalteu reagent, 0.5% Na-CMC, distilled water, 0.9% NaCl, acetic acid, heavy metal standards (As, Cd, Hg, Pb, Sn), pro-analysis grade. Alloxan monohydrate and glibenclamide for antihyperglycemic testing.

Stages of Research

The research was conducted Conducted June–August 2025 at Food Chemical Analysis Laboratory, Faculty of Agriculture; Phytochemistry and Microbiology Laboratory, Faculty of Pharmacy, Universitas Sumatera Utara; Helvetia Health Institute; and Integrated Laboratory, Universitas Padjadjaran. Experimental Design: Randomized Complete Block Design (RCBD) with two factors. Factor 1: soursop-stevia powder ratios (75:25, 50:50, 25:75). Factor 2: brewing times (3, 5, 7 min). Three replicates, yielding 27 units.

Research Procedure

Preparation of Leaf Powder and Herbal Tea Bags
Soursop leaves and stevia leaves were washed clean, air-dried, then oven-dried at 70°C for soursop leaves and

55°C for stevia leaves. The dried leaves were then ground and sieved to obtain fine powder. 2 g of the leaf powder mixture was packed into tea bags according to the treatment ratios. Brewing was performed using hot water at 85°C for 3, 5, and 7 minutes.

Physicochemical and Bioactive Analysis

The resulting herbal tea bags were analyzed for moisture content, total soluble solids, pH, color intensity, total phenolic content, and antioxidant activity using the DPPH method. Sensory evaluation was conducted using the hedonic method. Heavy metal contamination analysis (As, Cd, Hg, Pb, and Sn) was performed using the ICP-OES method.

Determination of the Best Formula

The best formula was determined based on physicochemical, bioactive, and sensory parameters using the De Garmo method.

Toxicity Test (BSLT)

Acute toxicity testing was conducted using the Brine Shrimp Lethality Test (BSLT) method. 48-hour-old *Artemia salina* larvae were exposed to various concentrations of the herbal tea extract. Mortality observation was carried out after 24 hours, and the LC₅₀ value was determined using probit analysis.

Flowchart Stage of Research

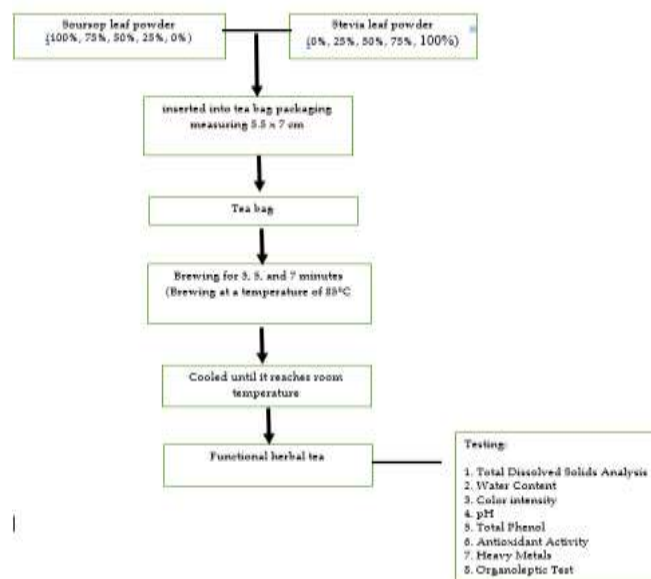


Figure 1. Flowchart for the Production of Fungtional Beverages

Antihyperglycemic Activity Test

The test animals used were male mice weighing 20–30 g and aged 2–3 months. Diabetes induction was performed using alloxan monohydrate via intraperitoneal injection. The mice were divided into

five groups: negative control (0.5% Na-CMC), positive control (glibenclamide), and three treatment groups administered herbal tea at doses of 2.8, 4.2, and 5.6 mg/20 g body weight. Blood glucose levels were measured using a glucometer for seven consecutive days.

Data Analysis

The obtained data were analyzed using two-way ANOVA followed by Tukey's post-hoc test at a significance level of $\alpha = 0.05$.

Result and Discussion

Qualitative Test of Bioactive Compounds

Phytochemical screening results showed that ethanol extracts of soursop leaves and stevia leaves contain bioactive compounds such as alkaloids, flavonoids, tannins, saponins, and steroids, which have potential as antioxidants and antidiabetics. These findings align with previous studies reporting high flavonoid and phenolic content in soursop and stevia leaves as functional food ingredients (Rumiyanti, 2019); (Jamal, 2024). The use of 70% ethanol maceration method effectively extracts polar-semi-polar compounds while maintaining secondary metabolite stability, supporting the potential of both materials for antidiabetic functional beverage development.

Table 1. Results of Bioactive Component Testing from Phytochemical Screening of Soursop and Stevia Leaves

Phytochemical Test	Reagent	Result
Alkaloid	Mayer, Wagner, Dragendorff	+
Flavonoid	Mg + HCl	+
Tannin	FeCl ₃	+
Saponin	FeCl ₃	+
Steroid	H ₂ O + HCl	+

Raw Material Characteristics

Characteristics of soursop and stevia leaf powders include moisture content, total phenol and flavonoid content, and antioxidant activity as initial quality indicators before herbal tea formulation. Moisture content of both materials was below the maximum limit of SNI 03-3836-2013, indicating material stability during storage. Stevia leaves had higher total phenol and flavonoid content compared to soursop leaves, consistent with (Ali, 2022). Stevia contains many phytochemicals that are beneficial for lowering blood sugar levels. The glycosides in stevia have high anti-hyperglycemic activity and serve as a substitute for sucrose in diabetic patients. The hypoglycemic effect is achieved thru the reduction of glycogenolysis and gluconeogenesis processes, and the absorption of

glucose in the duodenum (Jan, 2021); (Sulastri, 2022). Conversely, soursop leaves showed higher antioxidant activity, indicating its main contribution to the antioxidant capacity of the herbal tea infusion, consistent with (Kamaluddin, 2024).

Table 2. Raw Material Analysis Results

Analysis	Soursop Powder \pm SD	Stevia Powder \pm SD
Moisture Content (%)	6.98 \pm 0.32	7.45 \pm 0.20
Ash Content (%)	4.80 \pm 0.18	5.90 \pm 0.10
Flavonoid Content (mgQE/g)	1.307 \pm 0.01	1.9697 \pm 0.07
Phenol Content (mg GAE/g)	41.6439 \pm 0.07	46.9008 \pm 0.04
Antioxidant Activity (ppm)	54.4818 \pm 0.01	40.3332 \pm 0.06

Note: Table values represent averages of 3 replicates \pm standard deviation. Testing performed in 3 replicates.

1. Total Soluble Solids

Total soluble solids (TDS) reflect the amount of dissolved compounds such as sugars, organic acids, and phenolic compounds in the herbal tea infusion (Nicola, 2015); (Ismawati, 2017). Two-way ANOVA results showed that soursop-stevia leaf ratios and brewing time significantly affected TDS values ($p < 0.05$). The highest TDS value was obtained at 25% soursop : 75% stevia ratio (3.78 °Brix), while the lowest was at 75% : 25% ratio (3.33 °Brix). The TDS increase with higher stevia proportion is likely related to steviol glycoside content that readily dissolves in hot water and contributes to increased °Brix values, as reported by (Harto, 2016) and (Nizori, 2023).

Table 3. Testing Data on the Combination of Soursop Leaves and Stevia on Total Dissolved Solids with Steeping Time

Soursop : Stevia Ratio	Brewing Time	Average (Mean \pm SD)
75% : 25%	3 minutes	3.24 ^a \pm 0.01
75% : 25%	5 minutes	3.32 ^{ab} \pm 0.08
75% : 25%	7 minutes	3.42 ^b \pm 0.10
50% : 50%	3 minutes	3.45 ^b \pm 0.13
50% : 50%	5 minutes	3.55 ^b \pm 0.32
50% : 50%	7 minutes	3.50 ^b \pm 0.10
25% : 75%	3 minutes	3.73 ^c \pm 0.12
25% : 75%	5 minutes	3.74 ^c \pm 0.06
25% : 75%	7 minutes	3.86 ^c \pm 0.05

Note: Different letter notations for the average results of 3 repetitions indicate a significant difference at the 0.05 significance level.

2. Moisture Content

Moisture content is an important quality parameter for herbal tea as it affects product stability and shelf life (Fikriyah, 2021). One-way ANOVA results showed that soursop-stevia leaf ratios significantly affected herbal

tea bag moisture content ($p < 0.05$), with the lowest value at 75% soursop : 25% stevia ratio (7.10%) and highest at 25% soursop : 75% stevia ratio (7.33%). The moisture increase with higher soursop proportion is likely related to thicker leaf tissue structure and higher water binding capacity (Nasir, 2020). All treatments had moisture content below the maximum SNI 01-3836-2000 limit (8.00%), so the herbal tea bag product meets quality standards and is suitable for storage, consistent with (Siagian, 2020) and (Rahmayanti., 2022)

Table 4. Data on Testing the Combination of Soursop Leaves and Stevia on Moisture Content

Soursop : Stevia Ratio	Average (Mean \pm SD)
75% : 25%	7.10 \pm 0.02 ^a
50% : 50%	7.22 \pm 0.03 ^b
25% : 75%	7.33 \pm 0.08 ^c

Note: Different letter notations for the average results of 3 repetitions indicate a significant difference at the 0.05 significance level.

3. pH

pH value is an important parameter affecting herbal tea product stability and safety (Latief, 2024); (Desy, 2020). Two-way ANOVA analysis showed that soursop-stevia leaf ratios, brewing time, and their interaction had no significant effect on herbal tea infusion pH ($p > 0.05$). All treatment pH values ranged from 6.65–6.82, indicating slightly acidic to near-neutral characteristics. This pH stability indicates that bioactive compounds extracted from soursop and stevia leaves are relatively resistant to brewing time variations and do not produce significant acidic compounds, consistent with findings from (Ibrahim, 2015) and (Safitri E.R., 2018). This pH range remains within safe limits for herbal beverage consumption (Hedyana, 2021), so soursop-stevia combination has potential to produce functional tea bags with good chemical stability without acidity increase risk during brewing.

Table 5. Data on the Testing of Soursop Leaf and Stevia Combination on pH with Soaking Duration

Soursop : Stevia Ratio	Brewing Time	Average (Mean \pm SD)
75% : 25%	3 minutes	6.65 \pm 0.07 ^a
75% : 25%	5 minutes	6.67 \pm 0.19 ^b
75% : 25%	7 minutes	6.67 \pm 0.07 ^b
50% : 50%	3 minutes	6.66 \pm 0.05 ^{ab}
50% : 50%	5 minutes	6.89 \pm 0.08 ^c
50% : 50%	7 minutes	6.77 \pm 0.20 ^f
25% : 75%	3 minutes	6.80 \pm 0.07 ^c
25% : 75%	5 minutes	6.78 \pm 0.19 ^{ef}
25% : 75%	7 minutes	6.82 \pm 0.04 ^{fg}

4. Color Intensity

Color intensity serves as an important visual indicator reflecting the purity level and strength of color

in herbal tea infusions (Widiantoro, 2008). Two-way ANOVA results showed that soursop-stevia leaf ratios had a highly significant effect on color intensity ($p < 0.05$), while brewing time showed an increasing trend without significant interaction effects. Herbal tea infusion color intensity values ranged from 65.40–67.56%, with the highest value obtained at 25% soursop : 75% stevia ratio, indicating brighter and more vibrant color. This color intensity increase is likely related to high chromophore compound content, particularly flavonoid glycosides and steviosides in stevia leaves, which contribute to yellow to yellowish-red color formation (Desy, 2020); (Fadilah, 2023). All color intensity values remain within the dry tea color quality standards according to SNI 01-3836-2013, so the soursop-stevia combination has potential to produce herbal tea bags with stable and consumer-acceptable visual characteristics.

Table 6. Testing Data on the Effect of Soursop Leaf and Stevia Ratio on Color Intensity with Steeping Duration

Soursop : Stevia Ratio	Brewing Time	Average (Mean \pm SD)
75%:25%	3 min	65.40 \pm 0.39 ^a
75%:25%	5 min	65.44 \pm 0.18 ^a
50%:50%	3 min	65.64 \pm 0.35 ^b
75%:25%	7 min	65.93 \pm 0.05 ^c
25%:75%	3 min	66.50 \pm 0.25 ^d
50%:50%	5 min	66.74 \pm 0.15 ^e
		66.74 \pm 0.15 ^e
50%:50%	7 min	67.54 \pm 0.18 ^f
25%:75%	5 min	67.54 \pm 0.37 ^f
25%:75%	7 min	67.56 \pm 0.32

5. Total Phenol

Total phenol was determined to estimate the antioxidant activity potential of herbal tea, as phenolic compounds can donate hydrogen atoms to neutralize free radicals (Miguel, 2017). Two-way ANOVA results showed that soursop:stevia leaf ratios, brewing time, and their interaction had highly significant effects ($p < 0.01$) on total phenol content. Total phenol values increased with higher stevia proportions and longer brewing times, ranging from 25.85–49.36 mg GAE/g, with the highest value at 25% soursop : 75% stevia ratio with 7 minutes brewing. This increase is likely due to optimal extraction of phenolic compounds from stevia and soursop leaves at higher stevia proportions and longer water contact time.

Table 7. Data on the Testing of Soursop Leaf and Stevia Combination on Total Phenol with Steeping Duration

Soursop : Stevia Ratio	Brewing Time	Average (Mean ± SD)
75%:25%	3 min	25.85 ^a ± 0.60
75%:25%	5 min	30.83 ^b ± 0.06
50%:50%	3 min	33.66 ^c ± 0.27
75%:25%	7 min	35.46 ^d ± 0.12
25%:75%	3 min	36.89 ^e ± 0.53
50%:50%	5 min	37.46 ^f ± 0.39
50%:50%	7 min	41.69 ^g ± 0.91
25%:75%	5 min	44.34 ^h ± 0.22
25%:75%	7 min	49.36 ⁱ ± 0.22

6. Antioxidant Activity

Herbal tea infusion antioxidant activity was determined based on DPPH IC₅₀ values, where lower IC₅₀ indicates higher antioxidant activity. Two-way ANOVA showed soursop:stevia ratios, brewing time, and their interaction had highly significant effects on antioxidant activity (p < 0.01). IC₅₀ values ranged from 42.33–68.74 ppm, with highest antioxidant activity at 25% soursop : 75% stevia ratio with 5 minutes brewing, and lowest at 75% soursop : 25% stevia with 3 minutes brewing.

Table 8. Data on the Testing of Soursop Leaf and Stevia Combination on Antioxidant Activity with Steeping Time

Soursop : Stevia Ratio	Brewing Time	Average (Mean ± SD)
75% : 25%	3 minutes	68.74 ^h ± 1.13
75% : 25%	5 minutes	56.25 ^g ± 4.89
75% : 25%	7 minutes	50.53 ^e ± 0.32
50% : 50%	3 minutes	55.65 ^f ± 0.54
50% : 50%	5 minutes	46.65 ^c ± 0.75
50% : 50%	7 minutes	43.73 ^b ± 0.59
25% : 75%	3 minutes	46.53 ^c ± 2.80
25% : 75%	5 minutes	42.33 ^a ± 0.45
25% : 75%	7 minutes	48.90 ^d ± 0.16

7. Organoleptic Evaluation

Organoleptic evaluation is a common method for assessing food product quality due to its accuracy (Dahlan, 2024). Preference testing using scoring technique was conducted by 100 panelists on three samples based on color, aroma, viscosity, taste, and overall acceptance parameters

8. Color

The longer the drying process is carried out, the darker the color intensity of the tea becomes. This is caused by the degradation of natural pigments, such as chlorophyll, due to excessive heat exposure during drying (Yamin, 2017). Two-way ANOVA showed

soursop-stevia ratios significantly affected color preference (p < 0.05), while brewing time and interaction had no significant effect. Hedonic color scores ranged 4.67–5.00, with highest preference at 25% soursop : 75% stevia ratio.

9. Aroma

Aroma is a sensory parameter evaluated using the sense of smell (Dahlan, 2024); (Maharani, 2021) . Two-way ANOVA showed ratios significantly affected aroma preference (p < 0.05), while brewing time had no effect. Hedonic aroma scores (neutral category 4.42–4.58) were highest at 25% soursop : 75% stevia.

10. Taste

Taste is a sensation received through taste buds influenced by smell interaction (Dilasari, 2022); (Drummond, 2010). Two-way ANOVA showed no significant effects on taste preference (p > 0.05). Higher stevia proportions yielded sweeter, more balanced taste.

11. Overall Acceptance

Overall acceptance reflects panelist perception integration of color, aroma, and taste. Ratios and brewing time significantly affected acceptance (p < 0.05). Highest scores (4.55–4.80, neutral) at 25% soursop : 75% stevia.

12. Heavy Metal Contamination

Heavy metal analysis used ICP-OES after acid digestion. All metals (As, Cd, Hg, Pb, Sn) below SNI 01-3836-2013 limits; Hg not detected.

Table 9. Heavy Metal Content in Herbal Tea from Soursop Leaves and Stevia Based on Mixing Ratios

Metal Type	75% : 25% (mg/kg)	50% : 50% (mg/kg)	25% : 75% (mg/kg)	SNI 01-3836-2013 Limit (mg/kg)
Arsenic (As)	0.1352	0.1807	0.1652	Max. 40
Cadmium (Cd)	0.01117	0.0547	0.1132	Max. 0.2
Mercury (Hg)	<0.0001	<0.0001	<0.0001	Max. 0.0378
Lead (Pb)	0.3227	0.4021	0.5360	Max. 2.0
Tin (Sn)	0.2479	0.3926	0.5405	Max. 40.

13. Toxicity Test Using the Brine Shrimp Lethality Test (BSLT) Method

Toxicity Test This study uses 48-hour-old *Artemia salina* Leach shrimp larvae as test animals. The selection of this larval age is because the larvae have fully formed digestive systems, making them sensitive to any substance introduced (Wulandari, 2014). The principle

of the Brine Shrimp Lethality Test (BSLT) is to evaluate the toxic effects of an extract on *Artemia* shrimp larvae. An extract is said to have a toxic effect if its LC₅₀ value is less than 100 ppm; conversely, if LC₅₀ ≥ 100 ppm, the extract is considered non-toxic. In general, there is an increase in the percentage of larval mortality as the concentration of the extract increases. The higher the concentration, the higher the mortality rate of *Artemia salina* Leach larvae, which means the toxicity of the sample is greater (more toxic) (Muaja, 2013.)

Table 10. Toxicity test data

Concentration (ppm)	Test Larvae	Dead Larvae	% Mortality
0	30	2	6.67%
20	30	4	13.33%
40	30	3	10.00%
60	30	4	13.33%
80	30	4	13.33%
100	30	11	36.67%

13. Antidiabetic Effectiveness Test

Tested on alloxan-induced male white mice (>200 mg/dL blood glucose). Treatments given for 7 days showed significant glucose reduction, especially highest dose (5.6 mg/20g BW) approaching normal levels.

Table 11. average glucose levels (mg/dL) in each treatment group

Group	T0	T1	Day 1	Day 3	Day 5	Day 7
K1 (Na-CMC)	136±5.66 ^b	210.5±3.54 ^b	209.2±2.59 ^c	206±1.92 ^c	206±0.71 ^c	206.1±0.55 ^d
K2 (Glibenclamide)	150.5±0.71 ^c	223.5±0.71 ^c	201±0.71 ^b	190±1.58 ^b	172.4±1.58 ^c	115±0.71 ^b
K3 (2.8 mg/20g)	124.5±0.71 ^a	202.5±0.71 ^a	201.6±1.58 ^b	187±1.58 ^b	180.4±1.58 ^d	139±0.71 ^c
K4 (4.2 mg/20g)	124.5±0.71 ^a	204.5±0.71 ^{ab}	199.6±1.58 ^b	178±1.92 ^a	134.2±1.92 ^b	124±0.71 ^b
K5 (5.6 mg/20g)	157.5±0.71 ^d	203.5±0.71 ^a	200±0.71 ^b	160±1.58 ^a	120.2±1.58 ^a	98±0.71 ^a

Conclusion

The combination of soursop leaves and stevia leaves affects the physical, chemical, sensory characteristics, and biological activity of herbal tea. The best treatment was obtained at 25% soursop : 75% stevia ratio with seven minutes brewing time, which produced the highest antioxidant activity, total phenol content, color intensity, and panelist acceptance. The ratio of leaves and steeping time shows that a 25% soursop leaf to 75% stevia ratio with a seven-minute steeping time yields optimal results in antioxidant activity, total phenols, color intensity, and panelist acceptance. An excessively long steeping time can decrease panelist preference due to bitterness and overly intense color. The interaction between the leaf ratio and steeping time is significant for antioxidant activity, total phenols, color, and aroma, but not significant for pH, total dissolved solids, taste, and overall acceptance.

The characteristics of the raw materials, soursop leaves and stevia, are stable and of good quality. The infusion color tends to be yellowish-red with increasing intensity as the proportion of stevia leaves and steeping time increase. The aroma remains characteristic of soursop leaves, while the sweetness is more pronounced with a higher proportion of stevia, affecting the panelists' acceptance of the herbal tea.

Heavy metal contamination analysis shows that the levels of arsenic, cadmium, mercury, lead, and tin are still far below the maximum threshold of SNI 01-3836-2013, making herbal tea safe for consumption. The leaf ratio does not significantly affect the heavy metal

content. The results of the Brine Shrimp Lethality Test (BSLT) toxicity test showed an LC₅₀ value of around 562 ppm, which means the extract has low toxicity and is safe to use for antidiabetic testing.

The antidiabetic effectiveness test on mice showed that herbal tea extract was able to significantly lower blood glucose levels compared to the negative control, with a more pronounced decrease at higher doses. The combination of soursop leaves and stevia provides optimal effects on glucose levels, infusion taste, and panelist acceptance.

Acknowledgments

Thanks to all parties who have supported the implementation of this research.

Author Contributions

The authors listed in this article, have read and agree to the published version of the manuscript.

Funding

This research received no external funding”

Conflicts of Interest

The authors declare no conflict of interest

References

Ali, A. S. (2022). Antioxidation and Antiglycation Properties of a Natural Sweetener: Stevia rebaudiana. . *Sugar Tech*, 24(2), 563-575. <https://doi.org/10.1007/s12355-021-01023-0>.

- Dahlan, S. A. (2024). Physicochemical Characteristics in the Production of Gumitir Flower Tea. *In Proceedings of the National Seminar on Student Mini Research* E-ISSN: 2964-0202 Vol. 3 (1).
- Desy, I. S. (2020). Physical, Chemical, and Organoleptic Characteristics of Fig Leaf Tea Bags with Stevia Leaf (*Stevia rebaudiana* B.) Addition as Sweetener. *Jurnal Teknologi Pangan*, 4(1), 23-29. <https://doi.org/10.14710/jtp.2020.23875>.
- Dilasari, E. M. (2022). "The Influence of Taste and Promotion Thru Social Media on Consumer Purchase Decisions of Janji Jiwa Coffee Bandar Lampung". *Revenue: Journal of Islamic Business Management*, 25-42. Volume 1, No 1(2020) Doi : 10.24042/revenue.v3i1.10448
- Drummond, K. E. (2010). *Nutrition for Foodservice and Foodservice and Culinary Professional's Seventh Edition*. John Wiley & Sons, Inc.
- Fadilah, R. N. (2023). . Effect of Dayak Onion Extract (*Eleutherine palmifolia* (L.) Merr) Fortification on Synbiotic Yoghurt Quality in Terms of Viscosity, Total Lactic Acid Bacteria, Color, and Sensory Quality. *Universitas Brawijaya, Malang. Asian Food Science Journal* 22 (2):9-18. <https://doi.org/10.9734/afsj/2023/v22i2617>.
- Fikriyah, Y. U. (2021). Analysis of Moisture and Ash Content in Marketed Black Tea Using Gravimetric Method. *Amina*, 3(2), 50-54. <https://journal.arraniry.ac.id/index.php/amina/issue/view/146>.<https://doi.org/10.22373/amina.v3i2.2000>
- Harto, Y. Y. (2016). Physical, Chemical, and Organoleptic Characteristics of Sapodilla Jam (*Achras zapota* L.) with Pectin and Sucrose Addition. *Jurnal Agroindustri*, 6(2), 88-100. ISSN 2088-5369.
- Hedyana, V. W. (2021). Effect of Stevia Leaf Powder and Green Grass Jelly Leaf Pectin Addition on Physical, Chemical, and Organoleptic Properties of Red Dragon Fruit Jam. *Food Technology and Halal Science Journal*, 4(1), 66-81. <https://doi.org/10.22219/fths.v4i1.15636>.
- Ibrahim, A. M. (2015). Effect of Extraction Temperature and Time on Chemical and Physical Properties of Red Ginger Juice Drink with Honey Addition as Sweetener. *Jurnal Pangan dan Agroindustri*, 3(2), 530-541.
- Ismawati, N. N. (2017). pH Value, Total Soluble Solids, and Sensory Properties of Yoghurt with Beet Extract (*Beta vulgaris* L.) Addition. *Jurnal Aplikasi Teknologi Pangan*, 5(3), 89-93. <https://doi.org/10.17728/jatp.181>
- Jamal, S. B. (2024). Phytochemical screening and antihyperglycemic effects of Stevia rebaudiana leaves extract on glucose loaded rats. *Oriental Journal of Chemistry*, 40(1), 74-81. <https://doi.org/10.13005/ojc/400109>.
- Jan, S. A. (2021). The anti-diabetic activities of natural sweetener plant Stevia: an updated review. *SN Applied Sciences*, 3(4), 1-6. <https://doi.org/10.1007/s42452-021-04519-2>.
- Kamaluddin, I. D. (2024). Comparative Analysis of Antioxidants in Moringa Leaves and Soursop Leaves. *Jurnal Biologi Tropis*, 24(2), 81-88. <https://doi.org/10.29303/jbt.v24i2.6760>
- Kurniasih, E. A. (2019). *Socialization of Free Radical Dangers and Natural Antioxidant Functions for Health*.*JurnalVokasi*,3(1),1.<http://dx.doi.org/10.30811/vokasi.v3i1.960>
- Latief, M. A. (2024). Characteristics of Herbal Tea Bags from Gotu Kola Leaf Powder (*Centella asiatica* L.) Mixed with Secang Wood Powder (*Caesalpinia sappan* L.) as Functional Drink. *Universitas Andalas, Padang*. <http://scholar.unand.ac.id/id/eprint/461533>
- Lingga, L. (2014). *Lingga, Lanny. (2014). The Healing Power Of Antioxidant*. Elex Media Komputindo. ISBN: 6020030830
- Maharani, S. M. (2021). The Effect of Brewing Time on pH values, Polyphenols Content and Antioxidant of Coffee Husk Tea. *Journal of Physics: Conference Series*, 1869(1).<https://doi.org/10.1088/1742-6596/1869/1/012050>.
- Miguel, C. R. (2017). Phenolic Antioxidant Capacity: A Review of the State of the Art. London. DOI: 10.5772/66897
- Muaja, A. H. (2013). Toxicity Test using the BSLT Method and Phytochemical Content Analysis of Soyogik Leaf Extract using the Soxhlet Method. *Jurnal MIPA* <https://doi.org/10.35799/jm.2.2.2013.3000>.
- Nasir, A. S. (2020). Utilization of Dragon Fruit Peel (*Hylocereus polyrhizus*) as Raw Material for Herbal Tea Bags with Cinnamon Wood (*Cinnamomum burmannii* L.) Addition. *Jurnal Sains dan Aplikasi*, 8(1), 1-14. <https://doi.org/10.32672/jss.v8i1.2038>
- Nicola, F. (2015). Relationship between Conductivity, TDS (Total Dissolved Solid) and TSS (Total Suspended Solid) with Fe²⁺ and Total Fe Content in Dug Well Water. *Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Jember, East Java*, p7.
- Rahmayanti, d. (2022). Utilization of Soursop Leaf Tea (*Annona muricata* L.) on Total Cholesterol, Triglycerides, and Blood Glucose Levels in Patients with Diabetes Mellitus and Hypertension. *Scientific Journal of Health Analysis Vol. 8 No 2 p-ISSN.2088-5687 e ISSN: 2745-6099*.

- Rumiyanti, L. R. (2019). Phytochemical Screening of Soursop Leaf Extract (*Annona muricata*) and Its Effect on ST 37 Carbon Steel Corrosion Rate. *Jurnal Teori dan Aplikasi Fisika*, 7(1), 1. <https://doi.org/10.23960/jtaf.v7i1.1917>
- Safitri E.R., R. d. (2018). Phytochemical Screening and Antioxidant Activity Test of Chinese Senna Flower Extract (*Senna alata* (L.) Roxb) using the DPPH Method. *Journal of Pharmaceutical Care and Science*, Vol 1 (1) :10-18. <https://doi.org/10.33859/jpcs.v1i1>
- Shibula, K. &. (2015). Determination of phytochemicals in methanolic extract of *Annona muricata* leaf using GC-MS technique. *International Journal of Pharmacognosy and Phytochemical Research*, 7(6), 1251-1255.
- Siagian, I. D. (2020). Physical, chemical, and organoleptic characteristics of fig leaf tea bags with stevia leaf (*Stevia rebaudiana* Bertoni) addition as sweetener. *Jurnal Teknologi Pangan*, 4(1), 24-29. <https://doi.org/10.14710/jtp.2020.23875>
- Sulastri, L. S. (2022). Antidiabetic Formulation Development Based on Natural Materials as α -Glucosidase Enzyme Inhibitor. *Journal of Hunan University (Natural Sciences)*, 49(1). <https://doi.org/10.55463/issn.1674-2974.49.1.29>
- Terauchi, Y. I. (2023). Impact of glycated hemoglobin on 2-year clinical outcomes in elderly patients with atrial fibrillation: sub-analysis of ANAFIE Registry, a large observational study. 1-10. <https://doi.org/10.1186/s12933-023-01915-3>
- Wulandari, F. (2014). Acute Toxicity Test of Methanol Extract of Crown of God Leaves on *Artemia Salina* Leach Larvae Using the Brine Shrimp Lethality Test (BSLT) Method. *UIN Syarif Hidayatullah, Jakarta*.
- Yahaya Gavamukulya, F. A.-E. (2014). "Phytochemical screening, anti-oxidant activity and in vitro anticancer potential of ethanolic and water leaves extract of *Annona Muricata* (Graviola). *Asian PAc J Trop Med*, vol 7, pp S355 S363. [https://doi.org/10.1016/s1995-7645\(14\)60258-3](https://doi.org/10.1016/s1995-7645(14)60258-3)
- Yamin, M. D. (2017). Drying duration on the Antioxidant Activity and Quality of Chinese Senna Herbal Tea. *Jurnal Faperta* 4(2):1-15.
- Yuslianti, E. R. (2018). *Introduction to Free Radicals and Antioxidants*. . Yogyakarta.: Deepublish Publisher.