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STABILITY OF MONK FRUIT SWEETENER SIAMENOSIDE I UNDER ACIDIC AND THERMAL CONDITIONS AND ITS DEGRADATION PRODUCTS

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ABSTRACT: This study evaluated the stability of siamenoside I, a minor sweet component of *Siraitia grosvenorii* (Monk Fruit), under pH and temperature conditions representative of commercial beverage storage, as well as under photostability conditions. Mock beverage solutions, formulated to ~500 mg/L siamenoside I, were prepared at four pH values (2.8-4.2)) and stored at temperatures of 5°C-40°C for 26 weeks and degradation products were quantified at scheduled intervals. Under all conditions, siamenoside I exhibited high stability. Six known degradation products/impurities (compounds 3,6,7,8,9 and 14) were detected at levels ≥0.500 mg/L (≥0.100% of the starting concentration). Photostability testing indicated minimal degradation under fluorescent light exposure. No changes in appearance were observed; all samples remained colorless and clear. Siamenoside I in mock beverages demonstrated chemical stability under conditions simulating both typical and extreme commercial beverage storage and handling, including light exposure, supporting their suitability for use in acidic, ready-to-drink formulations.

INTRODUCTION: Natural plant-derived sweeteners are increasingly valued as alternatives to artificial sweeteners and refined sugars[1]. Mogrosides, cucurbitane type triterpene glycosides from *Siraitia grosvenorii* (monk fruit), are notable for their intense sweetness up to 300 times that of sucrose and negligible caloric content, making them attractive for food and beverage applications [2-7]. While mogroside V is well studied[8-10], Siamenoside I, regarded as one of the best-tasting mogrosides[11], remains less explored. Monk fruit extracts have a long history in China as sweeteners and in traditional medicine[4,12-17], yet their commercial adoption faces challenges related to complex purification, production cost, and uncertain stability in formulated products[18].

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Data on the pH and thermal stability of Siamenoside I are limited, despite their importance for ready-to-drink beverages, where acidic environments, elevated temperatures, and light exposure may occur during processing and storage. Degradation under such conditions could compromise flavor, reduce bioactivity, and shorten shelf life[18-19].

This study addresses this gap by evaluating the stability of Siamenoside I in acidic carbonated mock beverage solutions representative of common soft drink formulations cola (pH 2.8 and 3.2), lemon–lime (pH 3.8), and root beer (pH 4.2) without flavor components over 26 weeks and temperatures (5°C–40°C), with additional photostability testing.

Mass balance profiles for Siamenoside I and its major degradation products were determined, providing insights into its suitability for long-term storage in commercial acidic beverage formulations.

MATERIALS AND METHODS:

Reagents and Chemicals: Glacial acetic acid was obtained from EMD (Gibbstown, NJ) and ammonium acetate was from Fluka (a part of Sigma- Aldrich, Bellefonte, PA) both of which were reagent grade. The acetonitrile, HPLC grade, was purchased from Burdick & Jackson (Muskegon, MI). Water was purified using a Millipore system (Billerica, MA).

Reference Standards and Materials: The reference standards mogroside V, siamenoside I and 11-oxomogroside V were obtained from Chromadex (Irvine, California, USA). Additional reference material including mogroside III, mogroside IIIE, mogroside IIE, mogroside IIIA1, mogroside IIA1, mogroside IIA, mogroside IE, Mogroside IA, 11-oxomogrosisde IV, 11-oxosiamenoside I, 7-oxosiamenoside I and mogroside IV were also purchased from Chromadex. Additionally, isomogroside V and mogrol were sourced from Chengdu Biopurify Phytochemicals Ltd.

The ingredient used in this study was an approximately 96% w/w (anhydrous basis) siamenoside I (4) mixture containing compounds 1 (mogroside V), 2 (mogroside III A1), 10 (11-oxomogroside IVA), 5 (isomogroside V), 12 (11-oxosiamenoside I), 11 (7-oxosiamenoside I) and 13 (7-hydroxysiamenoside I) **Fig. 1.** These process related impurities stem from the hydrolysis of mogroside V, a bioconversion process involving enzymatic modification followed by separation and purification processes[20]. Siamenoside I is highly soluble in water (soluble at 50%w/w up to 3 hours at room temperature, 7.5% w/w concentration >15 days at room temperature) and makes it more suitable for use in food and beverage applications.

Instruments: The assay and impurity methods were performed on an Agilent (Wilmington, DE) 1200 HPLC, with a gradient pump, a temperature-controlled auto sampler and a UV detector capable of background correction, and CAD (ESA, Inc. Chelmsford, MA). For Karl Fischer moisture analysis, titration was performed using a Metrohm 784 KFP Titrino titrator.

Standard and Retention Time Marker Solutions Preparations: Each reference standard was placed in an open dish and allowed to equilibrate for at least an hour before moisture determination and standard preparation. This was necessary each time because of the hygroscopic nature and the fact that these compounds easily gain or lose moisture with changes in humidity. The concentrations were corrected for moisture (determined from KF), residual solvent and purity according to the certificate of analysis. Working standards of concentrations 0.5mg/L, 1mg/L, 10mg/L, 25mg/L, 50mg/L and 100mg/L were used for quantitation, and a retention time marker solution of 16mg/L was used to identify peaks in sample solutions.

HPLC Conditions: The mock beverage samples were degassed prior to analysis, if appropriate. Analytes were chromatographed using reversed phase chromatography with 215nm UV detection, with a reference wavelength of 600nm. Additionally, a CAD with nitrogen pressure of 35psi was leveraged for the identification and quantitation of impurities. Separation of the analytes was achieved using a gradient method consisting of 0.0284% ammonium acetate and 0.0116% acetic acid on channel A versus 100% Acetonitrile on channel B, **Table 1.** The Orochem, Orosil c18, 3 µm, 250 mm x 4.6 mm dimension column set to temperature of 60ºC was used for the analysis. Furthermore, the flow rate was set to 0.8mL/min with an injection volume of 50uL. The calibration standards (siamenoside I, mogroside V, and 11-oxomogroside V) were injected once at the beginning of the assay sequence. Check standards and the retention time marker solution were injected at regular intervals throughout the run, bracketing 2 independent samples per condition injected once. Data was considered suitable if five or more replicates of standard injections had an RSD ≤ 5% and check standards were within ±10% of theoretical concentration.

TABLE 1: RP-HPLC GRADIENT CONDITIONS FOR MOGROSIDES METHOD

Time (min)	% A	% B	Flow (ml/min)	C
0	75	25	0.8	Initial
4	75	25	0.8	Hold
20	69	31	0.8	Linear

35	25	75	0.8	Linear
38	25	75	0.8	Hold
38.1	75	25	0.8	Hold
43.0	75	25	0.8	Hold

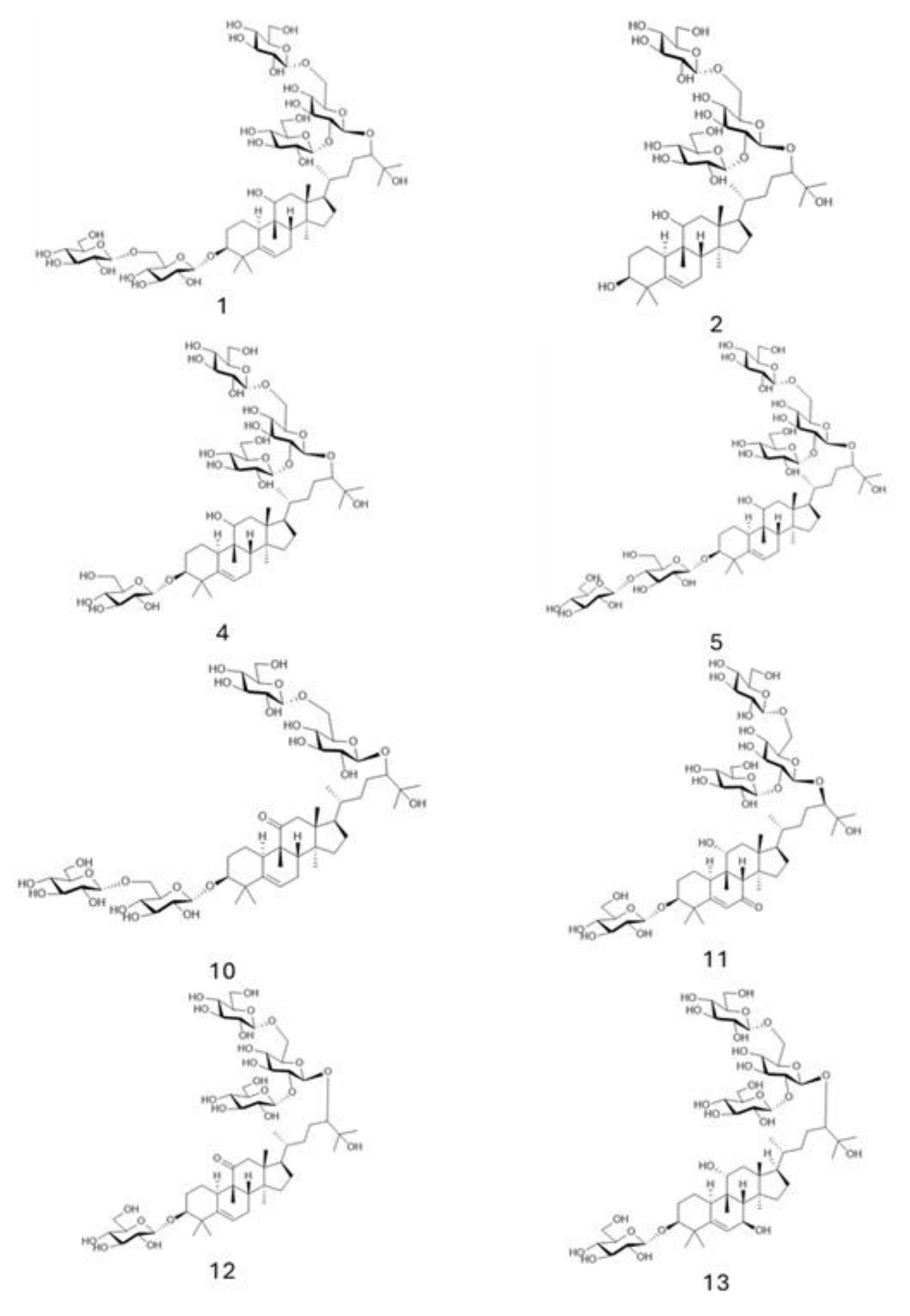

FIG. 1: STRUCTURE OF THE COMPOUNDS PRESENT IN THE INITIAL SIAMENOSIDE I MIXTURE. (Compounds: 1 (mogroside V), 2 (mogroside III A1), 4 (siamenoside I), 5 (isomogroside V) 10 (11-oxomogroside IVA) 11 (7-oxosiamenoside I) 12 (11-oxosiamenoside I),) and 13 (7-hydroxysiamenoside I).

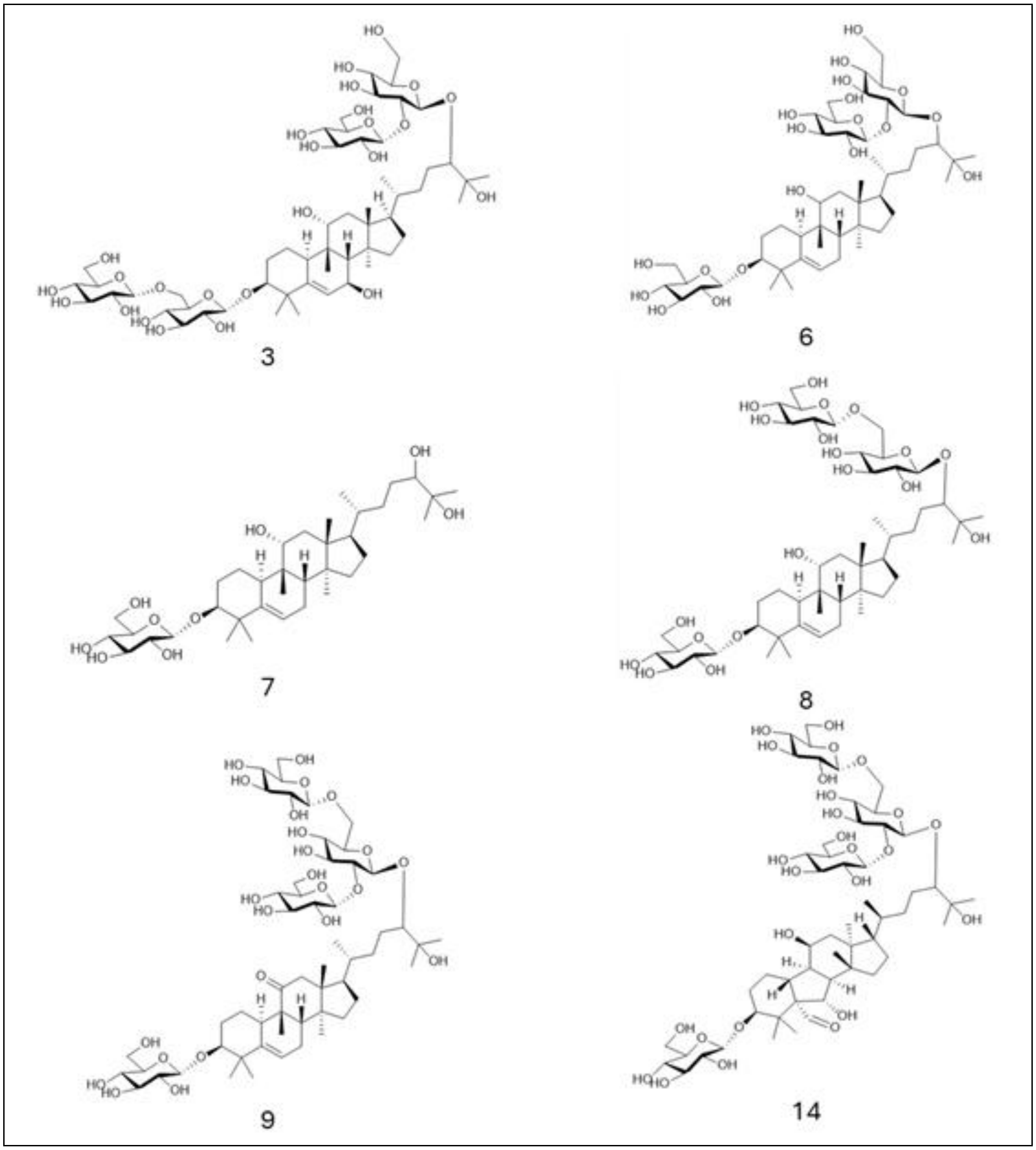

FIG. 2: STRUCTURE OF THE DEGRADATION PRODUCTS FORMED DURING THE STORAGE PERIOD OF 26 WEEKS. Compounds: 3 (mogroside IV), 6 (mogroside IIIE), 7 (mogroside IEI), 8 (mogroside III), 9 (unknown) and 14 (unknown).

Preparation of Mock Beverage Samples, Carbonation and Bottling: Bottles of mock beverages containing deionized water, potassium benzoate, tri-sodium citrate (dihydrate), potassium chloride, sodium chloride, magnesium chloride, and calcium sulfate (anhydrous) were prepared at pH 2.8 and 3.2 using phosphoric acid. Mock beverages at 3.8 and 4.2 were prepared utilizing citric acid anhydrous in place of phosphoric acid. All the reagents used are of reagent grade and were purchased from Fisher Scientific (Pittsburgh, PA). Eight different formulations representing 2 products (one with siamenoside I at a concentration of about 500 mg/L and the other one without siamenoside I) at each pH 2.8, 3.2, 3.8 and 4.2 were prepared. The formulations of mock beverages with and without siamenoside I are shown **Table 2.**

TABLE 2: PREPARATION SUMMARY OF MOCK BEVERAGE FORMULATIONS

Ingredients	**Concentrations (g/kg) at Different pH**			
Without Siamenoside I	**pH 2.8**	**pH 3.2**	**pH 3.8**	**pH 4.2**
Deionized Water	997.747	998.528	997.829	998.346

Potassium Benzoate	0.501	0.501	0.501	0.501
Phosphoric Acid (75%)	1.188	0.659	NA	NA
Citric Acid Anhydrous	NA	NA	1.002	0.551
Tri-Sodium Citrate Dihydrate	0.325	0.124	0.447	0.386
Potassium Chloride	0.015	0.015	0.015	0.015
Sodium Chloride	0.020	0.020	0.020	0.020
Magnesium Chloride	0.087	0.087	0.087	0.087
Calcium Sulfate Anhydrous	0.090	0.090	0.090	0.090
With Siamenoside I	**pH 2.8**	**pH 3.2**	**pH 3.8**	**pH 4.2**
Deionized Water	997.274	998.002	997.342	997.859
Potassium Benzoate	0.501	0.501	0.501	0.501
Phosphoric Acid (75%)	1.188	0.659	NA	NA
Citric Acid Anhydrous	NA	NA	1.002	0.551
Tri-Sodium Citrate Dihydrate	0.325	0.124	0.447	0.386
Potassium Chloride	0.015	0.015	0.015	0.015
Sodium Chloride	0.020	0.020	0.020	0.020
Magnesium Chloride	0.087	0.087	0.087	0.087
Calcium Sulfate Anhydrous	0.090	0.090	0.090	0.090
Siamenoside I	0.501	0.501	0.501	0.501

The products were prepared in a stainless-steel kettle with a propeller mixture. The deionized water, which was pre-chilled in a refrigerated room at 4–5°C, was weighed and added first to the mixing kettle. The dry ingredients, phosphoric acid, which were pre-weighed into separated containers, were added sequentially into the mixing kettle to obtain mock beverage samples. Each product was placed into a Zahm & Nagel carbonator unit. The air was purged from the tank by sparging the product with CO_2 and bleeding off the headspace gas. The carbonator tank was then sealed, placed into an ice water bath and pressurized with CO_2.

The product was carbonated by adjusting the temperature and CO_2 pressure to levels that corresponded to 3.8 + 0.2 volumes of carbonation. Carbonation level was tested using a Zahm DT piercing device. When the product met the desired carbonation range, the product was bottled, sealed with a crimpon crown closures, and then placed into refrigerated storage. All the products were stored refrigerated in a desiccator at 5 ± 3°C. The stability of siamenoside I was evaluated in mock beverage solutions lacking flavor components by simulating the above eight formulations at temperatures 5 ±3°C, 20 ± 2°C, 30± 2°C, and 40± 2°C. Two sets of mock beverages at each pH under four temperatures were prepared and analyzed in duplicate using the HPLC method as stated above for siamenoside I, their known impurities and degradation products, as well as unidentified compounds that are greater than or equal to 0.100% from the starting concentration of siamenoside I at scheduled intervals (0, 1, 2, 6, 12, 18 and 26 weeks) throughout the 26 weeks. All samples were treated identically during analysis to minimize assay bias.

Fluorescent of Light Storage: At the 0-week testing interval, two samples were exposed to fluorescent light, while another two samples were wrapped in foil to block light exposure and placed in a photostability chamber. The foil-covered samples served as controls. For light exposure, the sample was exposed to a cool white, fluorescent lamp designed to produce an output analogous to the ISO 10977(1993) specification and a near fluorescent lamp having a spectral distribution from 320 to 400 nm with a maximum energy emission between 350 to 370 nm. A significant proportion of UV should be in both bands of 320 to 360 nm and 360 to 400 nm.

RESULTS AND DISCUSSION: Impurities and degradation products were identified by matching the retention times of sample peaks in the HPLC chromatogram with those of a reference solution containing known mogrosides **Fig. 1** and **Fig. 2.** The stability profiles of the identified compounds are summarized in **Table 3–6**, expressed as concentrations (mg/L) over the 26-week study period. The primary analyte, siamenoside I (4), served as the stability reference and remained remarkably stable throughout the study, showing only a 2% decrease under the most severe conditions tested (pH 2.8, 40 °C; see **Fig. 3**). Although degradation was minimal, the data indicate that pH, temperature, and storage time influenced the formation of degradation products, with increased levels observed under prolonged storage and elevated temperatures across various pH levels.

For example, Compounds 3 (mogroside IV), 8 (mogroside III), and 7 (mogroside IEI) were formed predominantly at lower pH values and higher temperatures, each resulting from hydrolysis of the glucose saccharide at position C24 of siamenoside I. Another C24 hydrolysis product, Compound 6 (mogroside IIIE), was detected at all pH levels under elevated temperatures, suggesting a predominantly thermally driven mechanism. Compound 9, formed through oxidation at position C11, appeared mainly at higher pH values and increased with temperature; it was also one of only two degradation products generated under light-stress conditions **Table 7–8.** By contrast, Compound 14 was typically detected after four weeks of storage across all pH levels, with concentrations highest at elevated pH and temperature.

Although sensory properties of the degradation products were not evaluated in the present study, previous reports (Chen *et al*[16]) noted that mogroside III related compounds generally impart light sweetness and bitterness, while mogroside IEI has been described as predominantly bitter.

Regarding process-related impurities, compounds 1 (mogroside V) and 5 (isomogroside V) remained stable across all tested pH levels and temperatures. Consistent with a study by Zou[21], which reported no statistically significant change ($p < 0.05$) in model juice at pH 3.5 and pH 5.0 during storage at 4 °C for up to 90 days for mogroside V. Taken together, these findings indicate that mogroside V is highly stable under conditions representative of typical juice and carbonated soft drink formulations.

Compounds 10 (11-oxomogroside IV A) and 11 (7-oxosiamenoside I) generally increased at higher pH and temperature over time; Compound 11, produced by oxidation at position C7, was the major degradant identified in the light-stress study. Compound 12 (11-oxosiamenoside I) remained relatively stable under all conditions tested. Compound 2 (mogroside IIIA1) was found primarily at pH 2.8 and increased significantly at 40 °C over time, likely due to heat- and pH induced hydrolysis of the glucose saccharide at position C3 of siamenoside I. Finally, Compound 13 (7-hydroxysiamenoside I) increased over time at 5 °C and $\text{pH} \geq 2.8$, as well as above 30 °C and pH 3.8, but was generally unstable under other conditions.

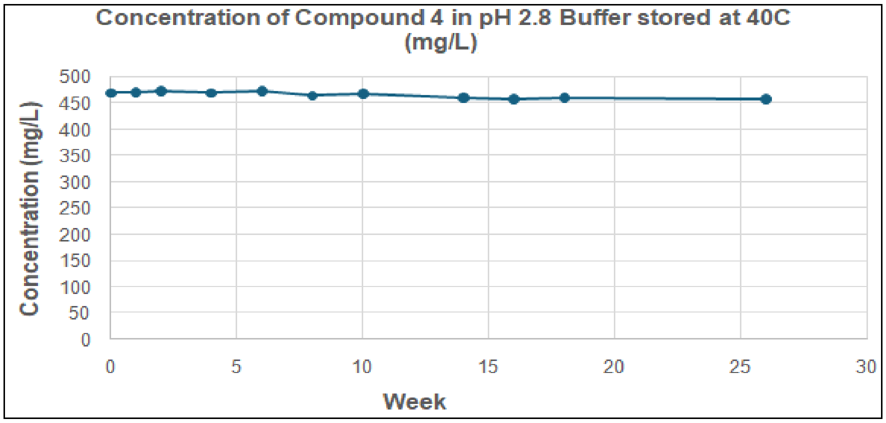

FIG. 3: CHANGE OF THE INITIAL CONCENTRATION OF SIAMENOSIDE I OVER 26 WEEKS (pH 2.8 AND 40°C)

TABLE 3: CONCENTRATION (MG/L) OF EACH ANALYTE IN MOCK BEVERAGE AT pH 2.8 UNDER VARIOUS TEMPERATURES

		Compounds													
Temperature	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
5°C	0	1.64	1.06	_	469	3.16	_	_	_	_	2.14	_	2.19	0.517	_
	1	1.69	_	_	473	3.28	_	_	_	_	2.14	_	2.1	0.532	_
	2	1.66	_	_	476	3.24	_	_	_	_	2.16	_	2.18	0.508	_
	4	1.67	_	_	475	3.22	_	_	_	_	2.24	_	2.07	0.56	2.31
	6	1.84	_	_	476	3.3	_	_	_	_	2.41	_	2.21	0.521	2.53

	8	1.59	_	_	471	3.04	_	_	_	_	2.19	_	2.3	0.536	2.51
	10	1.57	_	_	473	2.92	_	_	_	_	2.22	_	2.02	_	2.5
	14	1.47	_	_	468	2.79	_	_	_	_	2.2	_	2.08	0.653	2.5
	16	2.04	_	_	465	3.74	_	_	_	_	2.62	_	2.34	0.68	2.99
	18	1.88	_	_	468	3.38	_	_	_	_	2.91	_	2.24	0.563	2.69
	26	1.57	_	_	469	3.09	_	_	_	0.555	2.48	_	2.14	0.643	2.79
20°C	0	1.64	1.06	_	469	3.16	_	_	_	_	2.14	_	2.19	0.517	_
	1	1.67	0.96	_	470	3.2.	_	_	_	_	2.17	_	2.06	_	_
	2	1.67	1.07	_	473	3.15	_	_	_	_	2.21	_	2.18	_	_
	4	1.66	1.17	_	471	3.1	_	_	_	_	2.52	_	2.33	0.502	1.92
	6	1.77	1.7	_	472	3.4	_	_	_	_	2.2	_	2.1	_	1.75
	8	1.59	1.48	_	467	3.12	_	_	_	_	2.35	_	2.26	0.512	2.07
	10	1.57	1.29	_	467	2.96	_	_	_	_	2.38	0.502	2.02	_	1.95
	14	1.45	1.18	_	464	2.82	_	_	_	_	2.33	_	2.07	0.581	2.05
	16	2.03	1.39	_	462	3.78	_	_	_	_	3.2	0.671	2.59	0.512	2.31
	18	1.85	1.41	_	465	3.33	_	_	_	_	2.74	0.619	2.2	_	2.24
	26	1.59	_	_	465	3.12	_	_	_	_	2.23	0.608	2	_	2.17
30°C	0	1.64	1.06	_	469	3.16	_	_	_	_	2.14	_	2.19	0.517	_
	1	1.61	0.974	_	471	3.13	_	_	_	_	2.03	_	2.03	_	_
	2	1.67	1.19	_	476	3.16	_	_	_	_	2.41	_	2.24	_	_
	4	1.69	1.25	_	469	3.26	_	_	_	_	2.28	_	2.18	_	2.03
	6	1.59	1.39	_	466	2.98	_	_	_	_	2.22	_	2.12	_	1.78
	8	1.55	1.61	_	469	2.96	_	_	_	_	2.27	_	2.17	_	1.89
	10	1.52	1.68	_	468	2.87	_	_	_	_	2.26	_	2.01	_	1.86
	12	1.45	1.73	_	465	2.94	_	_	_	_	2.22	_	2.1	_	1.76
	14	2.09	2.37	_	460	3.66	_	_	0.825	_	2.33	0.615	2.35	_	2.07
	18	1.95	2.04	_	466	3.71	_	_	0.641	_	2.97	0.547	2.35	_	1.95
	26	1.53	0.8	_	464	3.03	_	_	0.747	_	2.25	0.538	2.02	_	1.84
40°C	0	1.64	1.06	_	469	3.16	_	_		_	2.14	_	2.19	0.517	_
	1	1.73	1.21	_	470	3.18	_	_		_	2.15	_	2.03	_	_
	2	1.63	1.54	_	472	3.17	_	_		_	2.4	_	2.13	_	_
	4	1.66	1.79	_	469	3.13	_	_	0.648	_	2.25	_	2.08	_	1.73
	6	1.77	2.72	_	473	3.4	_	_	1.05	_	2.45	_	2.21	_	1.48
	8	1.45	2.79	_	464	2.76	_	_	1.17	_	2.13	_	2.07	_	1.55
	10	1.55	3.28	_	467	2.99	_	_	1.38	_	2.28	_	2.03	_	1.37
	14	1.45	4.22	0.59	460	2.85	_	_	2.08	_	2.26	_	2.12	_	1.33
	16	1.97	4.15	0.774	457	3.65	0.504	0.573	2.65	_	2.53	_	2.34	_	1.51
	18	1.95	4.13	0.789	460	3.44	0.58	0.691	2.58	_	2.67	0.538	2.21	_	1.55
	26	1.61	3.82	0.875	458	3.09	0.59	0.8	3.22	_	2.08	0.554	1.91	_	1.23

Results are mean of two sample preparations.

TABLE 4: CONCENTRATION (MG/L) OF EACH ANALYTE IN MOCK BEVERAGE AT pH 3.2 UNDER VARIOUS TEMPERATURES

		Compounds												
Temperature	**Week**	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
5°C	0	1.64	_	_	470	3.12	_	_	_	2.09	0.508	2.17	0.479	_
	1	1.64	_	_	472	3.17	_	_	_	2.16	0.561	2.1	_	_
	2	1.69	_	_	473	3.18	_	_	_	2.11	_	2.18	_	_
	4	1.66	_	_	471	3.2	_	_	_	2.43	0.56	2.15	0.55	1.93
	6	1.76	_	_	477	3.36	_	_	_	2.23	0.668	2.16	_	1.78
	8	1.6	_	_	471	3.13	_	_	_	2.3	_	2.3	0.519	2.08
	10	1.51	_	_	469	2.95	_	_	_	2.3	_	2	_	1.85
	14	1.43	_	_	467	2.87	_	_	_	2.19	_	2.08	0.581	2.08
	16	2.07	_	_	463	3.97	_	_	_	3.34	0.616	2.42	0.636	2.28
	18	1.92	_	_	468	3.44	_	_	_	3.28	0.623	2.22	0.575	2.37
	26	1.56	_	_	467	3.11	_	_	_	2.37	0.559	1.99	0.542	2.35
			_	_										
20 °C	0	1.64	_	_	470	3.12	_	_	_	2.09	0.508	2.17	0.479	_
	1	1.67	_	_	474	3.19	_	_	_	2.1	0.575	2.08	_	_
	2	1.61	_	_	473	3.13	_	_	_	2.28	_	2.26	_	_
	4	1.66	_	_	473	3.12	_	_	_	2.35	0.52	2.1	0.525	2.01
	6	1.72	_	_	476	3.39	_	_	_	2.27	0.567	2.1	_	1.95
	8	1.65	_	_	472	3.13	_	_	_	2.35	_	2.32	_	2.14
	10	1.52	_	_	469	2.96	_	_	_	2.33	0.552	2.02	0.531	2.11
	14	1.48	_	_	466	2.84	_	_	_	2.18	0.573	2.06	0.55	2.09
	16	2.07	_	_	466	3.73	_	_	_	2.74	0.68	2.45	_	2.44
	18	1.86	_	_	468	3.42	_	_	0.523	2.73	0.759	2.24	_	2.3
	26	1.57	_	_	466	3.09	_	_	0.511	2.29	0.779	1.93	_	2.04
30°C	0	1.64	_	_	470	3.12	_	_	_	2.09	0.508	2.17	0.479	_
	1	1.68	_	_	473	3.19	_	_	_	2.1	0.648	2.04	0.573	_
	2	1.63	_	_	475	3.21	_	_	_	2.18	_	2.18	0.51	_
	4	1.65	_	_	472	3.11	_	_	_	2.55	_	2.08	0.587	2.14
	6	1.62	_	_	469	3.06	_	_	_	2.16	0.64	2.19	0.504	1.87
	8	1.48	_	_	469	2.82	_	_	_	1.97	_	2.1	_	1.92
	10	1.52	_	_	470	2.87	0.955	_	_	2.07	0.527	1.95	_	1.98

	14	1.46	_	_	468	2.95	_	_	0.527	2.25	_	2.17	_	2.19
	16	2.03	_	_	464	3.67	_	_	_	2.88	0.608	2.4	_	2.32
	18	1.93	0.539	_	468	3.9	_	_	_	2.62	0.595	2.4	_	2.47
	26	1.57	0.547	_	467	3.03	_	_	_	2.33	0.621	2.02	_	2.36
40°C	0	1.64	_	_	470	3.12	_	_	_	2.09	0.508	2.17	0.479	_
	1	1.65	_	_	471	3.15	_	_	_	2.13	_	2	0.518	_
	2	1.67	_	_	475	3.11	_	_	_	2.31	_	2.18	_	_
	4	1.65	_	_	471	3.14	_	_	_	2.33	_	2.08	_	2.09
	6	1.89	0.715	_	477	3.29	_	_	_	2.23	_	2.09	_	2.09
	8	1.5	1	_	471	2.83	_	_	_	2.13	_	2.16	_	1.99
	10	1.46	1.18	_	469	2.78	_	0.529	_	2.25	_	1.96	_	1.77
	14	1.5	1.59	_	465	2.78	_	0.838	_	2.39	_	2.1	_	2.07
	16	2.02	1.88	_	463	3.58	_	1.14	_	2.82	0.546	2.27	_	2.3
	18	1.8	1.88	_	464	3.16	0.777	1.12	_	2.68	0.777	2.25	_	2.24
	26	1.55	2.11	0.635	465	3.03	_	1.42	_	2.34	0.517	2.02	_	2.18

Results are mean of two sample preparations.

TABLE 5: CONCENTRATION (MG/L) OF EACH ANALYTE IN MOCK BEVERAGE AT pH 3.8 UNDER VARIOUS TEMPERATURES

		Compounds										
Temperature	**Week**	**1**	**2**	**4**	**5**	**6**	**9**	**10**	**11**	**12**	**13**	**14**
5°C	0	1.69	_	471	3.18	_	_	2.14	0.559	2.3	0.538	_
	1	1.62	_	472	3.13	_	_	2.11	0.591	2.06	_	_
	2	1.66	_	477	3.14	_	_	2.24	_	2.26	_	_
	4	1.61	_	474	3.11	_	_	2.17	0.599	2.11	_	1.8
	6	1.7	_	478	3.24	_	_	2.11	0.627	2.11	_	1.76
	8	1.61	_	472	3.12	_	_	2.31	_	2.34	0.519	1.87
	10	1.52	_	471	2.9	_	_	2.36	0.633	2.06	0.549	1.88
	14	1.41	_	467	2.83	_	_	2.16	0.636	2.02	0.588	2.02
	16	1.93	_	467	3.65	_	_	3.28	0.517	2.33	_	2.38
	18	1.78	_	469	3.46	_	_	2.82	0.534	2.36	_	2.22
	26	1.57	_	469	3.19	_	0.54	2.37	0.654	2.05	_	2.43
20 °C	0	1.69	_	471	3.18	_	_	2.14	0.559	2.3	0.538	_
	1	1.65	_	476	3.04	_	_	2.18	_	2.17	_	_
	2	1.63	_	475	3.12	_	_	2.46	_	2.37	_	_
	4	1.6	_	473	3.13	_	_	2.19	0.521	2.16	0.511	2.07
	6	1.76	_	478	3.37	_	_	2.38	_	2.12	_	2.54
	8	1.6	_	468	3.06	_	0.51	2.26	0.645	2.3	0.514	2.75
	10	1.54	_	470	2.94	_	_	2.32	0.674	2.03	0.627	2.98
	14	1.62	_	467	2.85	_	0.5	2.16	0.686	2.19	0.655	3.11
	16	1.87	_	464	3.63	_	_	2.85	0.964	2.44	0.633	3.49
	18	1.9	_	467	3.62	_	_	2.87	1.148	2.33	_	3.39
	26	1.56	_	467	3.17	_	0.673	2.1	0.988	1.93	0.511	3.92
30°C	0	1.69	_	471	3.18	_	_	2.14	0.559	2.3	0.538	_
	1	1.65	_	475	3.13	_	_	2.13	0.613	2.06	_	_
	2	1.72	_	478	3.25	_	_	2.29	_	2.23	0.532	_
	4	1.61	_	474	3.07	_	_	2.27	0.628	2.13	0.596	2.57
	6	1.6	_	470	3.31	_	0.516	1.88	0.599	2.17	0.552	2.72
	8	1.52	_	468	2.84	_	_	2.1	_	2.1	0.524	2.79
	10	1.51	_	469	2.87	_	_	2.12	0.555	1.98	0.573	3.22
	14	1.57	_	467	2.92	_	0.642	2.33	0.537	2.18	0.612	3.27
	16	2.04	_	464	3.73	_	_	3.22	0.722	2.3	0.596	4
	18	1.78	_	468	3.59	_	_	2.83	1.111	2.34	0.561	3.34
	26	1.53	_	467	3.01	_	0.643	2.25	0.835	1.93	_	3.39
40°C	0	1.69	_	471	3.18	_	_	2.14	0.559	2.3	0.538	_
	1	1.67	_	474	3.26	_	_	2.17	0.533	2.04	_	_
	2	1.67	_	476	3.25	_	_	2.13	0.528	2.16	_	_
	4	1.64	_	471	3.25	_	0.573	2.23	0.81	2.2	0.565	2.99
	6	1.58	_	476	3.18	_	0.533	2.38	0.549	2.18	_	3.3
	8	1.57	_	468	3	_	_	2.19	0.56	2.21	_	3.44
	10	1.45	_	471	2.81	_	_	2.18	0.545	1.87	_	3.28
	14	1.45	0.535	465	2.78	_	0.709	2.2	0.681	2.08	_	4.24
	16	2.03	0.69	461	3.64	0.599	_	2.61	0.731	2.44	_	4.14
	18	1.91	0.74	467	3.42	_	0.513	2.97	0.93	2.14	_	4.12
	26	1.53	0.741	463	3.09	_	0.736	2.2	0.835	2.01	_	5.05

Results are mean of two sample preparations.

TABLE 6: CONCENTRATION (MG/L) OF EACH ANALYTE IN MOCK BEVERAGE AT pH 4.2 UNDER VARIOUS TEMPERATURES

		Compounds									
Temperature	**Week**	**1**	**4**	**5**	**6**	**9**	**10**	**11**	**12**	**13**	**14**
5°C	0	1.68	473	3.16	_	_	2.17	0.695	2.29	0.556	_
	1	1.69	474	3.17	_	_	2.16	0.728	2.16	_	_

	2	1.66	477	3.16	_	_	2.28	_	2.32	_	_
	4	1.63	474	3.11	_	_	2.13	_	2.21	_	1.46
	6	1.81	476	3.42	_	_	2.28	0.552	2.17	_	1.44
	8	1.62	473	3.07	_	_	2.18	_	2.35	_	1.6
	10	1.54	474	2.96	_	_	2.53	_	2.06	_	1.58
	12	1.47	468	2.86	_	_	2.18	_	2.08	0.505	1.78
	16	2.02	468	3.79	_	_	2.42	_	2.55	_	1.95
	18	1.87	468	3.57	_	_	2.79	0.79	2.31	_	1.84
	26	1.58	470	2.95	_	0.517	2.34	_	2.14	_	1.87
20 °C	0	1.68	473	3.16	_	_	2.17	0.695	2.29	0.556	_
	1	1.69	476	3.17	_	_	2.17	0.596	2.1	0.636	_
	2	1.64	476	3.25	_	_	2.21	_	2.36	_	_
	4	1.73	474	3.39	_	_	2.33	_	2.21	_	1.83
	6	1.56	477	3.34	_	_	2.32	0.596	2.15	_	1.73
	8	1.58	469	3.03	_	_	2.38	0.534	2.31	_	2.46
	10	1.54	471	2.93	_	_	2.33	0.577	2.01	_	2.37
	12	1.53	468	2.86	_	0.511	2.3	_	2.18	0.528	2.35
	16	1.97	465	3.4	_	_	2.66	0.775	2.34	0.542	2.83
	18	1.77	469	3.4	_	_	2.72	0.951	2.42	_	2.61
	26	1.59	468	3.07	_	0.566	2.25	0.672	2.12	_	2.86
30°C	0	1.68	473	3.16	_	_	2.17	0.695	2.29	0.556	_
	1	1.67	476	3.13	_	_	2.18	0.631	2.12	_	_
	2	1.66	476	3.2	_	_	2.26	_	2.33	_	_
	4	1.62	476	3.11	_	_	2.21	0.521	2.07	_	2.13
	6	1.58	470	3.16	_	0.538	2.18	0.974	2.21	_	2.12
	8	1.45	472	2.79	_	_	2.07	0.527	2.08	_	2.31
	10	1.49	471	2.9	_	_	2.49	_	2.09	_	2.35
	12	1.45	468	2.79	_	_	2.26	0.525	2.13	_	2.61
	16	1.97	464	3.73	_	0.531	3.11	0.604	2.42	_	2.79
	18	1.91	469	3.62	_	_	2.78	0.919	2.24	_	3.01
	26	1.52	468	2.95	_	0.555	2.29	0.709	2.03	_	3.12
40°C	0	1.68	473	3.16	_	_	2.17	0.695	2.29	0.556	_
	1	1.69	473	3.13	_	_	2.18	0.631	2.13	_	_
	2	1.64	475	3.3	_	_	2.32	_	2.22	_	_
	4	1.64	473	3.16	_	_	2.18	0.521	2.1	_	2.48
	6	1.81	476	3.48	_	_	2.4	0.974	2.15	_	2.34
	8	1.55	471	3.02	_	_	2.4	0.527	2.32	_	2.84
	10	1.41	472	2.9	_	_	2.14	_	1.95	_	2.7
	12	1.46	464	2.87	1.7	0.637	2.18	0.525	2.1	_	3.12
	16	2.02	464	3.63	_	_	3.08	0.604	2.45	_	3.42
	18	1.78	463	3.42	_	_	3	0.919	2.23	_	3.39
	26	1.56	466	3.06	_	0.691	2.3	0.709	2	_	3.76

Results are mean of two sample preparations.

TABLE 7: CONCENTRATION (MG/L) OF EACH ANALYTE IN pH 3.8 LIGHT TREATED MOCK BEVERAGE

	Compounds mg/L						
Conditions	**1**	**4**	**5**	**9**	**10**	**11**	**12**
Fluorescent Light	1.58	458	3	0.533	2.2	4.55	2.16
Control Fluorescent Light	1.59	477	3.14	_	2.33	_	2.14

TABLE 8: CALCULATED MOLAR EQUIVALENTS (µMOLE/L) OF EACH ANALYTE IN pH 3.8 LIGHT TREATED MOCK BEVERAGE

	Compounds micro mole/L						
Conditions	**1**	**4**	**5**	**9**	**10**	**11**	**12**
Fluorescent Light	1.23	407	2.33	0.474	1.96	4	1.97
Control Fluorescent Light	1.23	424	2.44	_	2.07	_	1.95

CONCLUSION: Siamenoside I stability in mock beverage formulations was influenced by pH, temperature, and storage duration, with higher degradation rates observed under more acidic conditions and at elevated temperatures. Six known degradation products or impurities (compounds 3, 6, 7, 8, 9, and 14) were detected at concentrations ≥0.500 mg/L (≥0.100% of starting material). Photostability testing in ambient conditions with fluorescent light exposure showed minimal degradation. Collectively, these findings demonstrate that siamenoside I, major component, remains chemically stable under both typical beverage pH and temperature storage conditions, and high solubility in water supports its suitability for inclusion in commercial food and beverage applications.

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CONFLICTS OF INTEREST: Nil

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