Asian Journal of Applied Research for Community Development and Empowerment. Vol 8 (2024), No.3

AJARCDE
ASIAN JOURNAL OF APPLIED RESEARCH FOR COMMUNITY DEVELOPMENT AND EMPOWERMENT

Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

Physical and Microbiological Characteristics of Dadih Powder with Different Types and Concentrations of Encapsulated Ingredients

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ARTICLE INFO

Article History:
Received: 17 October 2024
Final Revision: 1 November 2024
Accepted: 7 November 2024
Online Publication: November 2024

KEYWORDS

Dadih, Dadih powder, food dehydrator, encapsulates, LAB viability.

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ABSTRACT

Dadih is one of the buffalo milk preparations that is rich in nutritional content and has the potential to be developed in West Sumatra. This research discusses the drying of dadih to extend the shelf life and maintain the nutritional content contained in the dadih. Dadih is dried to produce a product in the form of dadih powder. This study used food dehydrator drying with different types and concentrations of encapsulates to determine the right type and concentration to maintain the nutritional content and physical appearance of dadih powder. The research design used was a completely randomized design (CRD) with two factors, namely encapsulant type (CMC and Maltodextrin) and encapsulant concentration (0%, 10%, 20% and 30%). The results showed that dadih powder with different encapsulant types and concentrations significantly affected LAB viability, taste, and color. The dadih powder product with the addition of 20% maltodextrin gave the results of Total Lactic Acid Bacteria of 1.19 x 104 cfu/ml, the highest LAB viability of 77.01%, and has organoleptic test results that are preferred by panellists on the color and taste of dadih powder.

1. INTRODUCTION

1.1. Research Background

Dadih, as one of the culinary specialities of West Sumatra, has a deep cultural value and urges it to be preserved as a heritage supporting the development of the local agro-industry sector [1]. The popularity of dadih as a traditional food of the Minangkabau people has now expanded to six administrative regions, namely Tanah Datar, Lima Puluh Kota, Solok, Agam, and Sawahlunto/Sijunjung. Dadih has a high water content thus, dadih cannot be stored for too long. In addition to the high moisture content of dadih, the difficulty of handling in transportation and the impractical packaging of dadih causes local culinary wisdom to be almost lost because there are still many Minangkabau generations who do not know dadih [2].

Dadih can be a potential agro-industry in West Sumatra, so it is necessary to study how to transform dadih into a more practical product. Commercialized dadih in semi-solid form tends to have a high water content, so its durability is only about 3-4 days at room temperature or up to 2 weeks if stored in the refrigerator. As an alternative, dadih powder can be a processing option with the advantage of a longer shelf life and the ability to be stored at room temperature.

However, dadih is classified as heat-sensitive food and is susceptible to physical, chemical, and biological damage, so to get a good dry product (dadih powder), it is necessary to pay attention to the right drying method. The use of encapsulant materials is required to accelerate the drying process, improve the final result, coat the components, enrich the flavor, and protect the material from damage due to heat exposure. This study selected maltodextrin and CMC (carboxymethyl cellulose) as encapsulants.

The manufacture of dadih powder using a food dehydrator with the addition of encapsulant ingredients with varying concentrations of Maltodextrin and CMC has never been studied, so making dadih powder products (more practical) requires a study of the type and concentration of encapsulant ingredients that are suitable for dadih powder with drying using a food dehydrator. Proper drying is expected to produce dadih powder that does not experience a decrease in quality. So, it is necessary to study changes in lactic acid bacteria content, viability, and organoleptic on dadih powder.

1.2. Literature Review

Milk is defined as a food source that is highly nutritious for humans. Buffalo milk has the same composition as cow's milk but with a brighter color, lower water content, higher fat and dry matter content, smaller fat globules, easily digestible fat emulsified in milk, and healthy minerals. People who are allergic to cow's milk and have gastrointestinal disorders can drink buffalo milk [3].

Dadih is a traditional fermented product and specialty food of the Minangkabau region, which is also an integral part of its cultural identity. The process of making dadih is still done conventionally, and according to Ref. [4], about 70% of this production is still based on traditional businesses, which results in the absence of clear standards in the production process.

Dadih has a high water content, thus dadih cannot last too long. Reported that the moisture content of dadih in West Sumatra Province ranged from 80.70-81.95%, the highest moisture content was found in the centre of dadih agro-industry in Tanah Datar Regency, and the lowest moisture content was found in the centre of dadih agro-industry in Agam Regency [5]. In addition to the high moisture content of dadih, the difficulty of handling in transportation and the impractical packaging of dadih causes local culinary wisdom to be almost lost because there are still many Minangkabau generations who do not know dadih. According to a survey by Ref. [2] panellists' preferences in this study, 85.72% of them supported the development of data-based products designed to have high accessibility, ease of purchase and consumption, and practical mobility.

Drying is a technique that uses heat energy to reduce or extract relatively small amounts of water from materials. A dry material with less moisture is produced due to the drying process. During drying, unsaturated air is blown onto the material to be dried along with the evaporated water. The difference between the surface of the gas-solid material and the gas-phase water vapor concentration causes the water (or other liquid) to evaporate at a temperature lower than its boiling point. The drying medium is a hot gas that gives off water and generates heat to vaporize it [6].

Food dehydrators work based on heating elements that distribute heat, fans that distribute hot air to the foodstuff to be dried, and air vents that allow the water content dripping from the foodstuff to be removed. This process ensures that the processed foodstuffs dry quickly. A food dehydrator is not the same as a vacuum fryer as the former involves turning fruit into chips, which means the nutrients in the food are bound to be greatly reduced. There are additional uses for a food dehydrator where the food and the food it produces retain its nutritional value and flavor.

1.3. Research Objective

Encapsulation aims to preserve pigment flavor and aroma, improve solubility, and protect active components susceptible to oxidative damage and nutrient loss. Encapsulation techniques can convert less stable liquids into powders that are incorporated and easily handled in dry feed systems in water-soluble substances.

2. MATERIALS AND METHODS

2.1. Preparation of sample

The dadih used for the study was obtained from Aia Dingin, Solok Regency. The dadih used in this study is a semi-solid dadih texture/shaped like tofu, white to cream color, sour taste, 5 days old and sour aroma typical of dadih. After arriving at the laboratory, it was stored in a refrigerator with a temperature of 5°C. Then, it is used for drying according to the treatment of Maltodextrin and CMC with concentration. Dadih weighed 400 grams, as much as 24 for 24 experimental units. Maltodextrin and CMC were weighed according to the treatment (0%, 10%, 20% and 30%) of the 400 g dadih weight, namely 0 g, 40 g, 80 g, 120 g and 180 g, respectively. The encapsulation material is used by adding mixed and homogenised Maltodextrin and CMC with these concentrations. The homogenized dadih and encapsulant material mixture is placed on the food dehydrator drying rack.

2.2. Drying

Dadih was mixed with encapsulant ingredients (CMC and Maltodextrin) according to the percentage (0%, 10%, 20% and 30%), then dried at 45ºC for 30 hours; the food dehydrator was used. The steps taken were as follows:

a. Samples according to the treatment of 0% (400 g dadih), 10% (360 g dadih: 40 g encapsulant), 20% (320 g dadih: 80 g encapsulant) and 30% (280 g dadih: 120 g encapsulant) were placed in a 28 x 28 baking pan with the same capacity (gram/cm2), conditioned according to the treatment.
b. The baking sheet containing the sample was then put into the food dehydrator.
c. Then, the baking sheet is placed on a rack in the dryer.
d. Close the food dehydrator
e. Set the dryer temperature (45°C).
f. Dry until the moisture content of dadih powder is ≤15% for ± 30 hours, where weight changes (weighing) are observed every 15 minutes in the first hour and every 60 minutes in subsequent drying.
g. After drying (±30 hours), the sample was removed from the dryer and pulverized/reduced in size.

2.3. Research design

The approach applied in this study is the experimental method, which is based on experiments. The experimental design adopted was a Factorial Randomized Complete Block Design (CRD), which involved two variables, namely the type of encapsulant material (F1) and the percentage of encapsulant material used (F2). The encapsulant material used consists of two types, namely Maltodextrin and CMC. While the percentage of encapsulant material consisted of four levels, 0%, 10%, 20%, and 30%, eight treatment combinations were obtained, each repeated three times. So this study consisted of 24 experimental units. Observations were made in product analysis, namely total LAB analysis, LAB viability and organoleptic observations, including color, taste, aroma, and texture. The data obtained were tested using analysis of variance with a confidence level of 95% using the SPSS version 22 program. If each treatment had an effect, the Duncan Multiple Range Test (DMRT) was conducted to see which level produced differences in quality.

2.4. Observation

2.4.1. Total lactic acid bacteria (pour method)[7]

The calculation of total LAB began with a dilution process with a ratio of 1:9 from a concentration of 10^{-1} to 10^{-9}. The first dilution was done by adding 5 ml of sample into 45 ml of distilled water in an Erlenmeyer. For the second dilution, 1 ml of the sample diluted in the first stage was pipetted and put into 9 ml of sterile distilled water in a test tube. The third to ninth dilution process used the same method as in the second dilution.

The next stage is the flotation process, starting with dissolving 5.2 g of MRS broth in 100 ml of distilled water and then sterilising in an autoclave at 121ºC for 15 minutes. At this stage, 1 ml of samples that have been diluted at a concentration of 10^{-5} to 10^{-9} are put into a Petri dish. 10 ml of MRS broth medium, cooled to 47-50ºC, was poured into the Petri dish. The dish was then homogenized by moving it in a figure-eight pattern. After the medium solidified, the dishes were incubated in an inverted position at 37°C for 48 hours. The total amount of LAB was calculated using the standard plate counting method, which is based on the principle that every living bacterial cell will develop into a colony after incubation in the appropriate media and conditions. The total amount of LAB can be calculated as follows: Some colonies may merge to form larger colony aggregates, so the actual number of colonies may not be detected; however, they can be counted as one colony. Colonies marked with a thick line are considered as one colony. In addition, the number of colonies per ml can be calculated with the following formula:

$$\text{Colony count per ml} = \text{Number of colonies per plate } x\ \frac{1}{dilution\ factor}$$

2.4.2. Viability of LAB [8]

From the calculation of the total number of bacteria, the viability of bacteria can be determined with the following calculation:

$$Viability\ of\ LAB = \frac{\text{Log cfu /ml bacteria count of dried d}adih}{\text{Log cfu /ml bacteria count of f}resh\ \text{d}adih}\ x\ 100\%$$

2.4.3. Organoleptic analysis [9]

Organoleptic testing was conducted on the resulting product to evaluate panellists' preferences for dadih powder in taste, color, aroma, and texture. Samples were presented in a consistent format. This organoleptic test assessed the aspects of color, aroma, appearance, and consistency, which 30 panellists conducted. The method applied is the hedonic scale test with a rating range of 1 - 5. The scale is described according to the organoleptic test parameters carried out. The test parameters were scored (1) very dislike, (2) dislike, (3) neutral, (4) like, (5) very like.

3. RESULT AND DISCUSSION

3.1. Total Lactic Acid Bacteria

The amount of LAB present in a fermented product serves as an indicator to assess the microbiological quality of the product. The results of testing the amount of LAB in dadih powder by adding two types of encapsulants and several kinds of encapsulant concentrations obtained the total lactic acid bacteria results, which can be seen in Table 1.

Table 1: Average Results of Total Lactic Acid Bacteria of Dadih Powder

Treatments	Total LAB (cfu/ml)
J2K3 (Maltodekstrin 30%)	1.33×10^4
J2K2 (Maltodekstrin 20%)	1.19×10^4
J2K1 (Maltodekstrin 10%)	1.01×10^4
J1K3 (CMC 30%)	2.44×10^4
J1K2 (CMC 20%)	2.53×10^4
J1K1 (CMC 10%)	2.80×10^4
J1K0/J2K0 (control)	2.66×10^8

Source: Primary data processed, 2024

Table 1 shows that the highest LAB content in dadih powder is in the treatment with the addition of 10% CMC encapsulant, which is 2.80 x 104 cfu/ml, and the lowest total LAB is in the treatment with the addition of 10% Maltodextrin encapsulant which is 1.01 x 104 cfu/ml. This is because CMC is not a significant source of nutrients for lactic acid bacteria, but it can help create a more stable and viscous environment for bacterial growth. In contrast, although Maltodextrin can be used as a carbohydrate source, it may not always support bacterial growth as effectively as CMC. CMC can help maintain a more stable pH in the product, which is important for lactic acid bacteria growth. If maltodextrin-based formulations cause greater pH fluctuations, this may negatively affect bacterial growth. Maltodextrin may interact with other ingredients in the formulation that may inhibit or reduce the lactic acid bacteria population. With its viscosity-increasing properties, CMC may be better at retaining bacterial cells in suspension. The processing and fermentation carried out in products with Maltodextrin may not provide optimal conditions for lactic acid bacteria to increase, while products with CMC may favor ideal fermentation conditions. Overall, differences in physicochemical properties, pH stability, and interactions with other components contribute to the lower total lactic acid bacteria in products using Maltodextrin than those using CMC.

CMC and Maltodextrin function as encapsulant materials that can increase the product's viscosity, inhibiting the mobility of LAB in producing organic acids. Increased product viscosity inhibits lactic acid synthesis by LAB [10]. In addition, the addition of higher encapsulant concentrations will result in a decrease in lactic acid production. The decrease in LAB number also correlates with the decrease in protein content; as the protein content decreases, the number of LAB will be lower, considering that protein is the main component of microbial constituents. In addition, there is a positive relationship between total LAB and moisture content; if the moisture content decreases, the total LAB will also decrease. This aligns with the opinion [11], which states that bacteria grow better at high water content, while LAB growth will decrease at low water content.

3.2. *Viability of Lactic Acid Bacteria*

LAB viability testing was conducted by comparing the total amount of LAB before and after the drying process. Statistical analysis of LAB viability in dadih powder, which considered the effect of type, concentration, and interaction between type and concentration of encapsulant, showed high differences with α < 0.05. The results are known from Table 2.

Table 2: Average Viability Results of Lactic Acid Bacteria Dadih Powder

Encapsulant Types	**Concentration of Encapsulant (%)**			
	0	**10**	**20**	**30**
Maltodekstrin	81.40 ± 0.51 C c	74.14 ± 0.66 B a	77.01 ± 0.42 B b	76.14 ± 0.91 B b
CMC		69.98 ± 0.04 A a	69.68 ± 0.21 A b	69.95 ± 0.32 A b

Source: Primary data processed, 2024

*Note: Numbers followed by the same letter in the same lane or row are not significantly different at the 5% level according to DMRT (lowercase letters read horizontally and uppercase letters read vertically).

Table 2 shows that LAB viability of dadih powder with the addition of maltodextrin concentration 10, 20 and 30 is between 74.14 - 77.01%, while the addition of CMC concentration 10, 20 and 30% is between 69.68 - 69.98%. Among the treatments with the addition of encapsulant substances, Maltodextrin 20% had the highest LAB viability of 77.01%, where the treatment of the addition of Maltodextrin 20% encapsulant was not significantly different from the addition of Maltodextrin 30% encapsulant. This is because maltodextrin is a source of carbohydrates that LAB can easily use as energy to support the growth of these bacteria. Maltodextrin can help create a more stable environment for bacteria, protecting storage and processing, thus increasing their viability. Maltodextrin can help create a better suspension, keeping the bacterial cells in the solution, thus reducing the possibility of physical damage to the bacterial cells during processing. Although CMC can increase viscosity, it can bind water and change the concentration of substances necessary for bacterial growth.

In some cases, this interaction may not be as effective as Maltodextrin in maintaining viability. Fermentation conditions may be more optimal for bacterial growth in formulations with Maltodextrin, whereas formulations with CMC may be less ideal. Thus, Maltodextrin's properties as a more efficient carbohydrate source and its ability to support better conditions for bacteria contribute to higher lactic acid bacteria viability in maltodextrin-based products. At a concentration of 20%, Maltodextrin provides sufficient carbohydrates as an energy source for the bacteria. This supports the growth and metabolic activity of the bacteria, which is important for their viability.

Based on the results, the more the encapsulant was added, the more the microbial cell count decreased. This is also related to total LAB, protein and water content. The water content and protein will decrease if the addition of encapsulant is more so that the total LAB will also decrease and result in bacterial viability will also decrease.

3.3. *Organoleptic Test*

This test acts as one of the criteria for determining superior food products. This test will evaluate the panellist's preference for CMC and Maltodextrin concentration variations when making dadih powder using the food dehydrator drying method. The assessment was conducted based on observations of color, aroma, taste, and texture aspects from 30 panellists. This test is with a hedonic scale of 1 to 5, namely 1 = Very Dislike (STS), 2 = Dislike (TS), 3 = Somewhat Like (AS), 4 = Like (S), and 5 = Very Like (SS). The scale is described according to the observations made.

3.3.1. Color

Statistical analysis showed a large difference in the color of the dried dadih as influenced by the type of encapsulant and the encapsulant concentration at the sig level. α < 0.05. The average panellists' preference on the color of the dadih produced is listed in Table 3.

Table 3: Color Acceptance Scale of Dadih by Panelists

Treatments	**Panelist's Acceptance Score**
J2K3 (Maltodekstrin 30%)	3.70 ± 0.70^{c}
J2K2 (Maltodekstrin 20%)	3.97 ± 0.81^{c}
J2K1 (Maltodekstrin 10%)	3.57 ± 0.82^{bc}
J1K3 (CMC 30%)	2.93 ± 1.01^{a}
J1K2 (CMC 20%)	3.17 ± 1.05^{ab}
J1K1 (CMC 10%)	3.67 ± 0.84^{c}
J1K0/J2K0 (control)	3.67 ± 0.76^{c}

Source: Primary data processed, 2024

*Note: 1 = brownish yellow, 2 = yellowish, 3 = yellowish white, 4 = cream, 5 = white

The level of preference of panellists on the color of the dadih produced showed 2.93 - 3.97. The lowest assessment of panelists related to color was recorded on dadih treated with the addition of 30% CMC stabilizer. while the highest scale on color was on dadih treated with the addition of 20% Maltodextrin encapsulant. The color of the dadih produced is white to brownish yellow color. The yellowish-white color became the panellists' favorite in adding 20% Maltodextrin encapsulant. Fresh dadih was previously white; after drying the dadih powder, the color became cream. This color change is due to the drying process.

3.3.2. Flavor

The statistical tests on the taste of dadih drying results with the addition of encapsulant type and concentration differ at the significant level α < 0.05. The average of the panellists' liking of the dadih flavor produced is presented in Table 4.

Table 4: Flavor Acceptance Scale of Dadih by Panelists

Treatments	Panelist's Acceptance Score
J2K3 (Maltodekstrin 30%)	3.03 ± 1.09[bc]
J2K2 (Maltodekstrin 20%)	3.47 ± 1.07[c]
J2K1 (Maltodekstrin 10%)	2.47 ± 0.97[ab]
J1K3 (CMC 30%)	2.37 ± 1.15[a]
J1K2 (CMC 20%)	2.60 ± 1.35[ab]
J1K1 (CMC 10%)	2.80 ± 0.96[ab]
J1K0/J2K0 (control)	2.53 ± 0.81[ab]

Source: Primary data processed, 2024

*Note : 1 = not good, 2 = less good, 3 = slightly good, 4 = good, 5 = very good

Based on the scale of panellists' acceptance of the resulting dadih flavor is a scale range of 2.37 - 3.47. The dadih with the addition of 30% CMC encapsulant became the panellist's assessment on the taste with a low scale, while the largest scale on the taste was on the dadih with the treatment of adding 20% Maltodextrin encapsulant. The flavor of the dadih produced is not good to very good. In the dadih the treatment of the addition of 20% Maltodextrin encapsulant gave rise to a good taste that the panellists liked.

3.3.3. Aroma

Statistical analysis showed that the aroma of the dadih produced, with variations in encapsulant type and concentration, did not show a large difference at a real level of $\alpha > 0.05$. The average panellists' preference for the dadih aroma is presented in Table 5.

Table 5: Aroma Acceptance Scale of Dadih by Panelists

Treatments	Panelist's Acceptance Score
J2K3 (Maltodekstrin 30%)	3.43 ± 0.82[a]
J2K2 (Maltodekstrin 20%)	3.50 ± 0.73[a]
J2K1 (Maltodekstrin 10%)	3.33 ± 0.88[a]
J1K3 (CMC 30%)	3.33 ± 0.76[a]
J1K2 (CMC 20%)	3.20 ± 0.66[a]
J1K1 (CMC 10%)	3.20 ± 0.71[a]
J1K0/J2K0 (control)	2.97 ± 0.93[a]

Source: Primary data processed, 2024

*Note : 1 = not sour, 2 = less sour, 3 = slightly sour, 4 = sour, 5 = very sour

Based on the scale of panellist acceptance of the resulting dadih aroma is a scale range of 2.97 - 3.50. The dadih without the addition of encapsulant (control) became the panellist's assessment of the aroma, while the highest scale on the aroma was in the dadih treatment of the addition of 20% Maltodextrin encapsulant. The aroma of the dadih produced is not sour to sour. The aroma panellists liked was slightly sour in dadih with the treatment of adding 20% Maltodextrin encapsulant.

3.3.4. Texture

The results of statistical tests on dadih texture with the addition of encapsulant type and concentration were not different with a real level of $\alpha > 0.05$. The average level of panellists' liking of the texture of the dadih produced is presented in Table 6.

The level of panellist preference for dadih texture can be observed from the range of acceptance scale between 2.63 - 3.33. The lowest texture assessment occurred in dadih containing 30% CMC encapsulant, while the highest scale on texture was in dadih with 20% Maltodextrin encapsulant addition treatment. The texture of the dadih produced was slightly liquid to very semi-solid. The encapsulant can affect the texture of the dadih. The more encapsulant the additions, the thicker/semi-solid the dadih becomes. Panellists liked the texture of the dadih, which was slightly semi-solid in the dadih with the treatment of adding 20% Maltodextrin encapsulant.

Table 6: Texture Acceptance Scale of Dadih by Panelists

Treatments	Panelist's Acceptance Score
J2K3 (Maltodekstrin 30%)	3.07 ± 0.91[a]
J2K2 (Maltodekstrin 20%)	3.33 ± 1.03 [a]
J2K1 (Maltodekstrin 10%)	2.93 ± 0.98[a]
J1K3 (CMC 30%)	2.63 ± 1.07[a]
J1K2 (CMC 20%)	3.00 ± 1.11 [a]
J1K1 (CMC 10%)	3.07 ± 0.87[a]
J1K0/J2K0 (control)	3.00 ± 0.95[a]

Source: Primary data processed, 2024

*Note : 1 = liquid, 2 = not semi-solid, 3 = slightly semi-solid, 4 = semi-solid, 5 = very semi-solid

4. CONCLUSION

The interaction between the two factors of different types and concentrations of encapsulant substances significantly affects ($p<0.05$) the physical and microbiological characteristics of dadih powder, such as LAB viability, taste, and color. Drying with the addition of 20% Maltodextrin gave the results of Total Lactic Acid Bacteria of 1.19 x 104 cfu/ml, the highest LAB viability of 77.01%, and the organoleptic test results that are preferred by panellists on the color and taste of dadih powder.

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