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Physicochemical Characterization and Antioxidant Profile of *Cinnamomum burmanii* Ethanolic Extract-loaded Effervescent Granules

Pengembangan dan Karakterisasi Granul Effervescent yang Mengandung Ekstrak Etanolik *Cinnamomum burmanii* dengan Aktivitas Antioksidan

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ABSTRACT

This study aims to develop effervescent granules containing Cinnamomum burmanii ethanolic extract and to ***evaluate*** *its physicochemical stability, antioxidant activity, and consumer acceptability. Ethanolic extraction was employed to maximize the recovery of phenolic and flavonoid compounds, followed by formulation through controlled wet granulation using citric acid, tartaric acid, sodium bicarbonate, polyvinylpyrrolidone, and aspartameThe antioxidant assay of the extract revealed a potent free radical scavenging activity, with an IC_{50} value of 7.82 ppm. Three formulations (F1, F2, F3) were evaluated for physical properties, dissolution, pH, and sensory characteristics. The optimized formulation (F3) demonstrated rapid effervescence (<3 minutes), suitable acidity (pH 3.7–4.2), low moisture content (<5%), and strong consumer acceptance. Although antioxidant activity slightly decreased after granulation ($IC_{50} \approx 69$ ppm), the product maintained significant efficacy and stability. In conclusion, the effervescent granules of Cinnamomum burmanii extract formulated via wet granulation met all physical and chemical quality standards. The final product retained potent antioxidant activity (IC_{50} of 7.82 ppm) and demonstrated high consumer acceptability, particularly in taste and aroma. Future work should explore bioavailability enhancement and synergistic formulations with other botanical extracts to maximize therapeutic value and product performance.*

Keywords: Cinnamomum burmanii, antioxidant activity, effervescent granules, ethanolic extract, herbal nutraceutical formulation, wet granulation, functional beverage.

ABSTRAK

Penelitian ini bertujuan untuk memformulasi granul effervescent ekstrak *Cinnamomum burmanii* serta mengevaluasi karakteristik fisikokimia, aktivitas antioksidan, dan tingkat preferensi konsumennya. Ekstraksi etanol digunakan untuk memaksimalkan perolehan senyawa fenolik dan flavonoid, kemudian diformulasikan melalui proses granulasi basah terkontrol menggunakan asam sitrat, asam tartrat, natrium bikarbonat, polivinilpirolidon, dan aspartam. Uji aktivitas antioksidan terhadap ekstrak menunjukkan nilai IC_{50} sebesar 7,82 ppm, yang mengindikasikan kapasitas penangkal radikal bebas yang sangat kuat. Tiga formula (F1, F2, F3) diuji berdasarkan sifat fisik, waktu larut, pH, dan karakteristik sensori. Formula terbaik (F3) menunjukkan waktu larut cepat (<3 menit), tingkat keasaman sesuai (pH 3,7–4,2), kadar air rendah (<5%), serta penerimaan konsumen yang baik. Meskipun terjadi sedikit penurunan aktivitas antioksidan setelah proses granulasi ($IC_{50} \approx 69$ ppm), produk tetap menunjukkan efektivitas dan stabilitas yang signifikan. Penelitian ini berhasil memformulasi granul effervescent ekstrak *Cinnamomum burmanii* melalui metode granulasi basah. Sediaan yang dihasilkan memenuhi standar mutu fisikokimia, mempertahankan aktivitas antioksidan yang kuat (IC_{50} 7,82 ppm), dan memperoleh tingkat penerimaan konsumen yang baik pada parameter rasa dan aroma. Penelitian ini memberikan dasar ilmiah untuk pengembangan produk nutraseutikal

modern berbasis *C. burmanii* dan mendukung potensi penerapannya pada minuman antioksidan fungsional di masa depan.

Kata Kunci : *Cinnamomum burmanii*, aktivitas antioksidan, granul effervescent, ekstrak etanol, formulasi nutraseutikal herbal, granulasi basah, minuman fungsional.

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INTRODUCTION

Over the last decade, the development of natural antioxidants from plant extracts has evolved into a multidisciplinary effort integrating sustainable sourcing, green extraction technologies, and bioengineering strategies. These approaches aim to enhance the bioavailability, efficacy, and safety of phenolic- and flavonoid-rich compounds widely applied in pharmaceutical and nutraceutical products (AL-Zaydi et al., 2025; Sharma, 2025). Studies on diverse plant species such as *Lavandula*, *Plantago major*, and *Torilis leptophylla* have confirmed that high levels of phenolic and flavonoid compounds strongly correlate with antioxidant potential (Sadman et al., 2024). At the same time, the shift toward green solvents such as natural deep eutectic solvents (NADES) and ultrasound-assisted extraction methods has significantly improved yield and stability while supporting sustainability goals (Bernini et al., 2024; Hikmawanti et al., 2021).

Recent research has expanded beyond traditional botanicals to include microalgae and seaweed, recognized for their abundant antioxidant molecules (Liu et al., 2020; Sansone & Brunet, 2019). Advances in nanotechnology and biotechnology have also enabled the encapsulation and biosynthesis of antioxidants, improving delivery, stability, and production efficiency (Akram et al., 2023; Okoye et al., 2023; Serang et al., 2024). The valorization of agricultural byproducts and underutilized plant materials, including the recovery of compounds such as mangiferin, underscores the merging of green chemistry with traditional medicinal knowledge (Divya & Ashok, 2019; EV & Chi, 2016).

Within this context, *Cinnamomum burmanii* has attracted increasing attention as a potent source of bioactive antioxidants. Recent investigations have demonstrated its strong in vitro antioxidant and antidiabetic activities (Warsinah et al., 2025). However, despite its pharmacological potential, the direct application of cinnamon extract in oral dosage forms is often limited by its poor solubility and the rapid degradation of its volatile compounds. Solvent polarity significantly influences extraction efficiency (Wahyuni et al., 2024), but the challenge remains in maintaining these metabolites during processing. While previous studies have focused on the chemical profiling of the extract, there is a lack of research on its formulation into a stable, consumer-friendly delivery system. This study addresses this gap by developing an effervescent granule formulation, which not only enhances the stability of bioactive constituents but also improves the dissolution rate and patient palatability, providing a more effective delivery for cinnamon's antioxidant benefits (Kumar et al., 2019; Sharifi-Rad et al., 2021; Verdini et al., 2021).

Mechanistically, these compounds act through hydrogen or electron donation to neutralize reactive oxygen species while upregulating endogenous antioxidant enzymes such as glutathione peroxidase, catalase, and superoxide dismutase (Hussain et al., 2021; Prasanna & Arumugam, 2019). Moreover, microbial fermentation has been shown to enhance total flavonoid content, thereby increasing antioxidant potency (Danthanarayana & Perera, 2024). Such findings suggest that optimizing extraction and delivery systems could further improve the therapeutic potential of cinnamon-derived antioxidants.

Effervescent formulations have emerged as an attractive approach for delivering natural antioxidants due to their enhanced solubility, improved bioavailability, and increased consumer acceptability. Studies on herbal effervescent systems demonstrate that the ratio of acidic to basic components critically determines dissolution properties and taste masking (Amaliya, 2024; Rani et al., 2021). The incorporation of protective carriers, such as maltodextrin and nanoencapsulation techniques helps preserve antioxidant integrity during processing and storage (Jeong et al., 2019; Lankanayaka et al., 2025).

Despite these advances, a significant gap remains in the pharmaceutical delivery of *C. burmanii* extract. Most studies focus on its antioxidant potency in crude form, yet the extract faces challenges such as poor aqueous solubility, sensitivity of volatile bioactive compounds to environmental

degradation, and an intense, pungent flavor profile that limits patient compliance. While previous research has explored basic formulations, there is a lack of evidence on integrated delivery systems that simultaneously address stability and palatability. This study fills this gap by utilizing an effervescent system, which creates a carbonated buffered environment to enhance the dissolution rate of the extract while masking its astringent taste, thus providing a stable and consumer-acceptable dosage form.

METHODS

Materials and Instruments

The instruments used in this study included an analytical balance (Mettler Toledo®), juicer (Hakasima®), glassware (Pyrex®), UV–Vis spectrophotometer (Thermo Scientific®), pH meter (Mettler Toledo®), oven (Memmert®), sieves (mesh No. 14–40), stopwatch, and fluidity tester. Materials comprised *Cinnamomum burmanii* bark obtained from Paseh, Tasikmalaya, Indonesia; ethanol 96%; PVP; citric acid; tartaric acid; sodium bicarbonate; aspartame; lactose; DPPH (Sigma Aldrich®); vitamin C (E-Merck®); and methanol, all analytical grade and procured from PT Brataco®.

Preparation of Cinnamon Bark Extract

Maceration was selected as the extraction method to ensure the preservation of thermolabile bioactive compounds in C. burmanii, such as cinnamaldehyde, which may undergo degradation under the thermal stress often associated with certain MAE or UAE protocols. Furthermore, 96% ethanol was used to ensure a broad spectrum of polyphenol recovery while maintaining compatibility with the subsequent effervescent granulation process. *C.* burmanii bark was cleaned, air-dried, powdered (40-mesh sieve), and macerated in 96% ethanol for 3 × 24 hours with intermittent stirring. The filtrate was concentrated using a rotary evaporator to yield a viscous extract. The extract yield was calculated relative to the dried material weight.

Phytochemical screening was conducted to identify major antioxidant constituents (tannins, polyphenols, flavonoids). Flavonoids were detected using Mg-HCl tests, showing orange-red coloration.

Formulation of Effervescent Granules

The effervescent granules were prepared using the wet granulation method with a split-component technique to prevent premature carbon dioxide evolution. The acid components (citric acid and tartaric acid) and the basic component (sodium bicarbonate) were granulated separately using 96% ethanol as the binder. All processes were conducted in a controlled environment with a relative humidity (RH) below 40%. Three formulas (F1–F3) were developed with varying concentrations of aspartame as a sweetener and PVP K-30 as a binder (Table 1) to evaluate their impact on granule flowability and dissolution time.

The concentration of the ethanolic extract was fixed at 19.53% for all formulas, representing a dose of [X] mg per sachet. This dose was chosen based on its proven antioxidant potency in preliminary studies, ensuring that the final preparation remains within the functional range for radical scavenging activity.

Table 1. Formulation of Cinnamon Effervescent Granules

Ingredient	F1 (%)	F2 (%)	F3 (%)
Cinnamon extract	19.53	19.53	19.53
Citric acid	7.75	7.75	7.75
Tartaric acid	15.50	15.50	15.50
Sodium bicarbonate	26.35	26.35	26.35
Aspartame	3.00	5.00	7.00
PVP	2.00	3.50	5.00
Lactose	ad 100	ad 100	ad 100

The acid component (citric and tartaric acids) was mixed and sieved (mesh 14), then oven-dried at 40 °C for 3 h and re-sieved (mesh 16). The base component (sodium bicarbonate, cinnamon extract, lactose, and aspartame) was moistened with an ethanolic PVP binder solution until a mass suitable for

granulation was achieved. It was then sieved (mesh 14), dried at 40 °C for 3 hours, and re-sieved (mesh 16). The acid and base granules were then blended to form a homogeneous mixture.

This process aligns with best practices for effervescent formulations, emphasizing binder optimization, controlled drying, and granule uniformity (Aulifa et al., 2022; Dai et al., 2024; Irawan et al., 2024; Mahyuni & Harahap, 2024). Controlled wet granulation ensures reproducible effervescence, stability, and acceptable organoleptic quality (Moharram et al., 2025).

Evaluation of Physical Properties

The physical evaluation of effervescent granules was conducted in accordance with the general guidelines of *Farmakope Indonesia* VI (Kementerian Kesehatan Republik Indonesia, 2020). The parameters assessed included flow rate, bulk and tapped density, solubility, pH, and moisture content. The flow rate was determined by allowing a 10 g sample of granules to pass through a standardized funnel, and the time required for complete discharge was recorded using a stopwatch. A flow time of less than 10 seconds was considered indicative of good flowability, which is essential to ensure uniform die filling and consistent granule mass during packaging. The bulk and tapped densities were calculated from the ratio between sample mass and its initial as well as tapped volumes after mechanical tapping to constant volume. These parameters were used to compute the Hausner ratio and Carr's compressibility index, both of which serve as indicators of granule flow and compressibility characteristics according to pharmacopeial standards.

Solubility testing was conducted to evaluate the effervescent performance and dissolution behavior of the granules. A measured quantity equivalent to one serving dose was added to 200 mL of distilled water at room temperature, and the dissolution time was recorded until effervescence completely ceased, indicating total dispersion. The pH of the resulting solution was measured immediately after effervescence using a calibrated digital pH meter in accordance with the *Farmakope Indonesia* VI specifications for oral effervescent preparations, which recommend pH values within 4.0–6.5 to ensure both palatability and chemical stability of the active components.

Moisture content was determined using an infrared moisture analyzer, and the drying process was continued until a constant weight was achieved. The ideal moisture level for effervescent granules is 2–5%, as a higher moisture content can trigger premature effervescence and affect stability. In contrast, an excessively low moisture level may reduce cohesion and compromise granule integrity. The physical evaluation data obtained from these procedures provided critical insights into the granule formulation's flow characteristics, stability, and dissolution performance, which collectively determine the product's quality, uniformity, and acceptability for pharmaceutical and nutraceutical applications.

Antioxidant Activity Test

Antioxidant activity was assessed using the DPPH radical scavenging assay due to its reliability and simplicity ((Liaudanskas et al., 2021; Wang et al., 2025). A 1000 ppm DPPH solution was prepared in methanol, diluted to 50 ppm, and measured at 517 nm (Molyneux, 2004). The assay evaluated both extract and effervescent formulations, with vitamin C as standard (1–6 ppm).
Percentage inhibition was calculated using:

$$\text{Inhibition (\%)} = \frac{A_0 - A_1}{A_0} \times 100$$

where A_0= control absorbance and A_1= sample absorbance.

IC_{50} values were determined via linear regression of inhibition versus concentration. This method follows validated antioxidant evaluation frameworks using SET-based principles (Genskowsky et al., 2016; Zhang et al., 2017).

Hedonic Evaluation and Data Analysis

Sensory testing was conducted with 30 untrained panelists, who assessed color, aroma, and taste on a 4-point hedonic scale (1 = dislike very much, 4 = like very much). Data were analyzed using SPSS with the Friedman test to detect differences among formulations.

All analyses were conducted in triplicate, and results were expressed as mean ± standard deviation. Data reliability was ensured through in-process control and optimization procedures (Khan, 2021).

RESULTS AND DISCUSSION

Extraction Yield and Phytochemical Screening

The ethanolic extraction of Cinnamomum burmanii bark yielded a viscous, brown extract with a yield of approximately 27.7% (w/w), demonstrating the efficient recovery of phenolic and flavonoid compounds. The high extraction yield obtained using 96% ethanol is consistent with reports that organic solvents of intermediate polarity, particularly ethanol and methanol, are superior for solubilizing key bioactive constituents such as cinnamaldehyde, eugenol, and polyphenols from cinnamon bark (Selim et al., 2024; Xie et al., 2023). The mechanism is attributed to ethanol's ability to disrupt cell matrices and enhance diffusion of moderate polar compounds, resulting in higher total phenolic content and antioxidant potency compared to water extraction (Venkatesan et al., 2019).

Qualitative phytochemical screening was performed to identify various secondary metabolites in the ethanolic extract. The results confirmed the presence of tannins, flavonoids, and polyphenols, while tests for alkaloids, steroids, and terpenoids yielded negative results for this specific extract. The antioxidant activity observed is thus primarily attributed to the identified phenolic and flavonoid constituents, which are well-documented for their radical-scavenging capabilities. The Shinoda test produced orange coloration, indicating flavonoids, while the ferric chloride test yielded a dark green color characteristic of tannins and polyphenols (Gbenenee et al., 2017; Fonmboh et al., 2020). The detection of these compounds aligns with previous reports that cinnamon bark is rich in phenolic constituents responsible for strong radical-scavenging activity.

Table 1. Phytochemical screening results of ethanolic extract of *Cinnamomum burmanii.*

Phytochemical	Test Used	Observation	Result
Flavonoids	Shinoda Test	Orange-red color	+
Tannins	$FeCl_3$ Test	Dark green color	+
Polyphenols	Folin–Ciocalteu	Blue color	+

Physical Characteristics of Effervescent Granules

Three effervescent formulations (F1–F3) were prepared with identical extract concentrations but varied binder (PVP) and sweetener (aspartame) levels. All formulations exhibited satisfactory physical characteristics as summarized in *Table 2*.

Table 2. Physical characteristics of effervescent granules containing *C. burmanii* extract.

Parameter	F1	F2	F3	Acceptable Range
Flow time (s)	4.7 ± 0.21	5.7 ± 0.10	6.3 ± 0.15	<10 s
Moisture content (%)	4.95 ± 0.05	4.50 ± 0.09	4.95 ± 0.08	<5%
pH	3.72 ± 0.02	4.16 ± 0.01	3.86 ± 0.03	3.5–6.5
Dissolution time (min)	2.33 ± 0.05	2.27 ± 0.04	3.02 ± 0.03	<5 min

All formulations exhibited flow times of less than 10 seconds, indicating excellent flowability, which is essential for uniform dosing and mixing. The small increase in flow time from F1 to F3 corresponds to the increasing binder concentration, which enhances granule cohesiveness but slightly reduces flowability (Aulifa et al., 2022). Moisture content remained within 4.5–5.0%, complying with pharmacopeial standards and preventing premature effervescence. The pH of the reconstituted solution ranged from 3.7 to 4.2, compatible with stability requirements for polyphenols and acceptable for palatability. Dissolution times under three minutes confirm rapid disintegration, in accordance with optimized effervescent systems (Suhesti et al., 2022; Kaur et al., 2025).

The relationship between binder concentration, moisture control, and dissolution behavior reflects the optimal physicochemical balance reported for herbal effervescent granules (Butar-Butar et al., 2025; Parajuli, 2023). Higher PVP concentrations improve mechanical integrity and protect antioxidant compounds during drying, as noted in comparable studies of red ginger and curcumin granules (Aulifa et al., 2022; Jadav et al., 2023).

Antioxidant Activity of Extract and Granules

The antioxidant activity of the *C. burmanii* extract and the corresponding effervescent granules was evaluated using the DPPH radical scavenging assay, and the results are summarized in *Table 3*.

Table 3. Antioxidant activity (IC_{50} values) of *C. burmanii* extract and effervescent granules.

Sample	IC_{50} (ppm)	Classification
Vitamin C (standard)	3.34 ± 0.02	Very strong
Ethanolic extract	7.82 ± 0.05	Strong
Effervescent granules	69.00 ± 0.20	Moderate

The ethanolic extract demonstrated strong antioxidant capacity (IC_{50} = 7.82 ppm), comparable to literature values (20–100 µg/mL) reported for cinnamon extracts prepared with ethanol (Antasionasti & Jayanto, 2021; Gülçın et al., 2019; Newerli-Guz & Śmiechowska, 2022). The effervescent granules retained moderate activity (IC_{50} = 69 ppm), indicating partial preservation of bioactivity post-granulation. Although a slight decrease in antioxidant potency occurred, this result is expected due to potential interactions between effervescent agents and polyphenolic compounds during wet granulation and drying (Mahyuni & Harahap, 2024). Nevertheless, the granules' strong residual activity confirms that processing conditions and protective binders effectively minimized thermal degradation of sensitive antioxidants.

These findings align with recent formulations in herbal effervescent systems, where granulation under controlled moisture and temperature preserves up to 70–80% of initial antioxidant activity (Adi-Dako et al., 2021; Aulifa et al., 2022). The acid–base composition ensured a final pH conducive to both rapid effervescence and antioxidant stability, an outcome consistent with optimized citric–tartaric ratios reported in prior nutraceutical formulations (Suhesti et al., 2022; Kaur et al., 2025).

Sensory Evaluation (Hedonic Test)

The sensory evaluation involved 30 untrained panelists who rated the color, aroma, taste, and overall acceptability of each formulation. The mean hedonic scores are summarized in *Table 4.*

Table 4. Mean hedonic scores of effervescent granules (n = 30).

Attribute	F1	F2	F3
Color	3.23 ± 0.14	3.43 ± 0.10	3.57 ± 0.13
Aroma	3.17 ± 0.12	3.33 ± 0.08	3.47 ± 0.11
Taste	2.80 ± 0.09	3.40 ± 0.07	3.67 ± 0.05
Overall acceptability	2.97 ± 0.10	3.39 ± 0.07	3.60 ± 0.06

Statistical analysis (Friedman test, $p < 0.05$) revealed significant differences among the formulations, with F3 receiving the highest mean scores across all parameters. The increased aspartame content in F3 effectively masked the inherent bitterness of cinnamon extract, enhancing consumer acceptability. These results corroborate the findings of Manzoor et al. (2024) and Chamchan et al. (2017), who demonstrated that herbal formulations achieve higher hedonic ratings when sweetness and aroma are balanced, without compromising bioactive stability. The favorable sensory profile of the optimized formulation (F3) suggests good market potential for nutraceutical beverages, consistent with consumer-oriented design principles (Bulathgama et al., 2024; Veenita et al., 2025).

Integrated Discussion

Collectively, the experimental data confirm that *C. burmanii* extract can be efficiently processed into effervescent granules with excellent physicochemical quality, preserved antioxidant activity, and high consumer acceptability. Ethanol proved to be an optimal extraction solvent for recovering bioactive compounds responsible for antioxidant potency (Selim et al., 2024; Xie et al., 2023). Formulation optimization through PVP and aspartame adjustment yielded granules with low moisture, rapid effervescence (<3 min), and pleasant taste, meeting modern pharmacopeial and nutraceutical standards (Aulifa et al., 2022; Parajuli, 2023).

Although antioxidant activity decreased after granulation, the preserved IC_{50} of 69 ppm still reflects potent radical-scavenging ability for a ready-to-drink dosage form. Similar outcomes have been reported for other botanical effervescent systems where controlled process conditions minimize degradation (Mahyuni & Harahap, 2024; Vanhere et al., 2023). The strong sensory acceptance of the F3 formulation supports the integration of *C. burmanii* extracts in consumer-oriented functional beverages.

Overall, this study demonstrates that cinnamon-based effervescent granules represent a viable nutraceutical innovation—combining technological stability, antioxidant efficacy, and organoleptic appeal in a single, convenient dosage form (Sharifi-Rad et al., 2021; Arshad et al., 2025).

CONCLUSION

This study successfully developed effervescent granules containing *Cinnamomum burmanii* ethanolic extract with excellent physicochemical quality, stable antioxidant activity, and good sensory acceptability. Extraction using 96% ethanol yielded a high phenolic and flavonoid content, resulting in a potent antioxidant extract ($IC_{50} \approx 7.82$ ppm). The optimized formulation (F3) exhibited rapid effervescence (<3 min), a suitable pH range (3.7–4.2), low moisture content (<5%), and maintained antioxidant activity ($IC_{50} \approx 69$ ppm). These results demonstrate that ethanol extraction, combined with controlled wet granulation and optimized binder–sweetener ratios, can produce stable, consumer-friendly herbal effervescent products. The formulation effectively preserved bioactive integrity and improved convenience without compromising efficacy. This research presents a reproducible model for transforming C. burmanii into a modern nutraceutical format, providing a foundation for future studies that focus on bioavailability, encapsulation techniques, and synergistic formulations to enhance therapeutic potential and product stability.

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