Media Pendidikan Gizi dan Kuliner

Journal homepage: https://ejournal.upi.edu/index.php/Boga/index

Substituting Popping Boba in Coffee Serving Using a Gastronomic Method

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ABSTRACTS

Popping boba is a type of boba that does not use tapioca flour as its basic ingredient; therefore, it has a soft texture with a liquid core, characterized by a delicate outer layer and a burst of liquid inside. Coffee is recognized as one of Indonesia's key export commodities. Over the past five years, Indonesia has ranked fourth among the world's coffee exporters, behind Brazil, Colombia, and Vietnam. This study employed a questionnaire method using a hedonic (preference) test conducted by panelists. The authors first identified an appropriate formulation for popping boba, then distributed the samples to the panelists, and finally analyzed the respondents' questionnaire responses. The data were examined using descriptive statistics, including the mean, median, mode, and standard deviation. Based on the average scores of four sensory aspects taste, color, texture, and aroma the coffee popping boba formulation containing 75% calcium lactate, 75% sodium alginate, and 75% coffee achieved the best results. For expert panelists, this formulation received a total score of 36.6, with an average score of 3.1, while non-expert panelists gave a total score of 37.6, with an average score of 3.1. Overall, the results indicate that the use of calcium lactate and sodium alginate in the production of coffee popping boba was successful, as the hedonic test results were predominantly in the "liked" category.

ARTICLE INFO

Article History:
Received 15 May 2025
Revised 22 Jul 2025
Accepted 05 Sep 2025
Available online 01 Nov 2025

Keyword:
Acceptability,
Calcium Lactate and Sodium Alginate,
Popping Boba

1. INTRODUCTION

Culinary culture is widely recognized as a manifestation of culture that is closely associated with local communities. Beyond its primary function as a source of food to fulfill basic human needs, cuisine also embodies historical and philosophical values. Authentic cuisine reflects the creativity of local communities in preparing food ingredients while preserving traditional culinary values. Indonesian culinary heritage, therefore, is highly significant and must be preserved and safeguarded in its authenticity (Hakim & Hamidah, 2021; Abror et al., 2024). This authenticity adds value by enriching tourists' experiences through direct interaction with local communities. Culinary experiences are also consistently favored by tourists.

When travelers visit a destination, they often gain unique experiences by asking about local dishes, tasting traditional products, and learning about the communities' customs and traditions. Culinary aspects thus represent a distinctive advantage that both governments and local communities should continuously develop. Beverages constitute an integral part of the human diet, beginning from infancy. The dietary cycle starts with infant formula, a highly complex beverage rich in essential nutrients. As humans age and their nutritional requirements evolve, product developers respond by creating new and innovative beverages to meet these changing needs. Innovative beverage products commonly available in the market include matcha milk coffee and mango ice smoothies. However, gastronomic coffee products have not yet been widely explored. Therefore, this study aims to investigate "Popping Boba in Coffee Beverage Presentation Using Gastronomic Methods."

Popping boba is one type of boba that does not use tapioca flour as its base ingredient. Consequently, it has a soft texture with a liquid interior, characterized by a delicate outer layer and a bursting liquid core (Utami et al., 2021). In addition, popping boba production uses the spherification method, which forms spherical structures without heating; as a result, phenolic compounds and other nutrients are optimally preserved (Taku et al., 2025). Spherification is a technique that creates food products with a semi-solid outer surface and a liquid interior (Gaikwad et al., 2019). This method falls under the category of gel formation through diffusion. The primary materials used are sodium alginate and calcium lactate. When sodium alginate interacts with calcium ions, gelation occurs on the outer surface.

The longer the product remains immersed in a calcium lactate solution, the more the outer liquid layer transforms into a gel, while the inner core remains liquid. Sodium alginate is widely used in the food and pharmaceutical industries for gel formation. When dissolved in calcium lactate solution, sodium alginate rapidly forms an insoluble gel.

Coffee is recognized as one of Indonesia's key export commodities. Over the past five years, Indonesia has ranked fourth among the world's coffee exporters, behind Brazil, Colombia, and Vietnam. Traditionally, Indonesian coffee is brewed using the kopi tubruk method, in which coffee grounds are directly steeped in hot water. However, in certain regions, coffee enthusiasts have developed unique innovations that serve as distinctive characteristics of their local coffee culture.

Based on the above considerations, this study proposes an experimental approach to processing coffee beverages using gastronomic methods in order to provide a novel coffee-drinking experience. Accordingly, the study is entitled "Substitution of Popping Boba in Coffee Presentation Using Gastronomic Methods."

DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123

2. LITERATURE REVIEW

2.1. Definition of Popping Boba

Popping boba, also known as juice pearls, is a popular addition to beverages such as bubble tea and is recognized for its distinctive "burst-in-the-mouth" sensation when bitten (Nicholas et al., 2022). In the culinary field, popping boba has been creatively incorporated into healthy family beverages made from fruits and vegetables, demonstrating the versatility of these gel spheres (Sukaris et al., 2023).

Furthermore, popping boba is not limited to beverages; it has also been introduced in educational settings to teach students the concept of spherification, highlighting its versatility and educational value as a gel-based product (Singhal & Gupta, 2023). The sensory qualities of boba, including popping boba, have been a key focus of research, underscoring the importance of aroma, taste, and ingredients in creating a pleasurable culinary experience (Juliana et al., 2022).

2.2. Definition of Coffee

Coffee is widely recognized as a beverage that plays a significant role in both cultural and economic contexts across many countries. The coffee roasting process, for example, is a key factor in determining coffee quality (Santoso et al., 2021; Oliveira & Oliveira, 2023). In addition, coffee characteristics are influenced by factors such as bean variety, processing methods, and maturity level (Yusibani et al., 2023; Teran, 2024; Bollen et al., 2025). Arabica and Robusta are the two most commonly produced and consumed coffee species worldwide (Bunn et al., 2015).

2.3. Definition of Gastronomy

Gastronomy is a field of study that examines the relationship between culture and food (Rajan, 2023; Kapitány & Kapitány, 2024). In a broader sense, gastronomy encompasses all aspects related to the enjoyment of food and beverages. It explores various cultural dimensions with food as the central subject of study, often referred to as culinary art. Gastronomy, also known as culinary arts, is recognized as both an art and a science of good eating (*bonne cuisine*) (Lee & Bucher, 2023). Thus, gastronomy can be broadly defined as a discipline that studies food as an artistic and cultural expression.

2.4. Definition of Sodium Alginate

Sodium alginate serves as a thickening agent and can replace cetyl alcohol due to its functional properties. In addition to its ability to form gels, alginate is also widely used as a thickener, water-binding agent, emulsifier, and stabilizer in food and pharmaceutical applications (Wylie, 1973).

3. METHODS

This study analyzed preferences for Popping boba (taste, aroma, texture, and color) using organoleptic testing. Data analysis techniques are methods and procedures used to process and analyze data. In this study, the author will use quantitative research methods. This is an experimental study with three treatments based on jackfruit addition: control (P1), (P2), and (P3). The subjects were 30 non-expert panelists and three expert panelists.

DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

4. RESULTS AND DISCUSSION

The following are the conclusions from the calculation of the product "Substitution of Popping Boba in Serving Coffee Using the Gastronomic Method."

4.1. Sensory Evaluation by Expert Panelists

The data obtained regarding the sensory evaluation results by the expert panelists are shown in **Table 1**.

Table 1. Conclusion of the Questionnaire Results of Substitution Products Using Calcium Lactate and Sodium Alginate in Making Popping Boba Coffee.

Test	Dimensions	Total Score	Mean	Median	Modus	Standard Deviation
P1	Flavor	2,6	2,6	3	3	0,55
	Color	3,2	3,2	3	3	0,55
	Texture	2,4	2,4	2	2	0,55
	Aroma	3,8	3,8	3	3	0,84
P2	Flavor	3,8	3,8	4	4	0,45
	Color	3,6	3,6	4	4	0,55
	Texture	2,6	2,8	4	4	0,55
	Aroma	2,8	2,8	4	4	0,45
P3	Flavor	2,4	2,4	2	2	0,89
	Color	3,2	3,2	4	4	1,1
	Texture	2,6	2,6	3	2	0,89
	Aroma	2,4	2,4	3	3	0,71
	Total	**36,6**	**36,6**	**39**	**38**	**8,37**
	Average	**3,1**	**3,1**	**3,3**	**3,2**	**0,70**

In the production of coffee popping boba using calcium lactate and sodium alginate substitution, conclusions were obtained from questionnaire data from 5 panelists in the expert category. The selection of 5 expert panelists was in accordance with sensory evaluation standards for descriptive testing, which recommend 4-8 trained panelists to obtain valid and consistent results (Lawless & Heymann, 2010; Yadav et al., 2025). Expert panelists are individuals who have received extensive training in specific sensory attributes and can provide objective assessments of food product characteristics (Drake, 2007; Torrico et al., 2023).

The evaluation was conducted using four main sensory aspects: taste, color, texture, and aroma across three experimental formulations (P1, P2, and P3). The selection of these four aspects aligns with standard sensory evaluation parameters for spherification-based products, which emphasize appearance (color), flavor (taste), aroma, and texture as key factors in consumer acceptance (Głuchowski et al., 2021; Kunto et al., 2022). The total score for the taste aspect across the three experimental formulations was 3.1, with the conclusion of "tend to like". This positive taste assessment indicates that the combination of calcium lactate with coffee provides an acceptable flavor profile, where calcium lactate is known to have a neutral taste compared to calcium chloride, which tends to be bitter and salty (de Paula et al., 2014; Sen, 2017; Delompré et al., 2019).

The total score for the color aspect across the three experimental formulations was 3.1, with the conclusion of "tend to like". Color is the first visual parameter that influences consumer perception of product quality, and popping boba with attractive colors tends to increase taste expectations before consumption (Delwiche, 2004; King & Meiselman, 2010). The total score for the texture aspect across the three experimental formulations was 3.3,

DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123

with the conclusion of "tend to like". Optimal popping boba texture is characterized by a thin yet strong gel membrane with a distinctive "burst-in-mouth" effect, where the cross-linking reaction between calcium ions from calcium lactate and sodium alginate forms a stable gel structure (Sen, 2017). The total score for the aroma aspect across the three experimental formulations was 3.2, with the conclusion of "tend to like". The distinctive coffee aroma contributes significantly to the overall acceptability of popping boba products (Drake, 2007).

Based on the research results of the calcium lactate and sodium alginate substitution product in coffee popping boba production, a total overall score of 36.6 was obtained, which falls into the "very much like" category. This high total score indicates that the reverse spherification process using calcium lactate successfully produced a product with excellent sensory quality (Samard et al., 2023). The lowest indicator in the questionnaire was the taste aspect (P3), with a score of 2.4. The low score for formulation P3 was likely due to an imbalance in the calcium lactate-to-sodium alginate ratio, which affects membrane strength and flavor release. Meanwhile, the highest scores were in the taste, color, and aroma aspects (P2) and color and texture (P2), with a score of 3.8, indicating that formulation P2 has an optimal balance between gel-forming components and flavor liquid (Sen, 2017).

The research results show that expert panelists were interested in the experimental formulation of calcium lactate and sodium alginate in coffee popping boba production. The panelists' interest in molecular gastronomy-based product innovations aligns with the trend of increasing consumer demand for food products with unique textures and attractive sensory experiences (Głuchowski et al., 2021). Among the three experimental formulations of calcium lactate and sodium alginate for coffee popping boba production, based on collected panelist data, panelists preferred formulation P2. The preference for formulation P2 indicates that this composition produces superior sensory characteristics compared to other formulations, with a membrane that is neither too thick nor too thin, yet strong enough to maintain structural integrity and provide an optimal "popping" sensation when consumed (Bubin et al., 2019; Venkatachalam et al., 2025).

4.2. Sensory Evaluation by Non-Expert Panelists (Consumers)

The data obtained regarding the sensory evaluation results by the non-expert panelists are shown in **Table 2**.

Table 2. Conclusion of the Questionnaire Results for Substitution Products Using Calcium Lactate.

Test	Dimensions	Total Score	Mean	Median	Modus	Standard Deviation
P1	Flavor	3,6	3,6	4	4	0,62
	Color	3,0	3	4	4	0,51
	Texture	4	4	4	4	0,61
	Aroma	2,9	2,9	4	4	0,50
P2	Flavor	3	3	3	4	0,67
	Color	3,1	3,1	3	4	0,52
	Texture	3	3	4	3	0,59
	Aroma	2,9	2,9	3	3	0,66
P3	Flavor	2,8	2,8	3	4	0,75
	Color	2,6	2,6	3	3	0,72
	Texture	3	3	4	3	0,76
	Aroma	2,6	2,6	3	4	0,72
	Total	**37,6**	**37,4**	**40**	**38**	**7,64**

DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

Average	**3,1**	**3,1**	**3,3**	**3,2**	**0,64**

In the production of coffee popping boba using calcium lactate and sodium alginate substitution, conclusions were obtained from questionnaire data from 30 panelists in the non-expert (consumer) category. The use of 30 untrained panelists met the minimum recommendation for consumer hedonic testing, which requires a minimum of 75-80 consumers for 1-2 samples, although for preliminary studies, 20-50 panelists can be used (Lawless & Heymann, 2010; Torrico et al., 2023; Yadav et al., 2025). Non-expert panelists are general consumers who evaluate products based on personal preferences without specialized technical training, so their evaluations reflect more realistic market acceptance (Torrico et al., 2023).

The evaluation was conducted using four sensory aspects: taste, color, texture, and aroma across three experimental formulations. The use of hedonic scales to measure consumer preference levels is the most commonly used method in new food product development because it directly relates to consumer acceptance in the market (Lawless & Heymann, 2010; Jaeger et al., 2020). The total score for the taste aspect across the three experimental formulations was 3.1, with the conclusion of "tend to like". The consistency of taste scores between expert panelists and consumers shows that the developed flavor profile has broad acceptability. The total score for the color aspect across the three experimental formulations was 3.1, with the conclusion of "tend to like". The consistently positive color ratings from both panelist groups confirm that the product's visual aspect has met consumer expectations for coffee popping boba (Silva et al., 2025).

The total score for the texture aspect across the three experimental formulations was 3.3, with the conclusion of "tend to like". Texture received the highest score among all attributes, indicating that the "popping" effect and mouthfeel produced by the spherification process were highly appreciated by consumers (King & Meiselman, 2010; Sen, 2017). The spherification process using sodium alginate and calcium lactate creates a gel membrane that provides a unique sensation when it bursts in the mouth, suddenly releasing the coffee liquid inside (Kamil et al., 2025). The total score for the aroma aspect across the three experimental formulations was 3.2, with the conclusion of "tend to like", indicating that the distinctive coffee aroma was successfully retained through the encapsulation process in the alginate membrane (Drake, 2007).

Based on the research results on the calcium lactate and sodium alginate substitution product for coffee popping boba production, a total score of 37.6 was obtained, which falls into the "very much like" category. The slightly higher total score for consumer panelists (37.6) compared to expert panelists (36.6) indicates that this product has strong market acceptance potential (Lawless & Heymann, 2010; Yadav et al., 2025). The lowest indicator in the questionnaire was the taste aspect (P3), with a score of 2.4. The consistency of the lowest score for formulation P3 across both expert panelists and consumers strengthens the validity of the results, which indicate that this formulation requires further optimization (Torrico et al., 2023). Meanwhile, the highest scores were in the taste, color, and aroma aspects (P2) and color and texture (P2), with a score of 3.8.

The similarity in preferences between expert panelists and consumers for formulation P2 indicates a strong correlation between objective evaluation and subjective consumer acceptance (Drake, 2007; Głuchowski et al., 2021). The research results show that consumer panelists were interested in the experimental formulation of calcium lactate and sodium alginate in coffee popping boba production. Consumer interest in innovative molecular gastronomy-based products such as popping boba reflects the shift in modern consumer

DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123

preferences seeking new sensory experiences in beverage products (King & Meiselman, 2010). Among the three experimental formulations of calcium lactate and sodium alginate for coffee popping boba production, based on collected panelist data, panelists preferred formulation P2.

The consistent preference for formulation P2 by both panelist groups confirms that it is the optimal composition, providing the best balance between gel membrane strength, "popping" effect, flavor release, and product stability. Formulation P2 likely has an optimal ratio between sodium alginate (0.5-2.5% w/w) and calcium lactate (5% w/v solution) that produces a membrane with the right thickness to provide a pleasant burst sensation without texture that is too hard or too fragile (Sen, 2017). The use of calcium lactate as a calcium ion source has proven superior to calcium chloride in directly consumable product applications because it does not impart an unwanted aftertaste (Sen, 2017; Ecarma & Nolden, 2021).

Viewing from the four aspects (taste, color, texture, and aroma) among P1, P2, and P3 as shown in the table above, formulation P2 consistently shows the best performance, indicating that formulation optimization has reached the optimal balance point to produce coffee popping boba products with the highest acceptability (Lawless & Heymann, 2010; Torrico et al., 2023; Yadav et al., 2025). These results provide a strong scientific basis for the development of coffee-popping boba products on a commercial scale, using formulation P2 as the standard.

5. CONCLUSION

Based on the research results conducted by the Author entitled "Substitution of Popping Boba in Coffee Presentation Using Gastronomy Method", the following results were obtained: The trial results of using calcium lactate and sodium alginate in the production of coffee popping boba can be utilized as an innovation in popping boba manufacturing. The experimental trial of 3 formulas of calcium lactate and sodium alginate in the production of Coffee Popping Boba with different formulations, namely (50% Calcium lactate, Sodium alginate and 50% coffee), (75% Calcium lactate, Sodium alginate and 75% Coffee), and (100% calcium lactate, sodium alginate and 100% Coffee), concluded that the formulation used by the author in the application of calcium lactate and sodium alginate in the production of Coffee Popping Boba yielded good results. However, the base material containing 100% calcium lactate and sodium alginate lacks texture, resulting in a lack of chewiness. Based on the mean, median, mode, and standard deviation values obtained from calculations and questionnaire distribution to expert and non-expert panelists: For expert panelists: The overall product total value was 44.2 with an average value of 3.7, and the most preferred was P1 (50% calcium lactate, sodium alginate and 50% Coffee) with a total value of 108 and an average value of 15, with a mean of 3.75. For non-expert panelists: The overall product total value was 42.6, with an average value of 3.6, and the most preferred was P1 (50% calcium lactate, sodium alginate, and 50% Coffee), with a total value of 14.7 and an average value of 3.67. The product containing calcium lactate and sodium alginate in the production of Coffee Popping Boba was accepted, with values predominantly in the "Very Like" category for Taste, Color, and Texture. However, there were still "Dislike" ratings for the Aroma of calcium lactate and sodium alginate in the production of Coffee Popping Boba.

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p- ISSN 2775-8400 e- ISSN 2775-9857

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