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Formulation and Evaluation of Patchouli Oil Bath Bomb with Citric Acid as an Acidic Component

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ABSTRACT

Conventional bath bombs contain only acidic and basic agents for effervescence, without any antibacterial or pharmacologically active ingredients. This study developed a bath bomb formulation enriched with bioactive compounds to provide antibacterial and therapeutic benefits beyond conventional cosmetic use. Patchouli alcohol is contained in the essential oil present in patchouli leaves, which is known to have antibacterial activity. Bath bomb is a spa product that can provide a relaxing atmosphere during bathing, which is used by soaking. Bath bombs were made using the mixing method with citric acid variations FI 26.3%, F2 33.3% and F3 38.5%. Evaluation of characteristics included organoleptic properties, weight uniformity, pH, hardness, dissolution effectiveness, foam height and stability test, water content, and geometric surface area test. The results of the characteristics bath bombs showed that three formulas gave good evaluations. The formulas did not significantly affect the pH of the bath bomb formulations. However, higher citric acid levels influenced organoleptic properties, weight uniformity, hardness, dissolution time, moisture content, geometric surface area, and foam height stability.

***Keywords*:** Formulation; Physical evaluation; Bath bomb; Patchouli oil; Citric acid

INTRODUCTION

Conventional bath bomb formulations typically comprise only acidic and basic components, serving primarily as effervescent agents, without the inclusion of active ingredients exhibiting antibacterial or other pharmacologically relevant properties.[1] In this study, the formulation was innovatively developed by incorporating bioactive compounds with antibacterial and therapeutic potential into the bath bomb matrix. This approach aims to enhance the functional benefits of conventional bath bombs, transforming them from simple cosmetic products into delivery systems with added dermatological and health-promoting properties.

Patchouli oil contains Patchouli alcohol, which is known to have potent antioxidant activity because it contains pro-oxidant oxygenation from sesquiterpene compounds.[2] The Patchouli alcohol content in patchouli oil also has antibacterial properties against Staphylococcus aureus and E. coli.[3]

Patchouli oil is volatile, so there is air and light, which makes the use of patchouli oil as an antioxidant less stable. It will be difficult if essential oils are used directly because they are volatile. To overcome this, the product requires a better dosage form than patchouli oil, and for skin care needs

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that can increase body relaxation during bathing activities, such as bath bomb preparations.[4] Essential oils are formulated as bath bombs because they can reduce stress by providing a fragrant aroma and a relaxing sensation by relieving muscle tension, providing a feeling of comfort and refreshment to the body.

Bath bombs with a salt composition containing chemicals from cation derivatives (monoamine alkaloids) can have physical and psychological effects. There are several bath bombs with chemical components derived from cation: mephedrone, MPDV, methylone, and piperazine. Mephedrone works to increase the synthesis of dopamine and serotonin with addictive properties, thereby increasing the neurotransmitter spike. MDPV enhances the effect of the inhibitory neurotransmitters norepinephrine and dopamine. Methylone and piperazines show strong selective affinity for serotonin receptors, which results in hallucinations. Further impacts cause neuropsychiatric effects (psychosis, such as agitation and paranoia) and are at risk of causing organ failure and death.[1]

A bath bomb is a spa product used for bathing. Its characteristic is that it fizzes in water. This is because part of the bath bomb contains acids and bases, which, when mixed with water, cause a reaction with the resulting carbon dioxide gas.[6]

Citric acid is an acid component often used in effervescent products—citric acid functions as an acidifying agent capable of preventing clumping and the occurrence of brittle granules. Sodium bicarbonate, which is usually referred to as baking soda, has the advantage that it is very suitable for dealing with mild skin problems, such as wrinkles on the skin and so on, can create a relaxed atmosphere, soften the skin, and can produce chemical reactions with acids.

METHODS

Materials and equipment

The materials used in this study included patchouli essential oil (*Pogostemon cablin*, obtained from CV. Aroma Atsiri, Indonesia), citric acid ($C_6H_8O_7$, Merck, Germany), sodium bicarbonate ($NaHCO_3$, Brataco, Indonesia), corn starch (Maizena, Indonesia), sodium lauryl sulfate (SLS, Sigma-Aldrich, USA), and propylene glycol (Merck, Germany). All materials were of analytical or cosmetic grade and used without further purification.

The equipment utilized included a bath bomb mold (aluminum, local supplier, Indonesia), analytical balance (Ohaus Pioneer PA214, USA), hardness tester (Erweka TBH 125, Germany), pH meter (Hanna Instruments HI 2211, Romania), moisture balance (AND MX-50, Japan), ruler (Faber-Castell, Indonesia), and a stainless-steel mixing bowl (Oxone, Indonesia).

Preparation of Bath bomb

Mix 7 g of corn starch with 6 g of patchouli oil, little by little, stir until homogeneous, then add 2 g of SLS and some sodium bicarbonate while stirring, then add 1 g of propylene glycol little by little while stirring until smooth, and finally add citric acid: F1 10 g, F2 20 g, and F3 40 g. Then stir until the dough becomes easy to knead. Finally, the bath bomb mixture is molded using a mold in a room below 250 °C with room humidity or RH (Relative Humidity) of less than 30%, and left for 24 hours until the bath bomb dries and hardens. A physical characteristic test is carried out, which includes an organoleptic test, weight uniformity, hardness, water content, geometric surface area test, effectiveness test, dissolution time, pH, and foam height stability test.[8]

Evaluation of Bath bomb

Organoleptic test

Organoleptic testing is a physical measurement of dosage form, color, and odor carried out using the five senses, including the color, texture, and aroma of the bath bomb.

Weight uniformity test

The weight uniformity test refers to paper soap preparations. It was carried out

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by weighing 10 bath bombs individually and then recording the weight. The weight uniformity test is carried out to see that the weight of each preparation matches the desired weight. The smaller the weight difference, the more uniform the weight of the bath bomb preparation will be.[10]

Hardness test

Hardness describes the strength of the preparation against mechanical stress, shocks, and cracks, as well as its resistance to packaging, transportation, and distribution to consumers. Hardness testing was carried out by preparing five bath bombs and testing them using a hardness tester with the allowable hardness for effervescent tablets, namely 4-8 kg/cm^2.

Test of moisture content

We tested the water content using a moisture balance tool. The principle is based on the evaporation of water during heating. This test was repeated three times. The procedure involves weighing 1 g of bath bomb granules into the moisture balance device, then closing it and pressing the start button. The test will stop automatically according to the set time.

Test the geometric surface area.

The geometric surface area test is carried out by measuring the circumference of the bath bomb using the tube surface formula according to its shape.[11]

$$L = 2\pi r (r + t)$$

Information :

L = Area of the tube
π = 3.14
r = radius
t = height

Dissolving time effectiveness test

The dissolution time test was carried out three times by adding 1 g of the sample to a glass beaker containing 10 ml of distilled water. If the preparation is dispersed and the reaction is completed in less than 5 minutes, it is well dispersed. The soluble time test is calculated based on the time required for the sample for each formulation. The calculation is stopped when the preparation dissolves completely.[12] Perfect solubility is marked when carbon dioxide gas stops reacting in water.[13]

pH test

The degree of acidity or pH test aims to determine the acidity and alkalinity of bath bomb products. This acidity or pH level test is carried out using a pH meter. For each formulation, bath bomb water is poured into a beaker, and measurements are carried out three times. Next, look at the change in pH in each bath bomb.[14]

Foam height and stability test

The foam height stability test is a method used to evaluate the ability of foam to maintain its height and stability over time. A simple method is used to measure the height of the foam by placing 1 gram of bath bomb preparation in a beaker glass with 10 ml of water and then measuring the height of the foam formed using a ruler. According to Apgar (2010), the foam height requirement is 1.3-22 cm. Foam stability is determined by calculating the time required for the foam using a stopwatch from when the bath bomb is placed in the water until all the foam disappears or becomes clear again. [14]

RESULTS AND DISCUSSION

Organoleptic Test of Patchouli Oil Bath bomb

The organoleptic test was carried out by observing the color, texture, and aroma of the patchouli oil bath bomb preparation. It aims to determine the characteristics of the bath bomb preparation that has been made. The results of the organoleptic test for the patchouli oil bath bomb preparation can be seen in Figure 1. After organoleptic testing was carried out on the bath bomb preparations for aroma, there was no difference. At the same time, the color had a slight difference in each formula, namely, F1 had a color that tended to be slightly yellow, F2 had a bone white or cream color, and F3 had a white color.

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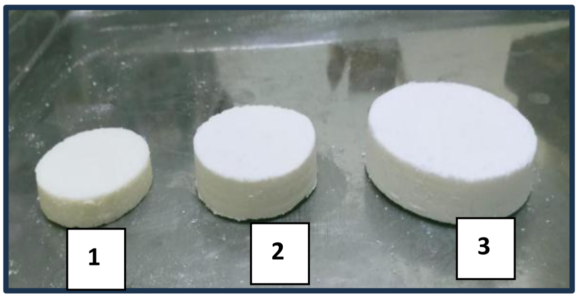

Figure 1. Patchouli Oil Bath bomb

The factor that can influence the difference in the color of this preparation is the presence of patchouli oil added to each formula, where each formula has a different citric acid concentration. Citric acid concentration F1: 26.3%, F2: 33.3% and F3: 38.5%. The organoleptic test results for F3 show a whiter color than F1 and F2 because the citric acid concentration in F3 is 38.5%. This is due to the addition of citric acid concentration, which can cause the preparation to become whiter.

Uniformity of Patchouli Oil Bath bomb Weight

The purpose of this weight uniformity test is to find out whether the patchouli oil bath bomb preparation produces a uniform weight or not. The parameter of the weight uniformity test is that the resulting weight does not deviate much from the predetermined weight. The smaller the difference in weight, the more uniform the bath bomb preparation.

The results of the patchouli oil weight uniformity test of the three formulas obtained formula 1 with a citric acid concentration of 26.3% had an average weight of 37.96 g of the set weight of 38 g, formula 2 with a citric acid concentration of 33.3% had a weight an average of 59.9 g of the specified weight of 60 g and formula 3 with a citric acid concentration of 38.5% has an average weight of 103.96 g of the initial weight determination of 104 g. The coefficient of variation from formulas 1, 2, and 3 meets the requirements because preparations are considered to meet weight uniformity if they have a coefficient of variation of ≤ 5%. The evaluation results of patchouli oil bath bomb weight uniformity met the requirements because, at the time of weighing, several bath bombs had different weights. However, the distance between the numbers was not too large. This is because during the process of making both bombs, which is done manually, the resulting weights cannot be the same[10].

Table 1. Test results for the uniformity of weight of patchouli oil bath bomb preparations

Replication	F1 (g)	F2 (g)	F3 (g)
1	37.98	59.97	103.99
2	37.98	59.89	103.99
3	37.89	59.98	103.98
4	37.98	59.98	103.89
5	37.88	59.98	103.99
6	37.98	59.89	103.88
7	37.98	59.89	103.99
8	37.89	59.97	103.99
9	37.98	59.97	103.89
10	37.98	59.97	103.99
Average ± SD	37.96 ± 0.04	59.9 ± 0.04	103.96 ± 0.04
%CV	0.12	0.07	0.05

The Hardness of Patchouli Oil Bath bombs

Hardness testing determines whether a patchouli oil bath bomb preparation resists impact or mechanical stress during production and distribution. The bath bomb is inserted into the hardness tester tool, which is then rotated until a hardness value is obtained.[15] The results of the patchouli oil bath bomb hardness test can be seen in Table 2. Testing the patchouli oil bath bomb hardness obtained from the three formulations, Formula 1 and Formula 2, which are known to meet the hardness value requirements, while Formula 3 does not. Formula 1 obtained an average hardness value of 4.2 kg/cm2, Formula 2 with an average hardness value of 7.3 kg/cm2, and Formula 3 produced an average hardness value of 10.1 kg/cm2. The hardness value for effervescent tablets is 4-8 kg/cm2.

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The difference in the hardness of this bath bomb occurs because the large size of the bath bomb requires great strength to crack, so large bath bombs have a larger hardness value when compared to small bath bombs. The difference in hardness in each formula is also due to the formation of bonds between citric acid and sodium bicarbonate. Citric acid and sodium bicarbonate will form CO2 and H2O when mixed. The greater the addition of citric acid and sodium bicarbonate, the greater the H2O content, which can increase the hardness of the bath bomb due to its hygroscopic nature. 12

Table 2. Hardness test results for patchouli oil bath bomb

Replication	Hardness Test (kg/cm²)		
	F1	F2	F3
1	4.3	7.7	10.8
2	4.3	8.0	10.1
3	4.0	7.4	8.9
4	4.1	7.2	9.7
5	4.2	6.3	11.0
Average ± SD	4.2 ± 0.13	7.3 ± 0.64	10.1 ± 0.85

Moisture Content of Patchouli Oil Bath bomb

The aim of measuring water content is to determine the percentage of water content contained in the patchouli oil bath bomb preparation. Water content is a significant characteristic because water can affect the texture and stability of a preparation. The results of testing the water content of the patchouli oil bath bomb can be seen in Table 3. The results of the water content test for patchouli oil bath bombs from the three formulas with citric acid concentrations of 26.3%, 33.3%, and 38.5% obtained the water content values of 9.5%, 12.6%, and 15.5%, respectively. Based on Figure 9, the highest water content test results were found in formula 3, namely 15.5%, with a proportion of citric acid concentration of 38.5%. Meanwhile, the lowest water content test results were found in formula 1, which was 9.5% with a citric acid proportion of 26.3%. Citric acid and sodium bicarbonate are hygroscopic materials (absorb water), so the greater the concentration of citric acid added, the greater the possibility of water vapor being absorbed, and vice versa. If a little citric acid is added, less water vapor absorption will occur. 12 The results of measuring the water content obtained from the three formulas, formula one and formula 2, have fulfilled the requirements. In contrast, formula 3's results were slightly higher because, according to SNI 06-3532-1994, the water content contained in solid bath soap preparations is a maximum of 15 %. In contrast, in the patchouli oil bath bomb, the water content ranged from 9.5 to 15.5%.

Table 3. Test results for the water content **of the patchouli oil bath bomb**

Replication	Water Content (%)		
	F1	F2	F3
1	9.7	13.0	15.0
2	7.8	12.0	13.6
3	10.9	12.7	17.9
Average ± SD	9.5 ± 1.56	12.6 ± 0.51	15.5 ± 2.19

Effectiveness of Patchouli Oil Bath Bomb Dissolving Time

The dissolving speed test aims to determine how long it takes to dissolve the patchouli oil bath bomb preparation into water.[12] The dissolving speed of patchouli oil bath bombs was tested in two ways: first, using bath bomb preparations in the form of granules, and second, using bath bomb preparations. Table 4 shows the results of the dissolving speed test, using granules and those from patchouli oil bath bomb preparations. Based on the data above, the results obtained for patchouli oil bath bombs for Formula 1 in granules require an average dissolving time of 117.67 seconds, while bath bombs require an average dissolving time of 1440 seconds. Formula 2 requires a dissolving time of 91.67 seconds in the form of granules, while it takes to dissolve the patchouli oil bath bomb is 1200 seconds. The time needed for formula 3 to dissolve patchouli oil bath bombs in the form of granules is 60.33 seconds, and for printed bath bombs, the time needed to dissolve them is 960 minutes.

Table 4. Results of the effectiveness test on the dissolving speed of patchouli oil bath bomb preparations

Formula	Average ± SD	
	granule	bath bomb
1	117.67 ± 5.8595	1440 ± 60
2	91.67 ± 2.0817	1200 ± 60
3	60.33 ± 2.5166	960 ± 60

The results obtained from the three formulas for the bath bomb granule soluble time test fulfilled the requirements, namely ≤ 300 seconds (5 minutes).[12] Patchouli oil bath bombs that have been printed require a longer dissolution time than the dissolving time of preparations in granule form. This is due to the pressure at the printing time, so the time needed to dissolve the bath bomb is longer. Dissolving time can occur due to the presence of CO2 gas, which is produced from acids and bases that react directly, so that it dissolves other substances.

The difference in citric acid concentration indicated a time difference in dissolving both bomb preparations. The higher the concentration of citric acid, the faster the time needed for both bomb preparations to dissolve. This is due to citric acid, which dissolves easily in water and reacts with sodium bicarbonate to produce CO2 gas.[12]

pH Bath bomb Patchouli Oil

pH testing of the preparation is carried out to determine its suitability and safety so that irritation does not occur. Topical preparations are expected to have a safe pH, where the pH value is not too low (acidic), because if the pH of the bath bomb is acidic, it will irritate the skin. In contrast, if the pH is too high (alkaline), it can cause the skin to become dry and scaly.[16] The results of the pH test for patchouli oil bath bomb preparations can be seen in Table 5.

Table 5. pH test results for patchouli oil bath bomb

Formula	R 1	R 2	R 3	Average ± SD
F1	5.98	5.94	5.96	5.96 ± 0.02
F2	5.97	6.00	5.98	5.98 ± 0.01
F3	5.99	5.96	5.98	5.98 ± 0.01

The results of measuring the pH of the patchouli oil bath bomb obtained from the three formulas have pH values that are known to meet the pH value requirements for topical preparations, in Formula 1 the average pH value is 5.96, Formula 2 has an average pH value of 5.98 and Formula 3 resulted in an average pH value of 5.98. The results showed that the patchouli oil bath bomb preparations from the three formulas met the pH requirements, namely 4-7[12].

Height and Stability of Patchouli Oil Bath bomb Foam

This test was carried out to determine the height of the foam from the prepared bath bombs. Foam is one of the important parameters in determining the quality of bath bombs, because consumers generally prefer abundant foam. The foam height test results were obtained for F1, which was 1.4 cm, F2, 2 cm, and F3, 2.6 cm. The foam height produced in each formula is quite good and meets the requirements for foam height, 1.3-22 cm.[17]

Bath bombs with higher concentrations of citric acid and other acidic components react with bicarbonates to produce increased CO2 release, which leads to more vigorous effervescence and consequently higher and more stable foams.[12,18] Essential oils such as patchouli oil contribute aroma and bioactive properties but may impact foam stability due to their volatility and interaction with surface-active agents, requiring optimized formulation to maintain consistent foam characteristics.[18] To maintain consistent foam

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characteristics, ingredients with a high saponin content may be added.[19] Saponins are a class of natural compounds with amphiphilic properties and the ability to reduce surface tension. The reduction in surface tension is caused by soap-forming constituents that can disrupt hydrogen bonding in water. Saponins lower the surface tension of water, enabling the formation of foam on the water surface after agitation [20]

The foam stability test was carried out to determine its ability to maintain its main parameters in a constant state for a specific time. The results of measuring the foam stability of the patchouli oil bath bomb were obtained in Formula 1, with an average foam stability value of 87 minutes, Formula 2, with an average foam stability value of 118 minutes, and Formula 3, with an average foam stability value of 152 minutes. Foam stability in bath products depends not only on foam height but also on bubble size, liquid drainage, and foam collapse mechanisms. The method of foam generation influences these properties, with stirring or mechanical agitation typically producing more stable foam structures than sparging alone. Stability tests emphasize the need to balance moisture content and ingredient ratios to prevent premature reaction and maintain functional foam properties over storage time.[18] The high yield and foam stability can be seen in Table 6.

Table 6. High test results and stability of the patchouli oil bath bomb foam

Replication	Height of foam (cm)			Stability of foam (second)		
	F1	F2	F3	F1	F2	F3
1	1.1	2.0	2.8	87	117	150
2	1.5	1.8	2.7	88	118	152
3	1.7	2.1	2.5	91	120	153
Avera	1.4	1.9	2.6	88.	118.	151.
ge ±	33	67	67	667	333	667
SD	0.3	0.1	0.1	2,0	1,52	1,52
	055	528	528	817	75	75

The results of the foam stability data were then analyzed using SPSS, and it was found that the data were normally distributed and homogeneous with a significance value of > 0.05. Then proceed with using the ANOVA test. The results of the ANOVA test obtained a significance value of <0.05, which means that there is a difference in the stability of the foam with the value of the citric acid concentration; the higher the citric acid concentration, the greater the impact on the stability of the foam produced during bath bomb preparation.

Geometric Surface Area of Patchouli Oil Bath bombs

This test aims to determine whether the bath bomb of each formula is the same size. The surface area test used the tube formula based on the bath bomb shape. The results of the geometric surface area test for patchouli oil bath bomb preparations can be seen in Table 7.

Table 7. The results of the patchouli oil geometric surface area test

Replication	Geometric surface area (cm)		
	F1	F2	F3
1	75.36	109.9	169.6
2	75.36	109.9	169.6
3	75.36	109.9	169.6
4	75.36	109.9	169.6
5	75.36	109.9	169.6
6	75.36	109.9	169.6
7	75.36	109.9	169.6
8	75.36	109.9	169.6
9	75.36	109.9	169.6
10	75.36	109.9	169.6
Average ±	75.36	109.9	169.6
SD	0	0	0

Based on the results obtained in each replication, measuring each patchouli oil bath bomb, it was obtained that the area or size was the same in formulas 1, 2, and 3. After calculating using the geometric surface area formula, the resulting formula 1 had an average area of 75.36 cm with a diameter of 6 cm, a height of 1 cm, formula 2 obtained an average geometric surface area value of 109.9 cm with a diameter of 7 cm, a height of 1.5 cm and formula 3 with

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an average geometric surface area of 169.6 cm with a diameter of 9 cm and 1.5 cm high.

Larger surface areas increase the bath bomb's exposure to water, enhancing the rate and completeness of the effervescent reaction and the dissolution time.[14,18] However, larger bombs with greater surface areas generally have higher hardness values and longer dissolution times, as observed with your formulas where F3 had the highest hardness value and quickest dissolution time due to higher citric acid facilitating faster reactions despite size.[15] The balance between surface area and formulation hardness is critical to ensure bath bombs dissolve effectively while maintaining structural integrity during handling and storage.[21]

CONCLUSION

The citric acid concentrations of 26.3%, 33.3%, and 38.5% on the physical characteristics of the bath bomb preparations did not affect the pH value. However, there are differences in organoleptic tests, uniformity of weight, hardness, effective time to dissolve, water content, geometric surface area, height, and stability of foam, along with variations in higher citric acid concentrations. The increase in citric acid concentration enhances foam characteristics while the geometric surface area reflects predictable size and dissolution effects in bath bomb products.

Conflict of Interest

The authors did not have a conflict of interest

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that they will bear any liability for claims relating to the content of this article.

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