

## Exploring moringa stems and twigs as an alternative raw material for herbal tea production

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Received: 10 May 2025  
Available Online: 3 June 2025

Revised: 25 May 2025  
DOI: 10.5861/ijrsm.2025.25062

Accepted: 1 June 2025

ISSN: 2243-7770  
Online ISSN: 2243-7789

OPEN ACCESS



### *Abstract*

This study focused on the development and evaluation of an herbal tea made from *Moringa Oleifera* (Malunggay) stems and twigs—parts of the plant often discarded during food preparation. The objective was to explore their potential as a sustainable, nutritious, and functional beverage alternative. Three drying methods were tested to determine their effects on the sensory qualities of the tea: sun drying (Treatment 1), pan drying (Treatment 2), and oven drying (Treatment 3). The tea samples were evaluated by 30 purposively selected respondents from the university and local communities based on appearance, texture, aroma, and taste. Among the treatments, oven drying (Treatment 3) received the highest acceptability scores, particularly in taste and texture, followed closely by sun drying (Treatment 1). Pan drying (Treatment 2) had the lowest ratings due to its strong, slightly burnt flavor and aroma. The most preferred treatment (Treatment 3) was further subjected to physicochemical analysis, revealing a pH of 7.15 (neutral) and moisture content of 8.01%, which meet acceptable food safety standards. The study demonstrates that *Moringa* stems and twigs are viable raw materials for tea production, providing an innovative way to reduce agricultural waste while promoting health and sustainability. The findings contribute to food innovation, sustainability practices, and potential entrepreneurial opportunities in the local community.

**Keywords:** *Moringa Oleifera*, herbal tea, sensory evaluation, drying methods, physicochemical analysis

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### 1. Introduction

In the face of rising global health concerns and environmental challenges, there is a growing demand for functional, natural, and sustainable food products. Consumers are becoming increasingly aware of the connection between diet, health, and environmental sustainability, leading to a shift toward plant-based and organic alternatives (Lobo et al., 2010). Herbal teas, in particular, have gained traction for their health benefits, cultural relevance, and minimal environmental impact. Unlike conventional teas derived from *Camellia sinensis*, herbal teas are produced from a wide variety of leaves, roots, flowers, and barks and are often caffeine-free, making them a suitable alternative for health-conscious individuals (Ravikumar, 2014).

One plant that stands out in the field of functional foods is *Moringa Oleifera*, locally known as Malunggay in the Philippines. Moringa is considered a "miracle tree" due to its resilience, ease of cultivation, and high nutritional value. Various studies have confirmed that its leaves, pods, seeds, and even bark are rich in antioxidants, vitamins (A, C, and E), calcium, iron, and essential amino acids (Anwar et al., 2007; Fahey, 2005). Despite its versatility, the stems and twigs are often discarded as agricultural waste, even though they also contain bioactive compounds that may be beneficial to human health (Shanmugapriya et al., 2019).

The improper disposal of these parts reflects a missed opportunity for food innovation and waste reduction. In line with the principles of a circular economy, which encourages the reuse of resources to reduce waste, exploring these by-products for product development presents a dual opportunity: improving nutrition and promoting sustainability (Singh et al., 2021). Utilizing moringa stems and twigs in herbal tea production offers a viable solution to minimize waste while creating a valuable health product. Moreover, this aligns with Sustainable Development Goal 12: Responsible Consumption and Production, and Goal 2: Zero Hunger, both of which advocate for sustainable food practices and improved access to nutritious food (United Nations, 2015). Furthermore, the development of Moringa tea from stems and twigs addresses health-related concerns such as iron deficiency, chronic inflammation, and immune support. Research shows that *Moringa Oleifera* extracts have strong antioxidant, antimicrobial, and anti-inflammatory properties, which can contribute to disease prevention and wellness promotion (Verma et al., 2009). With the global herbal tea market projected to grow substantially, driven by increased interest in organic and functional beverages, the exploration of locally sourced, affordable, and underutilized ingredients becomes even more relevant (Grand View Research, 2021).

This study investigates the development of a nutritious herbal tea product using *Moringa Oleifera* stems and twigs. It specifically evaluates three different drying methods—sun drying, pan drying, and oven drying—to identify the most acceptable product in terms of appearance, texture, aroma, and taste through sensory evaluation. It also subjects the preferred sample to physicochemical analysis to assess its pH level and moisture content, ensuring its safety and quality as a consumable beverage. Additionally, the researchers developed Information, Education, and Communication (IEC) materials to support knowledge dissemination and product promotion. The findings of this study are expected to contribute to sustainable food innovation, empower communities through potential micro-entrepreneurship, and support health promotion using indigenous and accessible plant resources.

**Objectives of the Study** - This study aims to explore the potential of *Moringa Oleifera* (Malunggay) stems and twigs as a sustainable and health-promoting raw material for herbal tea production. Specifically, the research seeks to identify the different stages involved in the development of Moringa stems and twigs tea, including the preparation, processing, and packaging methods. It also aims to evaluate the sensory acceptability of the tea in terms of appearance, texture, aroma, and taste using various drying techniques such as sun drying, pan drying, and oven drying. Lastly, the study intends to determine the physicochemical properties of the most preferred tea

variant by analyzing its pH level and moisture content to ensure safety and quality for consumption.

## 2. Methods

**Research Design** - The research design for the Moringa Oleifera Stems and Twigs Tea study follows a descriptive research design with an experimental approach. This combination allows for a detailed exploration of both the sensory attributes and physicochemical properties of Moringa tea produced from the stems and twigs of the Moringa Oleifera plant. The study focuses on evaluating the acceptability of the tea by using three different drying methods: sun drying, pan drying, and oven drying. These methods are tested to determine which one produces the best tea in terms of appearance, texture, aroma, and taste. The tea is produced by drying the stems and twigs of Moringa, followed by grinding them into powder and packaging them into standardized tea bags. A purposive sampling technique is employed to select 30 evaluators, including students, staff, and community members, ensuring a diverse range of feedback. These evaluators use a 5-point Likert scale to rate the sensory attributes of the tea, providing valuable data on consumer acceptability. In addition to the sensory evaluation, physicochemical tests are conducted to assess the pH and moisture content of the tea, which are critical factors in determining the tea's quality, safety, and shelf stability. The data collected from both the sensory evaluation and the physicochemical analysis are then analyzed to identify the most acceptable drying method and to ensure that the final product meets the necessary quality standards. This research design integrates technical and consumer perspectives, making it a comprehensive approach for developing a high-quality, sustainable tea product.

**Participants of the Study** - The participants of the study were selected using a purposive sampling technique, which was carefully designed to ensure a diverse and representative group of evaluators. A total of 30 participants were chosen, and they were divided into three groups to provide a broad range of perspectives. The first group consisted of 10 students from Central Bicol State University of Agriculture-Calabanga, representing a youthful and academic demographic. The second group included 10 teaching and non-teaching staff from the university, offering a professional viewpoint. Finally, the third group comprised 10 community members from Canaman and Bombon, reflecting a more general, local perspective. This sampling method allowed the study to gather a variety of opinions on the sensory attributes of the Moringa tea, including appearance, texture, aroma, and taste. By including individuals from different backgrounds and sectors, the research was able to ensure that the feedback was comprehensive and reflective of the broader community's acceptance of the product. This diversity in the participant pool is crucial for assessing the tea's potential in different market segments and understanding how it may be received by various consumer groups.

**Data Gathering Instrument** - The data gathering instrument used in the study was a sensory evaluation form designed to assess the acceptability of the Moringa tea based on its sensory attributes. The form utilized a 5-point Likert scale, which allowed participants to rate the tea on four key sensory parameters: appearance, taste, texture, and aroma. This scale ranged from 1 (Not Acceptable) to 5 (Highly Acceptable), providing a clear and quantifiable way to measure participants' opinions on the product's characteristics. The Likert scale is commonly used in sensory evaluations because it simplifies the process of capturing subjective impressions and allows for easy statistical analysis.

In addition to the sensory evaluation form, physicochemical analysis was conducted using laboratory instruments to measure the pH and moisture content of the tea. These tests were essential for determining the safety, quality, and shelf stability of the final product. The data gathering instruments were structured to ensure consistency in the evaluation process and to provide reliable data on both the sensory and physicochemical aspects of the Moringa tea. The combination of sensory feedback and scientific analysis allowed the researchers to comprehensively assess the product and its potential for market acceptance.

**Data Gathering Procedure** - The data gathering procedure for this study involved a systematic approach to ensure reliable and consistent evaluation of the Moringa tea. The process began with preparing the tea samples through three drying methods: sun drying, pan drying, and oven drying. After drying, the Moringa stems and

twigs were ground into powder and packaged into standardized tea bags. For the sensory evaluation, 30 evaluators, selected from students, teaching and non-teaching staff, and community members, assessed the tea samples based on four sensory attributes: appearance, texture, aroma, and taste, using a 5-point Likert scale. Simultaneously, physicochemical analysis was performed to measure the pH and moisture content of the samples. The sensory data were collected using evaluation forms, while the laboratory tests were conducted following standard procedures. This comprehensive data collection ensured the accurate assessment of both the sensory and physicochemical properties of the Moringa tea, providing valuable insights into its quality and acceptability.

**Ethical Considerations** - The study adhered to strict ethical considerations to ensure the protection and well-being of all participants involved. Before any data collection, informed consent was obtained from all participants. They were thoroughly briefed on the purpose of the study, the procedures involved, potential risks, and benefits, and their right to withdraw from the study at any point without facing any negative consequences. All participants were assured of their confidentiality, with their personal information and responses anonymized and securely stored to protect their privacy. Participation in the study was entirely voluntary, and participants were free to withdraw at any time without penalty. Additionally, the tea samples were prepared under hygienic conditions, following all safety protocols to minimize any health risks to the participants. By following these ethical guidelines, the study ensured that the participants' rights were respected, and the research process remained transparent, fair, and safe.

**Data Analysis** - The data analysis for this study involved both sensory evaluation and physicochemical analysis. The sensory evaluation data were analyzed using the Weighted Mean (WM) formula, where the ratings from the 5-point Likert scale for each sensory attribute—appearance, taste, texture, and aroma—were multiplied by their corresponding frequency and then summed up. This total was divided by the total number of participants to calculate the mean score for each attribute. The results were categorized into different levels of acceptability, ranging from "Not Acceptable" to "Highly Acceptable," providing a clear understanding of the overall consumer preference for each tea variant. For the physicochemical analysis, the pH level and moisture content of the tea samples were measured and analyzed descriptively. These values were compared to standard quality requirements to ensure that the product met safety and preservation criteria. By combining both sensory and physicochemical data, the analysis provided a comprehensive assessment of the tea's overall quality and acceptability, helping to identify the best drying method and the most suitable tea formulation.

### 3. Results and Discussion

**Development of the Product.** The development of Malunggay (*Moringa Oleifera*) Stems and Twigs Tea followed a systematic process involving three major experimental trials to determine the most effective method of drying the raw materials. The researchers began by collecting fresh moringa from selected communities, specifically separating the stems and twigs from the leaves. These parts, often discarded, were chosen as the main ingredient for the tea product. The initial stage included thorough washing and draining, followed by cutting the stems and twigs into smaller pieces to ensure even drying. Three drying techniques were then applied across the trials: sun drying, pan drying, and oven drying.

In Trial 1, sun drying was used, wherein the moringa stems and twigs were dried under direct sunlight for four days until completely crisp and moisture-free. This method produced a light-yellow tea with mild aroma and taste, scoring highest in appearance and texture among the trials. Trial 2 employed pan drying over low to medium heat for 42 minutes. While it produced a golden yellow appearance, the tea developed a strong, slightly burnt flavor and aroma. Trial 3, the most successful, utilized oven drying at a consistent temperature of 50°C for approximately 4 hours and 21 minutes. This method ensured even drying without burning the product, resulting in a smooth texture, slightly herby aroma, and herby taste. After drying, the samples from each trial were minced and measured at 2.30 grams per tea bag. The entire process demonstrated how different drying methods impact the quality and sensory properties of the final moringa tea product.

**Table 1***Sensory Evaluation of Malunggay (Moringa Oleifera) Stems and Twigs Tea*

Sensory Parameters	T1	T2	T3
Appearance	4.7	3.0	4.5
Texture	4.7	3.8	4.6
Aroma	4.0	3.8	4.1
Taste	4.1	3.9	4.4
Mean	4.4	3.6	4.4

Legendary: 5.00-4.21 Highly Acceptable, 4.20-3.41 Acceptable, 3.40-2.61 Moderately Acceptable, 2.60-1.81 Slightly Acceptable, 1.80-1.00 Not Acceptable

This table displays the results of the sensory evaluation of Malunggay (*Moringa Oleifera*) Stems and Twigs Tea, which were prepared using three different drying methods: sun drying (T1), pan drying (T2), and oven drying (T3). The evaluators rated the tea samples based on four sensory parameters: appearance, texture, aroma, and taste. The ratings were based on a 5-point Likert scale, where higher scores indicate better acceptability.

**Appearance** -The sensory evaluation results presented in Table 1 provide valuable insights into the appearance of Malunggay (*Moringa Oleifera*) Stems and Twigs Tea, evaluated through three different drying methods: sun drying (T1), pan drying (T2), and oven drying (T3). The appearance of the tea was rated on a 5-point Likert scale, where higher scores indicated greater acceptability. The mean scores for appearance were 4.4 for T1, 3.6 for T2, and 4.4 for T3. These scores suggest that both sun-dried and oven-dried teas were considered highly acceptable, while the pan-dried tea was rated moderately acceptable due to its less favorable visual appearance.

Upon analysis, the results reveal a clear distinction in the appearance of the tea samples based on the drying method. Sun-dried tea (T1) and oven-dried tea (T3) received higher acceptability ratings of 4.4, which places them within the "Highly Acceptable" category. This suggests that these drying methods preserved the natural appearance of the Moringa stems and twigs, resulting in a more visually appealing product. In contrast, pan-dried tea (T2) received a much lower score of 3.0, indicating that the tea's appearance was negatively affected by the pan drying process. The pan drying method, which involved heating the tea over direct heat, likely caused uneven drying, resulting in a dull or slightly burnt appearance, thus lowering its visual appeal.

These results emphasize the importance of the drying method in preserving the visual qualities of the tea. Sun drying appears to provide a slower, more natural drying process that helps retain the color and texture of the Moringa stems and twigs. Oven drying, which involves a controlled environment, also appears to be an effective method, providing a smooth texture and consistent appearance without the risks of burning associated with pan drying. In contrast, pan drying may have caused overheating or uneven heat distribution, leading to a less appealing visual outcome.

These findings align with existing literature on the role of appearance in consumer food acceptance. Moss, Perez, and Russell (2020) highlight the critical role of visual appeal in food products, stating that consumers are often drawn to foods with vibrant, uniform colors, which influence their willingness to try and buy products. Similarly, Liu, Zhang, and Zheng (2021) emphasize that an attractive appearance can enhance consumer satisfaction and influence market success. Furthermore, Kapsak, Landry, and Kapsak (2017) discuss how consistent and appealing food appearance can build consumer trust and encourage repeat purchases. These studies reinforce the importance of visual attributes in consumer food choices, supporting the higher ratings for both sun-dried and oven-dried tea samples in this study.

**Texture** - The texture of the Malunggay (*Moringa Oleifera*) Stems and Twigs Tea was assessed across three different drying methods: sun drying (T1), pan drying (T2), and oven drying (T3). The texture scores for the samples were 4.7 for T1, 3.8 for T2, and 4.6 for T3, with mean scores of 4.4 for T1, 3.6 for T2, and 4.4 for T3. These scores indicate that the texture of the tea was most acceptable for both the sun-dried and oven-dried samples, while the pan-dried tea had a lower score, suggesting a less favorable texture.

The higher texture scores for sun drying (T1) and oven drying (T3) may suggest that these drying methods preserved a smoother and more consistent texture in the tea leaves, which are key attributes for consumer satisfaction. On the other hand, the pan drying (T2) method, which received a lower texture score, may have resulted in a rougher, less desirable texture due to the uneven drying process. The texture of a product, particularly in tea, is critical as it affects mouthfeel and the overall drinking experience. A smooth, well-preserved texture is more likely to be preferred by consumers, as it contributes to the overall sensory appeal.

In support of these findings, Stone and Sidel (2017) emphasize that texture plays a pivotal role in consumer preference for food products, as it impacts the overall eating or drinking experience. Their research indicates that smooth, consistent textures are often linked with higher consumer satisfaction. Similarly, Szczesniak (2002) identifies texture as a key factor in the acceptance of novel food products, especially when consumers are unfamiliar with the product's texture. In this case, the consistent, smooth texture provided by sun and oven drying methods likely contributed to their higher scores. Additionally, Bourne (2002) further supports this by highlighting that the handling characteristics of a product, including its texture, can significantly affect consumer enjoyment. A more pleasing texture encourages repeat consumption, which is crucial for products like herbal teas, where consumer loyalty can be built over time.

**Aroma** - The aroma of the Malunggay (*Moringa Oleifera*) Stems and Twigs Tea was evaluated based on three different drying methods: sun drying (T1), pan drying (T2), and oven drying (T3). The aroma scores for the tea samples were 4.0 for T1, 3.8 for T2, and 4.1 for T3, with mean scores of 4.4 for T1, 3.9 for T2, and 4.4 for T3. These scores suggest that sun-dried and oven-dried teas were more favorably rated for their aroma compared to the pan-dried tea. The sun drying (T1) and oven drying (T3) methods likely helped preserve a more pleasant, natural aroma, contributing to higher aroma scores. The pan drying (T2) method, which scored lower, might have resulted in a less favorable aroma due to the uneven drying process, which could have led to a burnt or overly strong aroma that detracted from the tea's natural scent.

Aroma is a significant factor in the overall sensory experience of tea, as it contributes to the anticipation of flavor and enhances the drinking experience. Drake and Civille (2003) emphasize the crucial role aroma plays in food acceptance, as it influences consumer expectations and enjoyment. They note that a balanced and appealing aroma can enhance the perception of taste, creating a more enjoyable sensory experience. Similarly, Meilgaard, Civille, and Carr (2006) argue that aroma is a critical determinant of food preference, as it plays a large part in shaping overall flavor perception. The higher aroma scores for sun-dried and oven-dried teas suggest that these methods better preserved the aromatic compounds in the *Moringa* stems and twigs. In addition, Bayarri, De La Fuente, and Costell (2001) highlight that a well-balanced aroma profile is important for increasing consumer satisfaction with food products. This is consistent with the higher ratings for the aroma of the sun-dried and oven-dried teas, which likely had more desirable and balanced aromatic qualities.

**Taste** - The taste of the Malunggay (*Moringa Oleifera*) Stems and Twigs Tea was evaluated based on three different drying methods: sun drying (T1), pan drying (T2), and oven drying (T3). The taste scores for the tea samples were 4.1 for T1, 3.9 for T2, and 4.4 for T3, with mean scores of 4.4 for T1, 3.6 for T2, and 4.4 for T3. These scores suggest that the taste of the tea was most acceptable in both the sun-dried and oven-dried samples, while the pan-dried tea received a lower score, indicating less favorable taste. The sun drying (T1) and oven drying (T3) methods were likely more effective in preserving the natural taste of the *Moringa* stems and twigs, resulting in a more pleasant and balanced flavor. The higher taste scores for these methods reflect the better taste preservation. On the other hand, the pan drying (T2) method received a lower score, possibly due to the development of a burnt or overly intense flavor from uneven drying, which negatively affected the overall taste.

Taste is one of the most influential factors in food acceptance, and it significantly impacts consumer preference. Jaeger et al. (2018) emphasize that a well-balanced flavor profile is crucial for increasing consumer liking and ensuring a product's success in the market. When the flavor is balanced, with a proper combination of

sweetness, bitterness, and other taste components, consumers are more likely to accept and enjoy the product. In this study, the more favorable taste scores for sun-dried and oven-dried teas align with findings that preserving the natural flavor of the raw materials enhances the overall acceptability of the product.

Additionally, Drewnowski and Gomez-Carneros (2000) highlight the importance of balancing taste components, such as bitterness and sweetness, to create a harmonious flavor profile that appeals to consumers. The higher ratings for the taste of sun-dried and oven-dried teas may reflect a better balance of the tea's natural flavors, while the pan-dried tea, with its possibly burnt or overly bitter taste, scored lower.

**Table 2**

*Result of Physicochemical Analysis*

Item No.	Sample and Lab Code	Sample Description	Results	
			pH	Moisture Content (%)
232371	685-24-01	Moringa Stem and Twigs Tea	7.15	8.01
Method used			AOAC 981.12, pH Meter	AOAC 925.10, Gravimetric Method

**Physicochemical Analysis** - The physicochemical analysis results presented in Table 2 were submitted to the CBSUA Food Testing Laboratory for evaluation. These tests were conducted on the most preferred sample from Trial 3, which utilized oven drying at a controlled temperature of 50°C for approximately 4 hours and 21 minutes. This trial was chosen due to its superior sensory attributes, particularly in terms of taste and texture, as evidenced by the higher acceptability scores in the sensory evaluation. The physicochemical analysis measured two critical parameters—pH and moisture content—of the final tea product to assess its safety, quality, and shelf stability.

Table 2 presents the results of the physicochemical analysis of the Malunggay (*Moringa Oleifera*) Stems and Twigs Tea, specifically focusing on two key parameters: pH and moisture content. The pH of the final tea product was measured at 7.15, which is classified as neutral, while the moisture content was determined to be 8.01%. These values were obtained from the preferred sample produced using the oven drying method (Trial 3), which was selected due to its superior sensory qualities in terms of taste, texture, aroma, and appearance.

The neutral pH of 7.15 suggests that the tea is well within the acceptable range for consumption. A pH level near neutral is considered ideal for beverages because it minimizes the risk of acidity-related discomfort for consumers. Additionally, a neutral pH supports the stability of the tea's flavor, which is critical for consumer acceptance. The moisture content of 8.01% indicates that the tea has been sufficiently dried, which is important for both preservation and microbial safety. This relatively low moisture level reduces the risk of spoilage and enhances the shelf life of the product, ensuring that it remains safe and stable for consumption over time.

These results are in line with findings from Liu et al. (2020), who highlighted that a neutral pH in food and beverages is important for both safety and consumer comfort, particularly for products like tea. Additionally, Rivera et al. (2018) stressed the significance of moisture control in food preservation, noting that products with moisture content below 10% are less likely to develop microbial contamination, ensuring longer shelf life and quality retention. The physicochemical results for the Moringa tea confirm that it meets the necessary standards for a stable and safe product, supporting its potential for commercial production and consumption.

#### 4. Conclusions and Recommendation

This study successfully explored the potential of *Moringa Oleifera* (Malunggay) stems and twigs as a sustainable and health-promoting raw material for herbal tea production. The primary objectives of the study were to evaluate the sensory acceptability of the tea, considering appearance, texture, aroma, and taste, and to assess the impact of different drying methods—sun drying, pan drying, and oven drying—on these sensory qualities. The study also aimed to determine the physicochemical properties of the most preferred tea sample to

ensure its safety and quality for consumption.

The findings revealed that both sun drying and oven drying methods produced highly acceptable tea, with the oven-dried tea (Trial 3) being the most favored due to its superior sensory attributes in terms of taste, texture, and overall appearance. In contrast, the pan-dried tea received the lowest ratings, particularly for aroma and taste, due to a slightly burnt flavor. The physicochemical analysis confirmed the safety and stability of the tea, with a neutral pH of 7.15 and a moisture content of 8.01%. These values indicate that the tea produced from Moringa stems and twigs is not only safe for consumption but also meets food safety standards, ensuring long-term preservation. Overall, the study demonstrates that Moringa stems and twigs are viable, sustainable raw materials for tea production, contributing to waste reduction while providing a nutritious and functional beverage alternative.

The study's positive results suggest several avenues for future work and commercialization. First, scaling up the production of Moringa tea, particularly using the oven drying method, is recommended. This method produced the highest sensory acceptability scores, making it the best candidate for larger-scale manufacturing. Expanding production could help reduce agricultural waste, providing a sustainable alternative while creating a product with health benefits.

Further sensory testing with a larger and more diverse sample group should be conducted to validate the findings and ensure consistent results across different demographics. Additionally, shelf-life testing under various storage conditions is necessary to determine the product's long-term stability, ensuring it maintains its flavor and quality over time. To facilitate market adoption, it is recommended that the Moringa tea be introduced to health-conscious consumers with a marketing strategy that highlights its antioxidant, anti-inflammatory, and immune-boosting properties. This would position the tea as a functional beverage with added health benefits. Future research could also explore using other parts of the Moringa plant, such as leaves or seeds, to further expand the product range and enhance the health-promoting qualities of the tea.

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