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Phytochemical screening of alkaloid compounds on microencapsulation of *Moringa oleifera* leaf extract

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Abstract

Background: Moringa oleifera leaves are rich in bioactive compounds, including alkaloids. Alkaloid compounds are crucial for their pharmacological potential and role as natural antioxidants in improving food quality and stability. **Objective:** This study aimed to examine the presence of alkaloid compounds in the microencapsulation of Moringa oleifera leaf extract as a strategy to protect active compounds from degradation and retain their nutritional benefits. **Methods:** The Moringa oleifera leaf extract was formulated into microencapsulation using the freeze-drying method. Phytochemical screening for alkaloid compounds was performed using the Dragendorff, Bouchardat, and Wagner tests. **Results:** The phytochemical screening results confirmed the presence (positive) of alkaloid compounds in the microcapsule preparation. This positive result was characterized by the formation of an intense orange-red precipitate (Dragendorff), a reddish-brown precipitate (Bouchardat), and a brown precipitate (Wagner). **Conclusion:** The microencapsulation of Moringa oleifera leaf extract successfully presented positively detected alkaloid compounds. The retention of alkaloids as antioxidants in these microcapsules provides a strong foundation for their development as supplements or fortification ingredients in food products to enhance nutritional value.

Keywords: Microencapsulation; moringa extract; functional foods; antioxidants; alkaloids

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INTRODUCTION

The *Moringa oleifera* leaf, commonly known as the kelor leaf, is an abundant natural resource recognized globally for its superior nutritional content and profile of bioactive secondary metabolites.[1,13] These secondary metabolite compounds include alkaloids, flavonoids, phenolics, saponins, steroids, and quinones.[2,16] Alkaloid compounds are of significant interest due to their extensive pharmacological potential, including anti-inflammatory, anti-tumor, and antimicrobial effects.[1,14] This compound also functions as a powerful natural antioxidant.[3] The antioxidant role contributes significantly to the functionality, quality, and stability of the extract.[4,15]

Despite their rich benefits, bioactive compounds in plant extracts are often highly sensitive.[5,16] This compound is susceptible to rapid degradation.[17] Degradation occurs due to external factors such as exposure to oxygen, light, heat, and humidity.[5,18] This exposure occurs particularly during the drying, processing, and storage stages.[19] This degradation can significantly reduce the biological efficacy and nutritional stability of the extract.[12] Therefore, the degradation of bioactive compounds limits their utilization in the food and supplement industries.[12, 20] To overcome this stability challenge, microencapsulation is proposed as an effective protection strategy.[6, 21] This technique involves encapsulating the active compound (extract) within a polymer coating matrix.[11, 22] In this study, the freeze-drying method was applied.[7] This method is used to formulate Moringa oleifera leaf extract into microcapsule preparations.[8] Freeze-drying was chosen because of its ability to minimize thermal damage, which is ideal for maintaining the integrity of sensitive bioactive compounds, including alkaloids.[8, 23]

This study aims to examine the presence of alkaloid compounds in microencapsulated preparations of Moringa oleifera leaf extract processed using freeze drying.[10] Verifying the presence of alkaloids through phytochemical screening.[9] serves as an initial indicator of the successful encapsulation technique in protecting active compounds from degradation and maintaining their nutritional benefits.[6, 24]

METHODS

Study design and setting

This research is a laboratory experimental study conducted in August 2025 at the FST Laboratory of Jambi University and the Animal Husbandry Laboratory of Jambi University.

Population, samples and sampling

The sample used in this study was the microencapsulated powder of Moringa oleifera leaf extract (M. *oleifera* microcapsules). No human or animal subjects were involved. The variable involved was the presence of alkaloid compounds within the final microencapsulated product.

Instruments and criteria

The primary analytical instrument used was phytochemical screening with specific chemical reagents to detect alkaloid compounds.[9]

Procedure and data collection

The concentrated Moringa oleifera leaf extract was prepared through a standard extraction process.[1,16] The extract was then formulated with a coating material (polymer matrix) and subsequently processed into microcapsule powder.[22] The liquid preparation was dried using a freeze dryer to obtain the dry microcapsule product.[7]

Skrining fitokimia alkaloid

Qualitative phytochemical screening was performed on the Moringa oleifera extract microcapsules post-freeze-drying to test for the presence of secondary metabolite compounds.[10,24] The alkaloid test was specifically conducted using the Dragendorff, Bouchardat, and Wagner methods.[9,25] A positive result (detected) was indicated by the formation of specific precipitates: (1) Reagen Dragendorff: Endapan jingga-merah intens.[9]; (2) Reagen Bouchardat: Endapan cokelat kemerahan.[10]; (3) Reagen Wagner: Endapan cokelat.[9]

Statistical analysis

This study utilized qualitative analysis (phytochemical screening) to determine the presence or absence of alkaloid compounds.[24]

Ethical concideration

Since the research involved only plant-based materials and laboratory analysis, no specific ethical clearance from an ethics committee was required. The study was conducted following standard laboratory safety protocols.

RESULTS

The main outcome reported here is the result of the qualitative phytochemical analysis for alkaloid compounds in the microencapsulated product. The qualitative phytochemical screening results, as summarized in Table 1, indicate that the microencapsulated *Moringa oleifera* extract was positive for the Alkaloid compound group.[10]

Table 1. Alkaloid Phytochemical Screening on *Moringa oleifera* Microcapsules

Characteristics	Reagent Used	Result
Alkaloids	Dragendorff	Positif (Endapan jingga-merah intens)
	Bouchardat	Positif (Endapan cokelat kemerahan)
	Wagner	Positif (Endapan cokelat)

The positive results were consistently confirmed by the formation of the characteristic precipitates with all three reagents: an intense orange-red precipitate with Dragendorff, a reddish-brown precipitate with Bouchardat, and a brown precipitate with Wagner.[9, 10]

DISCUSSION

The positive result for alkaloid compounds in the microcapsule preparation is a critical finding [2, 10]. This confirms that the alkaloids initially present in the Moringa oleifera leaf extract were successfully protected and maintained during the processing.[1,24] This active compound is protected during the extraction, formulation, and microencapsulation stages.[6, 22] The freeze-drying method plays a key role in the success of this retention.[7, 8] This technique, also known as lyophilization, avoids the high temperatures that are typically damaging.[23, 26] Unlike conventional drying,

which can cause thermal degradation, freeze-drying maintains the integrity of compounds.[23] Minimizing this thermal damage is particularly important for sensitive and volatile bioactive compounds, including alkaloids.[23,24] Successful retention indicates that the selected polymer matrix and freeze-drying technique effectively form a physical protective barrier.[11,21]

This barrier prevents the compounds from being exposed to damaging external factors (oxygen, heat, light).[18,22] The presence of alkaloids is highly significant because they have been shown to function as powerful natural antioxidants.[3, 14] By successfully encapsulating these compounds, the microcapsule product offers enhanced stability.[15, 20] This increased stability also ensures longer retention of antioxidant properties.[4] The preservation of these alkaloids provides a strong foundation for developing microcapsules as functional ingredients.[12] These functional ingredients can be used effectively for food fortification or as nutritional supplements.[12,20] This utilization can help address malnutrition because Moringa is rich in essential nutrients.[13,1] A potential limitation of this study is that it is only a qualitative analysis (presence/absence).10 Further research should use quantitative methods (spectrophotometry) to determine the precise concentration of alkaloid compounds retained post-encapsulation.[27] Quantitative measurements are necessary to accurately assess encapsulation efficiency.[24] Additionally, it is important to compare these results with other encapsulation techniques, such as spray drying.[7,28]

CONCLUSIONS

The microencapsulation of Moringa oleifera leaf extract using the freeze-drying method was successful in protecting and retaining alkaloid compounds, as confirmed by positive results in the Dragendorff, Bouchardat, and Wagner tests.[9,10] The successful preservation of alkaloids known antioxidants in the microcapsules provides a strong foundation for developing this product as a stable and valuable ingredient for supplementing or fortifying food products to enhance their nutritional profile.[12, 20] Future work should focus on quantitative analysis to determine the encapsulation efficiency, assess the antioxidant activity in vitro and in vivo of the microcapsules, dan evaluate their stability under various storage conditions.[1]

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

This study used artificial intelligence (AI) tools and methodologies in the following capacities Manuscript writing support: AI-based language models, such as [for example, ChatGPT, Quillbot], were/was employed to: Language refinement (improving the grammar, sentence structure, and readability of the manuscript); Content summarization (assisting in summarizing the findings and conclusions concisely); Technical writing assistance (providing suggestions for structuring complex technical descriptions more effectively). We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the

integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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