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Development of dadih powder through spray drying using maltodextrin and gum Arabic encapsulation

[Pengembangan dadih bubuk dengan spray drying melalui enkapsulasi maltodekstrin dan gum Arab]

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ABSTRACT

Traditional fermented products such as dadih have great potential in addressing malnutrition among vulnerable populations, including children, the elderly, and individuals with special nutritional needs. This study aimed to develop dadih powder using the spray drying method with maltodextrin and gum arabic as encapsulating agents, and to contribute to the development of functional foods derived from traditional fermented milk. A completely randomized design (CRD) with a single factor was applied, consisting of five formulations of maltodextrin and gum arabic, each replicated three times. The results showed that the optimal formulation of 70% maltodextrin and 30% gum arabic produced a lactic acid bacteria viability of 9.0×10^7 CFU/g, protein content of 20.57%, moisture content of 3.40%, and the highest sensory scores for texture and taste (3.88). Although the lactic acid bacteria count decreased from the raw material (5.7×10^{10} CFU/g), the final product still exceeded the minimum threshold of 10^6 CFU/g required to provide probiotic benefits. With these characteristics, the product meets the criteria of a probiotic food and holds potential as a functional food. These findings highlight that spray drying with a combination of maltodextrin and gum arabic is an effective method to produce dadih powder with favorable nutritional quality, probiotic viability, and sensory attributes, while also enhancing the value of this traditional dairy product.

Keywords: dadih; spray drying; maltodextrin; gum arab; functional food

ABSTRAK

Produk fermentasi tradisional seperti dadih memiliki potensi besar dalam mengatasi kekurangan gizi pada populasi rentan, seperti anak-anak, lansia, atau individu dengan kebutuhan gizi khusus. Penelitian ini bertujuan mengembangkan dadih bubuk menggunakan metode *spray drying* melalui teknik enkapsulasi maltodekstrin dan gum arab, serta memberikan kontribusi terhadap pengembangan produk pangan fungsional berbasis susu fermentasi tradisional. Penelitian menggunakan rancangan acak lengkap (RAL) faktor tunggal dengan lima formulasi maltodekstrin dan gum arab yang dilakukan dengan tiga kali ulangan. Hasil penelitian menunjukkan bahwa formulasi optimal antara maltodekstrin (70%) dan gum arab (30%) menghasilkan viabilitas bakteri asam laktat 9,0 x 10^7 CFU/g, kadar protein 20,57%, kadar air 3,40%, serta sensori terbaik pada tekstur dan rasa (3,88) Meskipun terjadi penurunan jumlah bakteri asam laktat dari bahan baku, kandungan probiotik tetap berada di atas ambang batas minimum 10^6 CFU/g. Dengan karakteristik tersebut, produk ini memenuhi kriteria sebagai pangan probiotik, dan berpotensi dikembangkan sebagai pangan fungsional. Temuan ini menegaskan bahwa *spray drying* dengan kombinasi malodekstrin dan gum arab dapat menjadi metode yang efektif untuk menghasilkan dadih bubuk probiotik dengan kualitas gizi dan sensori yang baik, sekaligus meningkatkan nilai tambah pangan lokal.

Kata kunci: dadih, *spray drying*, maltodekstrin, gum arab, pangan fungsional

Introduction

The demand for functional foods in Indonesia has increased significantly in recent years, especially during the COVID-19 pandemic, with sales of products supporting immune health rising by 20%–40%, driven by growing public awareness of the importance of health (Kaur et al., 2022). Functional foods are not only designed to provide essential nutrients but also to offer additional health benefits, such as disease prevention and improved well-being. During pregnancy, adequate nutritional intake is crucial to support fetal development and maternal health (Dolin et al., 2021). One functional food with great potential is dadih, a traditional fermented product from West Sumatra. Dadih is an Indonesian traditional fermented dairy product made from buffalo milk through a natural fermentation process. This fermented product is naturally rich in probiotics beneficial for digestive health and high in protein and essential amino acids that support body tissue growth and repair (Pramana et al., 2025).

Dadih has the potential to be developed as a functional product to meet the high nutritional demand for lactic acid bacteria as probiotics (Arnold et al., 2021). One of the main challenges in developing powdered dadih products is maintaining nutritional stability. This challenge arises because the conversion from liquid to powder form through spray drying can reduce probiotic viability, decrease heat-sensitive vitamin content, and cause protein denaturation due to exposure to high temperatures and stressful conditions during the production process. Spray drying is one of the most commonly used processing techniques to convert liquid milk into powder, offering a fast and efficient process to reduce moisture content and extend product shelf life. This technology is widely applied, particularly in the dairy industry, accounting for about 80% of the total commercially produced milk powder (Kumoro et al., 2024). However, one limitation of spray drying is its dependence on high temperatures, which can damage heat-sensitive nutrients, including probiotics (Marlida et al., 2021).

Spray drying is a rapid drying process that converts liquid into powder by spraying the liquid into a stream of hot gas (Mardawati et al., 2020). However, this process can lead to the loss of certain types of lactic acid bacteria that are sensitive to high temperatures. To overcome this issue, the use of encapsulating agents such as maltodextrin and gum arabic can help protect probiotics during the spray drying process. Maltodextrin is selected for its ability to form a protective coating and its good hydrophilic properties, while gum arabic is chosen for its emulsifying properties, which help maintain structure and improve product stability during drying (Nguyen et al., 2017; Yusa Ali et al., 2024). The formulation of these two encapsulating materials is expected to optimize probiotic protection and maintain the nutritional quality of powdered dadih.

The formulation of instant milk with the addition of powdered dadih requires optimization of component composition to ensure optimal probiotic bacterial growth and consistent product quality. The use of 80% skim milk in the dadih formulation is based on the natural protein composition of milk, which consists of 80% casein and 20% whey protein—proportions proven to be optimal for the fermentation process (Malos et al., 2025). Standardizing this formulation is essential to ensure that probiotic viability reaches at least 10^7 CFU/g, as required for probiotic effectiveness in fermented food products (Vinderola et al., 2011). With the growing interest in functional foods, powdered dadih can serve as an innovative, value-added ingredient in ready-to-drink milk and other functional food products. Containing bioactive components beneficial to digestive and immune health, powdered dadih holds strong potential for global commercialization in support of the international trend toward healthy food consumption (Pramana et al., 2025). This study aims to develop powdered dadih using the spray drying method through encapsulation techniques with maltodextrin and gum arabic. The results of this research are expected to make a significant contribution to the development of dadih-based functional food products and to serve as a guideline for the food industry in selecting effective processing techniques. Furthermore, it supports innovation in the diversification of traditional fermented dairy products and enhances the added value of dadih as a local food with strong potential for broad commercialization at both national and international levels.

Materials and methods

Materials and equipment

The materials used in this study included dadih, a fermented dairy product made from buffalo milk originating from West Sumatra, Indonesia, Skim milk powder, maltodextrin and gum arabic as encapsulating agents.

Research methodology

This study employed a completely randomized design (CRD) with a single factor consisting of five formulation treatments of maltodextrin and gum arabic: A (100%:0%), B (80%:20%), C (70%:30%), D (60%:40%), and E (50%:50%). Each treatment was replicated three times. The data obtained were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level to determine differences among treatments (Djamaris et al., 2024).

Research implementation

The raw material used in this study was dadih, a fermented buffalo milk product originating from Nagari Aia Dingin, Lembah Gumanti District, West Sumatra. The dadih used was 48 hours old after the fermentation process began in bamboo containers. Before further processing, the dadih was characterized to determine its probiotic content, fat content, protein content, moisture content, ash content, and total lactic acid bacteria. This analysis was conducted to ensure that the dadih contained at least 10^{10} CFU/g before processing, so that the probiotics in the product would remain effective throughout the drying process (Parhusip et al., 2024).

After the dadih raw material was characterized—meeting the criteria of semi-solid consistency, a distinctive sour aroma, and containing at least 10^{10} CFU/g of lactic acid bacteria—the next stage was the homogenization of dadih with encapsulating agents consisting of maltodextrin (MD) and gum arabic (GA), following the method of Sumanti et al. (2016). This process was carried out using a high-speed mixer for 5 minutes to ensure complete mixing of the encapsulating materials with the dadih. The formulation of maltodextrin (MD) and gum arabic (GA) was selected based on the aim of achieving an optimal balance between probiotic stability and the sensory characteristics of the product, using appropriate carrier materials to optimize encapsulation. The variations in maltodextrin and gum arabic formulations used were as follows: A (100% Maltodextrin : 0% Gum Arabic), B (80% Maltodextrin : 20% Gum Arabic), • C (70% Maltodextrin : 30% Gum Arabic), D (60% Maltodextrin: 40% Gum Arabic), E (50% Maltodextrin: 50% Gum Arabic).

The drying of the dadih and encapsulant mixture was carried out using the spray drying method, referring to (Hanidah et al., mardawati2021) and Seveline (2018). The mixture was fed into a spray dryer with an inlet temperature of 140°C and an outlet temperature of 60°C to ensure optimal powder formation while maintaining the nutritional content of the final product. This process aimed to reduce the moisture content of the dadih, thereby improving its shelf life and product stability.

The powdered dadih obtained from spray drying was blended with 80 g of skim milk powder for every 20 g of dadih powder. This formulation was selected to optimize the protein and calcium content in the final product and to create a suitable texture for instant milk applications. All equipment used was sterilized to maintain product quality and hygiene. The mixing process was carried out aseptically under sterile, contamination free conditions to ensure that the final product remained safe and met the quality standards of functional foods. The addition of skim milk also aimed to enhance the nutritional value of the final product, while improving its texture and flavor.

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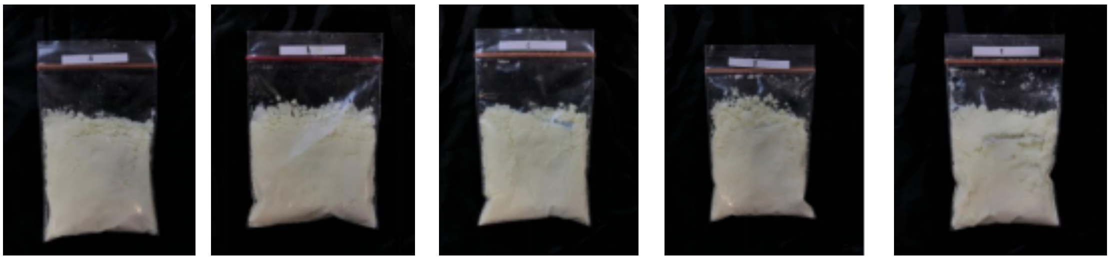

(a) (b) (c) (d) (e)

Figure 1. Powdered dadih milk with different formulations : (a) MD 100: GA 0, (b) MD 80: GA 20, (c) MD 70: GA 30, (d) MD 60: GA 40, (e) MD 50: GA 50

Research parameters

(1) Proximate analysis

Proximate analysis was carried out based on AOAC 2005: water and ash content using the gravimetric method, protein content using the micro Kjeldahl method, and fat content using the Soxhlet method with n-hexane as a solvent.

(2*) Total lactic acid bacteria*

The procedure for analyzing the total lactic acid bacteria (LAB) refers to (Li et al., 2024). One ml of the sample was dissolved in 9 ml of physiological saline to obtain the initial dilution. Serial dilutions were then prepared to the desired levels (e.g., 10^{-7}, 10^{-8}, and 10^{-9}). From each dilution, 0.1 ml of the solution was pipetted onto MRS agar in sterile Petri dishes using the spread plate method. The Petri dishes were then incubated in an inverted position at 37°C for 48 hours. After incubation, the grown colonies were counted using a colony counter, and the number of lactic acid bacteria in the sample was calculated in CFU/g based on the detected colony count. This procedure provided information on the total number of lactic acid bacteria present in the sample.

(3) Sensory evaluation

The hedonic analysis procedure (Setyaningsih et al., 2010) began with the preparation of samples to be tested, which were placed in containers labeled with random codes to avoid bias. The sensory evaluation involved 25 trained panelists. All panelists were provided with basic knowledge of sensory testing, including an understanding of the evaluated attributes and testing procedures, before the assessment. Panelists were then asked to assess the samples based on characteristics such as color, aroma, taste, and texture using a hedonic scale, where a score of 1 indicated “dislike very much” and a score of 5 indicated “like very much.” Each panelist was given a form to record their evaluations, and drinking water was provided to cleanse the palate between samples.

Results and discussion

(1) Nutritional quality of fresh dadih

Based on Table 1, the fresh dadih used as the raw material contained 5.7×10^{10} CFU/g of lactic acid bacteria, indicating excellent probiotic quality. The moisture content of fresh dadih reached 83.36%, which is typical for fermented dairy products. The protein content of 5.98% and fat content of 8.00% reflect its high nutritional value, while the ash content of 0.91% indicates a good mineral composition in the dadih raw material.

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Table 1. Nutritional quality and total LAB of fresh dadih before spray drying

Analysis	Content
Total LAB (CFU/g)	5.7 x 10^{10}
Moisture content (%)	83.36 ± 0.36
Ash content (%)	0.91 ± 0.007
Protein content (%)	5.98 ± 0.04
Fat content (%)	8.00 ± 0.17

(2) Nutritional quality of powder dadih

In the spray drying process, the encapsulant formulation of maltodextrin (MD) and gum arabic (GA) plays a crucial role in maintaining the quality of powdered dadih, particularly in preserving the number of lactic acid bacteria (LAB) and nutritional integrity (Medfai et al., 2023). The dadih mixture enriched with the optimal MD and GA formulation was atomized into fine droplets and rapidly dried at an inlet temperature of 140°C and an outlet temperature of 60°C. The addition of MD and GA before drying helped form a protective layer around the probiotics, thereby maintaining their viability during the thermal process (Gullifa et al., 2023). The results of the nutritional quality analysis of powdered dadih with various maltodextrin and gum arabic formulations are presented in Table 2. Based on statistical notation, treatment A (100% MD : 0% GA) showed the lowest moisture content (2.79%), while treatment E (50% MD: 50% GA) had the highest moisture content (3.96%). The higher moisture content observed in formulations with greater GA proportions is attributed to the hygroscopic nature of gum arabic, which enables it to attract and retain water (Jovic et al., 2023). Consequently, formulations containing higher levels of GA exhibited higher moisture contents. In contrast, formulations with higher MD proportions tended to have lower moisture levels, contributing to improved product stability (Anisuzzaman et al., 2022).

Table 2. Nutritional quality of powdered dadih milk based on maltodextrin and gum arab formulations

MD: GA	Moisture content(%)	Ash content (%)	Protein content(%)	Fat content (%)	LAB (CFU/mg)
A (100%: 0%)	2.79±0.26^{e}	1.94 ± 0.01^{e}	20.51±0.03^{d}	4.30±0.62^{e}	2 x 10^{7b}
B (80%: 20%)	3.09±0.09^{d}	2.36±0.08^{d}	20.56±0.01^{c}	4.55±0.36^{d}	1.3 x 10^{7c}
C (70%: 30%)	3.40±0.03^{c}	2.57±0.06^{c}	20.57±0.00^{c}	4.99±0.11^{c}	9 x 10^{7a}
D (60%: 40%)	3.54±0.04^{b}	2.62±0.01^{b}	20.65±0.07^{b}	5.46±0.62^{b}	1.8 x 10^{7bc}
E (50%: 50%)	3.96±0.03^{a}	2.66±0.01^{a}	20.79±0.02^{a}	5.99±0.27^{a}	1.9 x 10^{7b}

Note: Means followed by the same letter in the same column are not significantly different according to the 5% Duncan's Multiple Range Test (DMRT).

The ash content, which serves as an indicator of mineral composition, was also influenced by the encapsulation formulation. Gum arabic, being richer in minerals compared to maltodextrin, contributed to an increase in ash content, particularly in formulations with higher proportions of gum arabic. Formulation E (50% MD : 50% GA) exhibited the highest ash content at 2.66 ± 0.01%, whereas formulation A (100% MD : 0% GA) showed the lowest ash content at 1.94 ± 0.01%. This finding indicates that gum arabic can act as an effective mineral fortifying agent and help retain essential minerals during the spray drying process (García-Burgos et al., 2020). In formulations with higher maltodextrin proportions, the ash content tended to be lower, likely due to the relatively low mineral composition of maltodextrin.

The protein content was significantly influenced by the encapsulation formulation and drying method (Gaćina et al., 2022). The addition of gum arabic in the formulation helped to better preserve protein integrity, as GA forms a protective matrix around the protein, reducing thermal stress during the drying process (Wangkulangkool et al., 2023). This was evident in formulation E (50% MD : 50% GA), which showed the highest protein content at 5.99 ± 0.27%, while formulation A (100% MD : 0% GA) had the lowest protein content at 5.51 ± 0.03%, despite a slight decrease compared to the fresh curd base material (5.98 ± 0.04%). The lower thermal stress during spray drying helps minimize protein denaturation, which is crucial for maintaining nutritional quality — particularly for consumer groups with higher protein requirements, such as pregnant women (Berraquero-García et al., 2023).

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The fat content also showed significant variation, with formulation E (50% MD : 50% GA) having the highest fat level (5.99%), while formulation A (100% MD : 0% GA) exhibited the lowest (4.30%). The emulsifying properties of gum arabic contributed to better fat retention, which is crucial for preserving the bioactive lipid components during the drying process. This indicates that gum arabic plays an essential role in protecting lipids within the product, ensuring that the nutritional profile remains intact after spray drying (Atwaa et al., 2023).

The number of lactic acid bacteria (LAB), which serves as a key indicator of probiotic viability, was significantly influenced by the spray drying process (Kakuda et al., 2023). According to statistical notation, treatment C (70% MD : 30% GA) exhibited the highest LAB viability (9.0×10^7 CFU/g), while treatment B (80% MD : 20% GA) showed the lowest (1.3×10^7 CFU/g). These results indicate a substantial reduction in LAB viability after spray drying compared to the fresh dadih used as raw material (5.7×10^{10} CFU/g). However, the addition of maltodextrin and gum arab proved effective in minimizing cellular damage by forming a protective matrix around the probiotic cells (Clavijo-Romero et al., 2023). Despite the reduction, the LAB count in the final product still meets the minimum requirement for probiotic foods that confer health benefits.

(3) Sensory evaluation of powdered dadih milk

The sensory evaluation results of powdered dadih milk products with five different formulations of maltodextrin (MD) and gum arab (GA) are presented in Table 3. Data were obtained from 25 trained panelists who assessed aroma, texture, taste, and color attributes using a 5-point hedonic scale, where 1 indicates “dislike very much” and 5 indicates “like very much.” Based on the evaluation, all sensory parameters demonstrated good acceptance levels, with mean scores above 3, corresponding to the “slightly like” category.

Table 3. Sensory evaluation of powdered dadih milk based on maltodextrin and gum arab formulations.

MD : GA	Aroma	Texture	Taste	Color
C (70% : 30%)	3.60 ± 0.91^a	3.84 ± 0.80^a	3.88 ± 0.92^a	4.16 ± 0.62^a
E (50% : 50%)	3.64 ± 0.99^a	3.72 ± 0.99^{ab}	3.40 ± 0.86^{ab}	4.00 ± 0.57^a
A (100% : 0%)	3.64 ± 1.11^a	3.64 ± 0.67^{ab}	3.56 ± 1.12^{ab}	4.04 ± 0.53^a
D (60% : 40%)	3.56 ± 0.96^a	3.64 ± 0.63^{ab}	3.44 ± 0.86^{ab}	4.12 ± 0.66^a
B (80% : 20%)	3.08 ± 1.11^a	3.20 ± 0.95^b	3.20 ± 1.11^b	3.96 ± 0.53^a

Note : Means followed by the same letter in the same column are not significantly different according to the 5% Duncan’s Multiple Range Test (DMRT). Hedonic scale: 1 = dislike extremely; 2 = dislike; 3 = slightly like; 4 = like; 5 = like extremely.

Aroma did not show significant differences among the various formulations of maltodextrin (MD) and gum arab (GA), indicating that although changes in the encapsulating agents may influence other aspects, aroma remains a key element in the overall sensory experience (Zhang et al., 2020). The preferred aroma likely originates from volatile compounds such as acetaldehyde, diacetyl, esters, and organic acids produced during the fermentation and drying processes, supporting findings that emphasize the importance of aroma in consumer acceptance and satisfaction (Zhang et al., 2020). Based on the sensory evaluation, all formulations showed no significant differences in aroma scores ($p > 0.05$), as indicated by identical statistical notations across treatments. The highest aroma score was obtained in formulation E (50% MD : 50% GA) with a mean score of 3.64 ± 0.99, followed by formulations A (100% MD : 0% GA) and C (70% MD : 30% GA) with the same score of 3.64, formulation D (60% MD : 40% GA) with 3.56 ± 0.96, and the lowest in formulation B (80% MD : 20% GA) with 3.08 ± 1.11. Although the differences were not statistically significant, there was a tendency for formulations with higher proportions of gum arab to yield slightly higher aroma ratings. This can be attributed to the excellent encapsulation ability of gum arab for volatile aroma compounds, which helps preserve the distinctive aroma profile of dadih (Jafari et al., 2008).

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In contrast, formulations with higher maltodextrin content (such as formulation B) tended to produce a less desirable aroma, possibly due to its masking effect on the characteristic dadih aroma.

Texture is a highly important sensory attribute, as it directly influences consumer satisfaction and the likelihood of repeat purchases. The texture parameter showed clearer variations among the different formulations. Formulation C (70% MD : 30% GA) obtained the highest texture score of 3.84 ± 0.8, which was significantly different from formulation B (80% MD : 20% GA), which had the lowest score of 3.2 ± 0.95. Formulations E, A, and D showed no significant difference compared to formulation B, with scores of 3.72 ± 0.99, 3.64 ± 0.67, and 3.64 ± 0.63, respectively. The superior texture observed in formulation C (70% MD : 30% GA) indicates that this ratio of maltodextrin to gum arab produced the most preferred texture among panelists. A 30% proportion of gum arab contributed to a smoother, non-gritty texture, while 70% maltodextrin provided sufficient body to the product (Carneiro et al., 2013). Furthermore, the emulsifying property of gum arab combined with the low viscosity of maltodextrin acted synergistically to create an optimal texture (Gharsallaoui et al., 2007). In contrast, formulation B, which contained a higher concentration of maltodextrin (80%), resulted in a less favorable texture, possibly because excessive maltodextrin can lead to a coarse and gritty mouthfeel (Bhusari et al., 2014).

Evaluation of the flavor parameter showed that formulation C (70% MD : 30% GA) received the highest score of 3.88 ± 0.92, which was significantly different from formulation B (80% MD : 20% GA) that had the lowest score of 3.2 ± 1.11. Formulations E, A, and D were not significantly different from formulation B, with scores of 3.4 ± 0.86, 3.56 ± 1.12, and 3.44 ± 0.86, respectively. This difference occurred because the maltodextrin-to-gum arab ratio of 70:30 in formulation C produced an optimal flavor balance, where maltodextrin contributed a mild natural sweetness, while gum arab—being neutral and non-sweet—enhanced the product's palatability (English et al., 2023). In contrast, a higher concentration of maltodextrin (80%, as in formulation B) could mask or modify the natural flavor of the product (Ozcelik & Kulozik, 2023). Interactions between maltodextrin and volatile as well as non-volatile compounds in the food system may alter the overall flavor profile, reducing the distinctive taste of dadih expected by consumers.

Color, as a key sensory attribute, plays an important role in product evaluation since it often serves as the first indicator of quality for consumers. Sensory evaluation of the color parameter showed no significant differences among treatments ($p>0.05$). The highest color score was observed in formulation C (70% MD : 30% GA) with 4.16 ± 0.62, followed by formulation D (60% MD : 40% GA) with 4.12 ± 0.66, formulation A (100% MD : 0% GA) with 4.04 ± 0.53, formulation E (50% MD : 50% GA) with 4.00 ± 0.57, and the lowest in formulation B (80% MD : 20% GA) with 3.96 ± 0.53. Although not statistically significant, there was a tendency for formulations with a balanced ratio of maltodextrin and gum arab to produce more appealing color. This can be attributed to the ability of gum arab to preserve the natural color of dadih and prevent browning during the drying process (Tonon et al., 2011). An attractive color appearance plays a vital role in conveying a sense of quality and enhancing consumer appeal (Lestari et al., 2019).

(4) Determination of the best treatment

The determination of the best treatment was based on the formulation parameters of nutritional quality, lactic acid bacteria (LAB) viability, and sensory attributes, as presented in Table 4. Formulation C (70% MD : 30% GA) was selected as the best treatment because it exhibited the highest LAB viability (9.0×10^7 CFU/g), favorable protein content (20.57%), and the highest sensory scores for both texture (3.88) and flavor (3.88). Furthermore, as shown in Table 4, this formulation demonstrated an optimal balance between physical stability and sensory quality, making it a suitable reference for commercial product development.

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Table 4. Formulation of nutritional and sensory parameters for determining the best powdered dadih treatment.

Parameter	Value
Total lactic acid bacteria (CFU/g)	9×10^7
Moisture content (%)	3.40±0.03
Ash content (%)	2.57±0.06
Protein content (%)	20.57±0.00
Fat content (%)	4.99±0.11
Sensory evaluation :	
Aroma	3.6 ± 0.91 (Slightly like)
Texture	3.88 ± 0.80 (Slightly like)
Taste	3.88 ± 0.92 (Slightly like)
Color	4.16 ± 0.62 (Like)

Conclusion

The powdered dadih encapsulated with a formulation of 70% maltodextrin and 30% gum arabic (treatment C) using spray drying technology showed the most optimal results based on nutritional quality and sensory parameters. This treatment resulted in the highest lactic acid bacteria (LAB) viability, namely 9.0×10^7 CFU/g, with a high protein content (20.57%) and the best sensory scores for texture and taste (3.88). Although there was a decrease in LAB viability from 5.7×10^{10} CFU/g in the raw material to 9.0×10^7 CFU/g in the final product, this value still meets the criteria for probiotic products, as the LAB count remains above the minimum threshold of 10^7 CFU/g required to provide probiotic health benefits. The final product had a moisture content of 3.40%, contributing to improved storage stability and longer shelf life. The high protein content indicates that the encapsulation and drying processes did not significantly reduce nutritional quality, and even increased nutrient concentration in powder form. With these characteristics, the powdered dadih produced with the 70% maltodextrin and 30% gum arabic formulation has strong potential to be developed as a stable, high-nutritional-value functional probiotic food with good sensory acceptance.

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References

Anisuzzaman, S. M., Joseph, C. G., Nga, J. L. H., & Ismail, F. N. (2022). Effect of carrier agents andoperational parameters on the physical quality of spray-dried tomato powder: A review. *ASEAN Journal of Chemical Engineering*, 22 (2), 228–247. https://doi.org/10.22146/ajche.71487

AOAC. (2005). Official methods of analysis of the association of analytical chemist. In *Virginia USA: Association of Analytical Chemists* 1(1). https://doi.org/10.1201/9781003354116-6

Arnold, M., Rajagukguk, Y. V., & Gramza-Michałowska, A. (2021). Characterization of dadih: Traditional fermented buffalo milk of minangkabau. *Beverages*, 7(3), 54–72. https://doi.org/10.3390/beverages7030060

Atwaa, E. S. H., Shahein, M. R., Raya-Álvarez, E., Abd El-Sattar, E. S., Hassan, M. A. A., Hashim, M. A., Dahran, N., El-Khadragy, M. F., Agil, A., & Elmahallawy, E. K. (2023). Assessment of the physicochemical and sensory characteristics of fermented camel milk fortified with Cordia myxa and its biological effects against oxidative stress and hyperlipidemia in rats. *Frontiers in Nutrition*, 10(5), 1–11. https://doi.org/10.3389/fnut.2023.1130224

Berraquero-García, C., Pérez-Gálvez, R., Espejo-Carpio, F. J., Guadix, A., Guadix, E. M., & García-Moreno, P. J.

(2023). Encapsulation of bioactive peptides by spray-drying and electrospraying. *Foods*, 12(10), 301–319. https://doi.org/10.3390/foods12102005

Bhusari, S. N., Muzaffar, K., & Kumar, P. (2014). Effect of carrier agents on physical and microstructural properties of spray dried tamarind pulp powder. *Powder Technology*, 266(64), 354–364. https://doi.org/10.1016/j.powtec.2014.06.038

Carneiro, H. C. F., Tonon, R. V., Grosso, C. R. F., & Hubinger, M. D. (2013). Encapsulation efficiency and oxidative stability of flaxseed oil microencapsulated by spray drying using different combinations of wall materials. *Journal of Food Engineering*, 115(4), 443–451. https://doi.org/10.1016/j.jfoodeng.2012.03.033

Clavijo-Romero, A., Moyano-Molano, M., Bauer Estrada, K., Pachón-Rojas, L. V., & Quintanilla-Carvajal, M. X. (2023). Evaluation of the survival of lactobacillus fermentum k73 during the production of high-oleic palm oil macroemulsion powders using rotor-stator homogenizer and spray-drying technique. *Microorganisms*, 11(6), 1490–1501. https://doi.org/10.3390/microorganisms11061490

Djamaris, A., Ardiansyah, Sari, D. A. P., & Novianti, M. D. (2024). *Desain percobaan: teori dan aplikasi. Universitas Bakrie Press*. https://ubakriepress.bakrie.ac.id

Dolin, C. D., Compher, C. C., Oh, J. K., & Durnwald, C. P. (2021). Pregnant and hungry: addressing food insecurity in pregnant women during the COVID-19 pandemic in the United States. *American Journal of Obstetrics and Gynecology MFM*, 3(4), 103–133. https://doi.org/10.1016/j.ajogmf.2021.100378

English, M., Okagu, O. D., Stephens, K., Goertzen, A., & Udenigwe, C. C. (2023). Flavour encapsulation: A comparative analysis of relevant techniques , physiochemical characterisation , stability , and food applications. *Frontiers in Nutrition*, 1(2), 1–15. https://doi.org/10.3389/fnut.2023.1019211

García-Burgos, M., Moreno-Fernández, J., Alférez, M. J. M., Díaz-Castro, J., & López-Aliaga, I. (2020). New perspectives in fermented dairy products and their health relevance. *Journal of Functional Foods*, *72*(4), 104–119. https://doi.org/10.1016/j.jff.2020.104059

Gharsallaoui, A., Roudaut, G., Chambin, O., Voilley, A., & Saurel, R. (2007). Applications of spray-drying in microencapsulation of food ingredients: An overview. *Food Research International*, 40(9), 1107–1121. https://doi.org/10.1016/j.foodres.2007.07.004

Gullifa, G., Risoluti, R., Mazzoni, C., Barone, L., Papa, E., Battistini, A., Martin Fraguas, R., & Materazzi, S. (2023). Microencapsulation by a spray drying approach to produce innovative probiotics-based products extending the shelf-life in non-refrigerated conditions. *Molecules*, 28(2), 22–51. https://doi.org/10.3390/molecules28020860

Hanidah, I.-I., Kirana, A. I., Nurhadi, B., & Sumanti, D. M. (2021). The functionality of probiotic bacteria microencapsulation by spray drying: a literature review. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, 10(3), 274–282. https://doi.org/10.21776/ub.industria.2021.010.03.8

Jović, T., Elez Garofulić, I., Čulina, P., Pedisić, S., Dobroslavić, E., Cegledi, E., Dragović-Uzelac, V., & Zorić, Z. (2023). The effect of spray-drying conditions on the characteristics of powdered pistacia lentiscus leaf extract. *Processes*, 11(4), 88–106. https://doi.org/10.3390/pr11041229

Kakuda, L., Jaramillo, Y., Niño-Arias, F., Souza, M., Conceiçã, E., Alves, V., Almeida, O., De Martinis, E., & Oliveira, W. (2023). Process development for the spray-drying of probiotic bacteria and evaluation of the product quality. *J Vis Exp.*, 7(2), 194–214. https://doi.org/10.3791/65192

Kaur, H., Kaur, G., & Ali, S. A. (2022). Dairy-based probiotic-fermented functional foods: an update on their health-promoting properties. *Fermentation*, 8(9), 425–450. https://doi.org/doi.org/10.3390/fermentation8090425

Kumoro, A. C., Wardhani, D. H., Kusworo, T. D., Djaeni, M., Ping, T. C., & Alhanif, M. (2024). A brief overview of spray drying technology and its potential in food applications. *Journal of Human, Earth, and Future*, 5(2), 279–305. https://doi.org/10.28991/HEF-2024-05-02-09

Lestari, E., Sandri, D., Fatimah, F., & Umaira, U. (2019). Volume kembang adonan dan sensory roti manis yang dibuat dari Modified Talipuk Flour (MOTAF). *Jurnal Teknologi & Industri Hasil Pertanian*, 24(2), 113–123. https://doi.org/10.23960/jtihp.v24i2.113-120

Malos, I. G., Ghizdareanu, A. I., Vidu, L., Matei, C. B., & Pasarin, D. (2025). The role of whey in functional microorganism growth and metabolite generation: a biotechnological perspective. *Foods*, 14(9), 1–36. https://doi.org/10.3390/foods14091488

Mardawati, E., Rialita, T., Suryadi, E., Rahmah, D. M., Anggraini, S., & Bindar, Y. (2020). The evaluation of spray drying process condition on the characteristics of xylitol powder from oil palm empty fruit bunches. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, 9(1), 17–24. https://doi.org/10.21776/ub.industria.2020.009.01.3

Marlida, Y., Huda, N., Harnentis, H., Nur, Y. S., Lestari, N. M., Adzitey, F., & Sulaiman, M. R. (2021). Potential probiotic yeast isolated from an indonesian indigenous fermented fish (ikan Budu). *Potravinarstvo Slovak Journal of Food Sciences*, 15(5), 460–466. https://doi.org/10.5219/1544

Medfai, W., Oueslati, I., Dumas, E., Harzalli, Z., Viton, C., Mhamdi, R., & Gharsallaoui, A. (2023). Physicochemical and biological characterization of encapsulated olive leaf extracts for food preservation. *Antibiotics*, 12(6), 156–178. https://doi.org/10.3390/antibiotics12060987

Nguyen, D. Q., Mounir, S., & Allaf, K. (2017). Optimization of the spray drying operating conditions for producing the powder mixture of gum Arabic and maltodextrin. *International Journal of Food Engineering*, 13(8), 188–201. https://doi.org/10.1515/ijfe-2016-0271

Ozcelik, M., & Kulozik, U. (2023). The role of maltodextrin concentration in maintaining storage stability of dried fruit foams texturized using plant protein–polysaccharide blends. *Foods*, 12(8), 40–54. https://doi.org/10.3390/foods12081673

Parhusip, A. J. N., Fraulencia, J., Alfredo, Kritianto, E., Sanaky, F. M. N., Anugrahati, N. A., & Kurniawan, C. J. (2024). Microencapsulation of probiotic lactic acid bacteria using freeze drying with isolated whey protein and trehalose as coating material. *Jurnal Teknologi & Industri Hasil Pertanian*, 29(1), 168–175. https://doi.org/10.23960/jtihp.v29i2.168-175

Pramana, A., Yudhistira, B., Jayalaksamana, M., Kurnia, D., Husnayain, N., & Pramitasari, R. (2025). Dadih, traditional fermented buffalo milk: a comprehensive review of the aspects of gastronomy, health benefits, and product development. *Journal of Ethnic Foods*, 12(1), 1–17. https://doi.org/10.1186/s42779-024-00261-3

Setyaningsih, D., Ariyantono, A., & S, M. P. (2010). *Analisis sensori*. IPB Press.

Seveline. (2018). Kajian pustaka teknik pengeringan semprot (spray drying) untuk pengawetan dan produksi probiotik. *Jurnal Agroindustri Halal*, 3(1), 80–86. https://doi.org/10.30997/jah.v3i1.692

Sumanti, D. M., Lanti, I., Hanidah, I.-I., Sukarminah, E., & Giovanni, A. (2016). Pengaruh konsentrasi susu skim dan maltodekstrin sebagai penyalut terhadap viabilitas dan karakteristik mikroenkapsulasi suspensi bakteri lactobacillus plantarum menggunakan metode freeze drying. *Jurnal Penelitian Pangan (Indonesian Journal of Food Research)*, 1(1), 7–13. https://doi.org/10.24198/jp2.2016.vol1.1.02

Vinderola, G., Binetti, A., Burns, P., & Reinheimer, J. (2011). Cell viability and functionality of probiotic bacteria in dairy products. *Frontiers in Microbiology*, 2(5), 1–6. https://doi.org/10.3389/fmicb.2011.00070

Wangkulangkool, M., Ketthaisong, D., Tangwongchai, R., Boonmars, T., & Lomthaisong, K. (2023). Microencapsulation of chia oil using whey protein and gum arabic for oxidation prevention: a comparative study of spray-drying and freeze-drying methods. *Processes*, 11(5), 69–84. https://doi.org/10.3390/pr11051462

Yusa Ali, D., Pramita, H. S., Widyaningsih, T. D., & Vania Jayanti, T. (2024). Optimization of maltodextrin concentration and spray drying temperature on physicochemical characteristics of powdered edamame milk. *Advances in Food Science, Sustainable Agriculture and Agroindustrial Engineering*, 7(2), 119–126. https://doi.org/10.21776/ub.afssaae.2024.007.02.1

Zhang, L., Mi, S., Liu, R., Sang, Y., & Wang, X. (2020). Evaluation of volatile compounds in milks fermented using traditional starter cultures and probiotics based on odor activity value and chemometric techniques. *Molecules*, 25(5), 87–105. https://doi.org/10.3390/molecules25051129