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Effect of Zinc Oxide Concentration on Physical Characteristics of Paste Containing *Jatropha curcas* Latex and *Piper crocatum*

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ABSTRAK

Zink oksida (ZnO) banyak digunakan sebagai bahan dasar berbagai pasta berkat sifat fisik dan kimianya yang unik. Penelitian ini bertujuan untuk mengetahui pengaruh konsentrasi ZnO terhadap karakteristik fisik pasta yang mengandung getah *Jatropha curcas* dan ekstrak daun *Piper crocatum*. Ekstrak dianalisis dengan melakukan skrining terhadap kandungan saponin dan tanin. Pasta dibedakan dalam 3 formula FI, FII, dan FIII dengan berbagai konsentrasi ZnO masing masing 10% w/w, 15% w/w, dan 20% w/w. Semua formulasi dievaluasi berdasarkan karakteristik fisiknya, termasuk sifat organoleptik, pH, daya rekat, daya sebar, viskositas, dan stabilitas menggunakan uji sentrifugasi. Seluruh pengujian dilakukan dalam tiga kali pengulangan (n=3) Analisis statistic dengan analisis scatter plot digunakan untuk menentukan korelasi antara parameter-parameter tersebut. Uji skrining fitokimia menunjukkan bahwa getah *Jatropha curcas* mengandung saponin dan tanin. Semua formulasi memenuhi persyaratan pasta yang dapat diterima untuk pH (5,34–6,41), daya sebar (2,59–2,71 cm), dan daya rekat (1,69–5,12 s). Analisis scatter plot menunjukkan korelasi negatif antara viskositas dan daya sebar (R^2 = 0,840; r = −0,916; p > 0,05), serta korelasi positif antara viskositas dan gaya adhesi (R^2 = 0,647; r = +0,804; p > 0,05). Namun, formulasi tersebut menunjukkan ketidakstabilan yang ditnjukkan dengan adanya pemisahan fase. Studi ini menunjukkan bahwa konsentrasi ZnO memainkan peran penting dalam karakteristik reologi pasta berbasis J. curcas dan P. crocatum.

Kata kunci: ZnO, Paste, J. curcas, P. crocatum

ABSTRACT

Zinc oxide (ZnO) is widely used as a base for various pastes due to its unique physical and chemical properties. This study aimed to understand the effect of ZnO concentration on the physical characteristics of the paste containing *Jatropha curcas* latex and *Piper crocatum* leaf extract. The extract was characterized by screening for saponins and tannins. Three formulations (FI-FIII) of the paste were prepared with various ZnO concentrations: 10% w/w, 15% w/w, and 20% w/w. All formulations were evaluated for their physical characteristics, including organoleptic properties, pH, adhesion, spreadability, viscosity, and stability, using a centrifugation test. All tests were conducted in triplicate (n=3). Analysis, statistics, and a scatter plot were used to determine the correlation between the parameters. *Jatropha curcas* latex contains saponin and tannin. All formulations meet acceptable paste requirements for pH (5.34-6.41), spreadability (2.59 -2.71 cm), and adhesion (1.69 -5.12 s). Scatter-plot analysis showed a negative correlation between viscosity and spreadability (R^2 = 0.840; r = −0.916; p > 0.05), and a positive correlation between viscosity and adhesive force (R^2 = 0.647; r = +0.804; p > 0.05). However, the formulation showed instability, with a separation phase. The study indicates that ZnO concentration plays a crucial role in the rheological characteristics of pastes based on J. curcas and P. crocatum.

Key words: ZnO, Paste, J. curcas, P. crocatum

1. INTRODUCTION

Pulp devitalization is a dental procedure used to manage irreversibly inflamed or necrotic dental pulp (Mirah, 2023). Paraformaldehyde or arsenic trioxide are the devitalizing agent that have been widely used due to their strong necrotizing properties. However, their application may cause serious effects. Arsenic trioxide has been associated with severe bone necrosis, particularly in the mandible, following its use in endodontic treatments. Paraformaldehyde can cause localized necrosis of the gingiva and alveolar bone if it leaks during treatment. In addition, paraformaldehyde may penetrate the dentine and be released as formaldehyde, which can affect periodontal and bone tissues (Yavuz et al., 2008). Due to their toxicity, there is a need alternative active compound of pulp devitalization with safer, biocompatible and has minimal adverse effects.

Currently, medicinal plants have gained significant attention as sources of bioactive compounds with anti-inflammatory, antimicrobial, and wound-healing properties. *Jatropha curcas* latex has anti-inflammatory and antimicrobial effects due to its active compounds, such as diterpenoids and flavonoids. The latex of *Jatropha curcas* is also a rich source of tannins and saponins, contributing to its bioactive. Both tannins and saponins are highly beneficial in wound healing properties (Vijayalakshmi et al., 2022). Similarly, *Piper crocatum* (red betel leaf) extract is rich in polyphenolic compounds that contribute to its antioxidant and anti-inflammatory potential. The antioxidant activity of it may help reduce oxidative stress and enhance healing in oral tissues. It also contains β-sitosterol, which is known to have inhibitory effects against oral pathogens such as Streptococcus mutans, Streptococcus sanguinis, and Candida albicans (Tristyaningrum et al., 2025). Combining these two plants may provide a synergistic effect for inflammatory responses and prevent infections during dental procedures.

In the formulation of devitalization pastes, zinc oxide (ZnO) is commonly used as a base material due to its excellent physicochemical stability, astringent effect, and antimicrobial properties. ZnO also plays a crucial factor to enhance the paste's consistency and stability. Moreover, ZnO has been reported posses mild anti-inflammatory activity and the ability to promote macrophage migration, which promote healing process in dental tissues. Studied showed that for time periods less than 8 hours, higher ZnO concentrations result in better long-term thermal stability. However, for periods longer than 8 hours, the stability decreases with higher ZnO concentrations (Ju et al., 2020)

The physical characteristics of the paste are crucial to determining its performance, stability, and patient acceptability. These parameters are influenced by several factors, one of which is the concentration of bases. Previous studies have reported that ZnO is widely used in paste formulations. However, the effect of ZnO in paste containing plants such as *J. curcas* latex and *P. crocatum* is still underexplored, particularly since there is sap or latex content in the formulation. Therefore, this study aims to evaluate the effect of varying zinc oxide concentrations on the physical and rheological characteristics of a paste containing *Jatropha curcas* latex and *Piper crocatum* extract, as well as to analyze the correlation between the evaluated parameters. This study serves as a preliminary investigation to provide insight into the role of ZnO concentration in influencing the physicochemical properties of natural-based paste formulations, which may contribute to the future optimization of herbal dental preparations.

2. METHODS

Materials

Jatropha curcas latex was collected from Bantul, Yogyakarta. Plant authentication was performed at the Biology Laboratory, Universitas Ahmad Dahlan, Yogyakarta, Indonesia. The specimen was identified as *Jatropha curcas* L. and documented under determination number 291/Lab.Bio/B/IX/2021. *Piper crocatum* was obtained from CV Herbal Anugrah Jaya, Bantul, Yogyakarta. The identity of the plant material was confirmed based on a certificate of plant identification provided by the supplier.

Extraction Piper crocatum

Red betel leaf powder (250 g) was weighed then added ethanol 70 % (v/v) 750 mL. The mixtured stored at room temperature (25 ± 2 °C) for five days, with occasional stirring. After five days, the macerate was first filtered through whatman filter, then evaporated using vacuum rotary evaporator at temperature under 40 °C.

Phytochemical Screening

Test of Tannin

500 mg of the *Jatropha curcas* latex was added to the 5 ml of distilled water and filtered. Then, 3 drops of the 1% $FeCl_3$ were added to the filtrate. The presence of tannin was observed by blue or black coloration (Godlewska et al., 2023).

Test of Saponins

500 mg of *Jatropha curcas* latex was combined with 5 ml of distilled water and agitated. The formation of foam observed the presence of saponins (Godlewska et al., 2023).

Phytochemical screening of Jatropha curcas latex was performed to identify the presence of tannins and saponins using standard qualitative methods.

Formulation of the paste

The formulation of the paste was conducted according 3 *Table 1*. Methyl paraben, BHT, and propylene glycol were first dissolved in the aqueous phase under continuous stirring until a clear solution was obtained. Then, zinc oxide is added gradually to the mixture solution, ensuring the homogeneity of the zinc oxide. After forming a homogeneous mixture, the latex resin of Jatropha was incorporated into the mixture and continuously stirred for 10 minutes to achieve a consistent paste texture. The red betel leaf extract was added, and the mixture was stirred for an additional 5 minutes until it became homogeneous.

Table 1. Formulation of the devitalisation paste containing *Jatropha curcas* latex and *Piper crocatum* leaf extract

Composition	Concentration (%w/w)		
	FI	FII	FIII
Jatropha Curcas Sap	5	5	5
Red Betel Leaf Extract	0.25	0.25	0.25
Zinc oxide	10	15	20
Propyl paraben	0.3	0.3	0.3
Methyl paraben	0.3	0.3	0.3
Amylum	30	30	30
ad vaselin album	100	100	100

Physical characteristic of the paste

Organoleptic

The organoleptic assessment was conducted by determined appearance, colour, aroma, and texture of the paste.

pH

pH was measured using digital pH meter *(*Mettler Toledo International Inc., Greifensee, Switzerland), in triplicate.

Viscosity

Rheological properties of the paste was conducted using viscometer (DV-I+ model, AMETEK Brookfield, Middleboro, MA, USA) with spindle RV-3, and spindle speed 50 rpm at room temperature (25 ± 0.5 °C). Each formulation was measured in triplicate and the mean viscosity (± standard deviation) reported.

Spreadability

1 g of the sample was placed between two glass plates (20 × 20 cm). A weight of 50-1000 g was applied to the upper plate for 1 minute at room temperature (25 ± 2 °C). The diameter of the sample was measured at three points using a caliper after removing the weight. The mean diameter ± standard deviation (n = 3) was calculated for each formulation (Bakhrushina et al., 2022).

Adhesion test

0.25 g of the sample was placed between two glass plates. A weight of 1 kg was placed for 5 minutes, then the 80 g secondary weight was released. The time release of the sample from the glass object was recorded (Sirait et al., 2022).

Centrifugation test(Gandova et al., n.d.-a)

Centrifugation testing was performed using a centrifuge at a speed of 3750 rpm for 5 hours. After centrifugation, the formulations were observed visually for signs of physical instability, including phase separation, sedimentation, creaming, and cracking (Gandova et al., 2022).

Analysis Statistical

The relationships between viscosity, spreadability, and adhesion were analyzed using Pearson's correlation test. Correlation coefficients (r), coefficients of determination (R^2), and p-values were calculated to evaluate the strength and direction of the relationships. Statistical significance was set at $p < 0.05$.

3. RESULTS AND DISCUSSION

Phytochemical screening of *Jatropha curcas* latex (Table *2*) showed the presence of tannins and saponins. The formation of a dark coloration in the ferric chloride test indicated a positive reaction for tannins, while the persistence of foam confirmed the presence of saponins. These findings are consistent with previous reports (Gandova et al., 2022) describing the presence of secondary metabolites in *J. curcas* latex.

The presence of tannins and saponins may contribute to the functional properties of the formulation. Tannins are known to exhibit astringent characteristics through their ability to bind and precipitate proteins, which may support tissue contraction and surface interaction (Ammam et al., 2026). Meanwhile, saponins possess surface-active properties and have been associated with membrane permeability and antimicrobial effects (Wei et al., 2021). These characteristics suggest that the latex component may play a role in supporting the overall performance of the paste. However, it should be noted that the present study only employed qualitative phytochemical screening. Therefore, the specific concentration and activity of these compounds were not determined. Further quantitative analysis and biological evaluation are required to better understand their contribution to the intended application of the formulation.

Table 2. Phytochemical Screening Results of Jatropha curcas latex

Chemical Compound	Result
Tannins	+
Saponin	+

Zinc oxide is widely used in various paste formulations due to its beneficial properties. Specifically for dental treatment, these pastes are easy to apply and can be used without the need for advanced equipment or techniques (Tian et al., 2022). Despite, ZnO in paste exhibit good tolerance with the tissues, biocompatibility with various dental materials, and may increase healing efficacy (Abdullah et al., 2024). ZnO is an insoluble material that may prolong the stability of the materials (Leitner et al., 2018).

The physical characteristics of the paste formulation was presented in Table *3*. All formulation exhibited a smooth, greenish white color, and specific aroma of the *P.crocatum*.

Table 3. Physical Characteristics of the paste containing *Jatropha curcas* latex and *Piper crocatum* leaf extract

Physical Characteristics	Formulation		
	FI	FII	FIII
Organoleptic	smooth, greenish white color, and specific aroma of the *P.crocatum*.	smooth, greenish white color, and specific aroma of the *P.crocatum*.	smooth, greenish white color, and specific aroma of the *P.crocatum*.
pH	6.41±0.10	5.91±0.13	5.34±0.05
Spreadability (cm)	2.71 ± 0,01	2.66 ± 0,02	2.59±0.02
Adhesion (second)	1.69 ± 0.27	3.45 ± 0,72	5.12±0.54
Viscosity (cP)	56243.00 ± 37.00	86000.00 ± 1501.11	101666.67±5344.57

As shown in Table *3*, all formulations exhibited a pH range of 5.3 to 6.4. Generally, pastes containing ZnO tend to have a neutral pH (pH 7) slightly alkaline(Raszewski et al., 2025). The ideal pH contributes to maintaining the oral tissue conditions, stability, and effectiveness of the dental paste (Leitner et al., 2018). The pH environment may contribute to dental treatments success, involving zinc oxide-based materials. Acidic conditions enhance zinc ion release, improving antimicrobial properties, while neutral and alkaline conditions provide stability and healing(Raszewski et al., 2025). According to the previous study, these materials can maintain high success rates over extended periods, indicating their stability and effectiveness in various pH conditions(Moskovitz et al., 2021). These properties make zinc oxide-based materials effective for dental pulp therapy.

The spreadability indicate the easy of the products can applied on the skin. All formulations comply with the required standard except the viscosity, ranging from 20.000 to 50.000 cP (Rina et al., 2024). FI possesses bigger spreadability and lower adhesion than FII and FIII. pH values for FI, FII and FIII respectively 6.41±0.10, 5.91±0.13, 5.34±0.05.

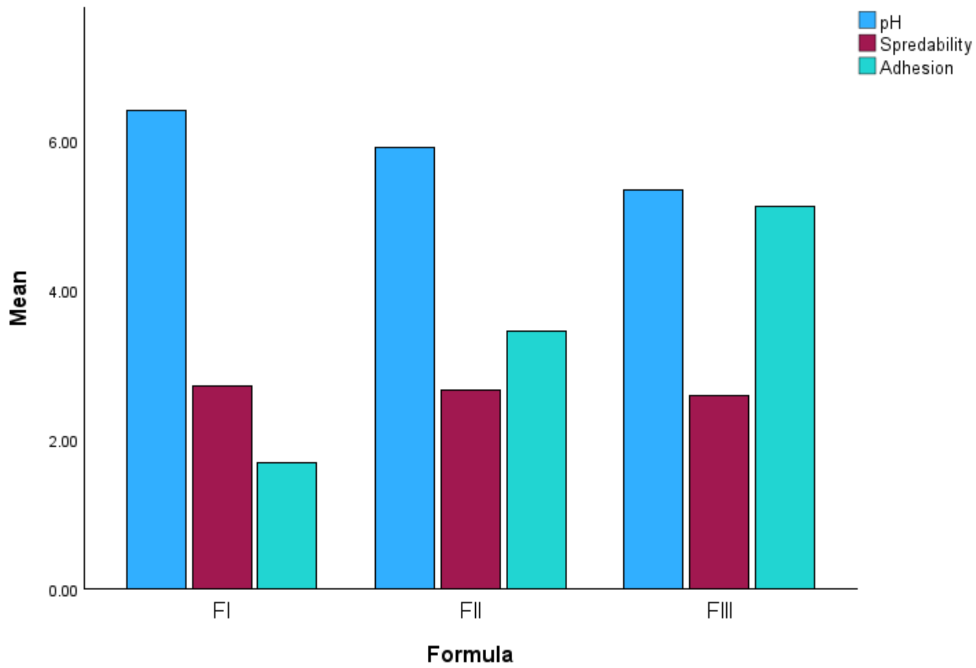

Figure 1. Comparison of physical characteristics (pH, spreadability, adhesion time) of three paste formulations Data represent mean ± SD (n = 3).

The scatter-plot analysis indicated an inverse relationship between the pH and adhesion (y = 21.84 – 3.13 x; R^2 = 0.814). Although the correlation coefficient indicates a strong trend (R^2=0.814), this relationship was not statistically significant, indicating the present results do not provide sufficient evidence of an association between pH and adhesion. However, these results are in line with previous studies reported (Maslii et al., 2020) which indicate an increase in pH followed by a decrease in adhesive force. The study reports that pH 6.6 showed the lowest adhesive force. This phenomenon may be attributed to changes in hydrogen bonding interactions, as slightly acidic conditions favor stronger intermolecular interactions, potentially enhancing surface contact and cohesio (Singh, 2024).

As shown in Table 3, the spreadability tend to decrease with increasing the ZnO concentration. The increase in ZnO concentration is comparable with the decrease in the spreadability. The study showed that the spreadability of this research is vulnerable to 2.59-2.71, which is within the acceptable range according to the requirements (N Egam et al., 2023). The scatter plot analysis showed a negative trend between spreadability and adhesive force (*R^2 = 0.398; r = -0.631).* Although the relationship between spreadability and adhesion was not statistically significant ($p > 0.05$), the observed trend was comparable to patterns reported in previous studies where formulations with higher spreadability generally exhibit lower adhesion due to their softer structure and reduced resistance to flow (Chuah et al., 2023). However, the present data do not provide sufficient statistical evidence to confirm such an association.

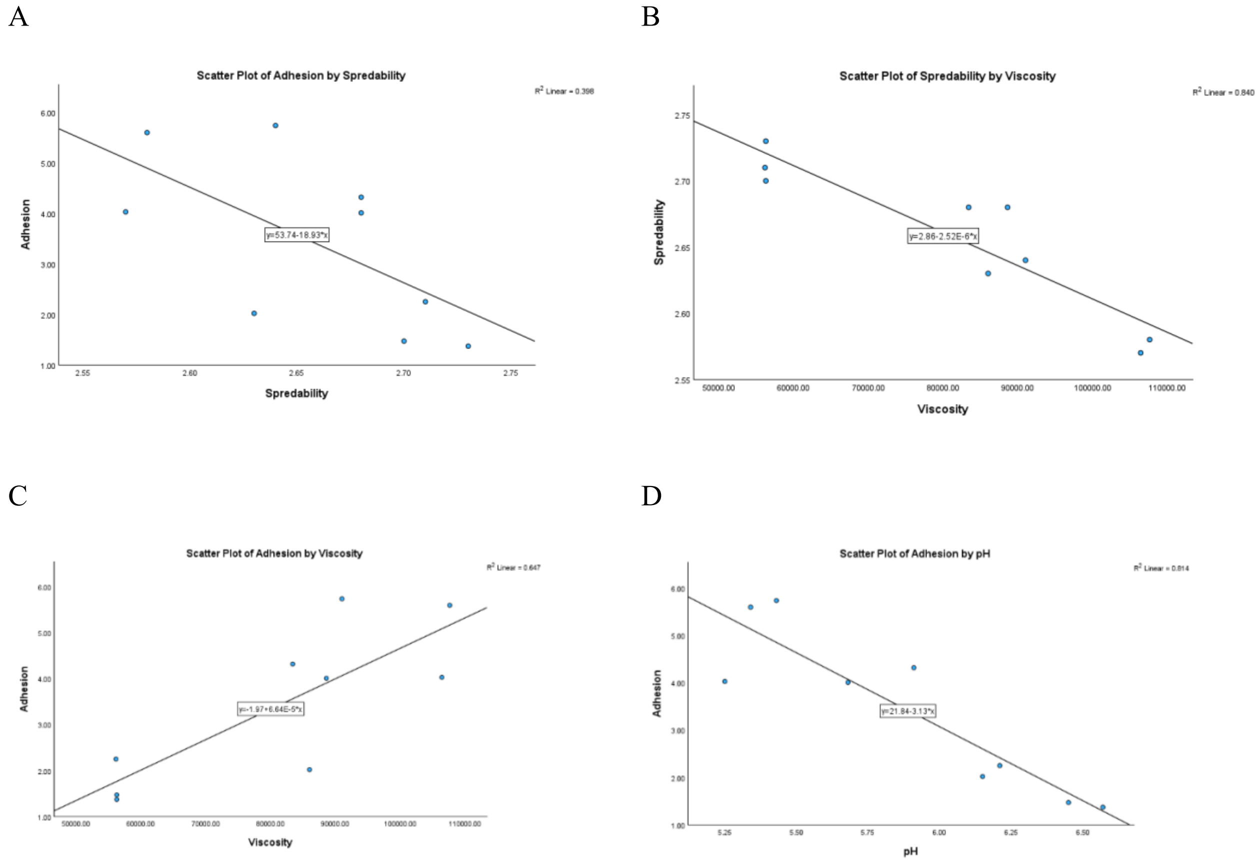

Figure 2. Scatter plot illustrating the relationship among physical parameters : (A) spreadability and adhesion time, (B) viscosity and spreadability, (C) viscosity and adhesion, (D) pH and adhesion, for paste FI, FII and FIII containing J. curcas latex and P. crocatum leaf extract (n = 3).

Viscosity, adhesion, and spreadability were analyzed to better understand the rheological behavior of the paste. Based on Figure 2, viscosity showed a negative trend with spreadability ($R^2 = 0.840$; $r = -0.916$; $p > 0.05$), and a positive trend with adhesive force ($R^2 = 0.647$; $r = +0.804$; $p > 0.05$). However, these trends were not statistically significant. Similar patterns have been reported in previous studies where higher viscosity was associated with increased adhesion due to increased molecular interactions and surface contact time and decreased spreadability (Safitri et al., 2021). Formulation with higher viscosity often exhibit lower spreadability because of their greater resistance to flow (Mandal & Singh, 2024). Viscosity is a measure of a fluid's resistance to flow. In paste dosage form, viscosity is critical for adhesion and spreadability. Increased viscosity often results from higher concentrations of thickening agents or polymers within the formulation. The increase in viscosity observed with higher ZnO concentrations may be associated with its interaction with components of the latex matrix.

Nevertheless, the limited number of formulations (n = 3) may have reduced the statistical power of the analysis. Therefore, to achieve an optimal physical characteristic of the paste it is recommended to expand the range of ZnO concentration and more comprehensive rheological analysis to better understand the relationship between formulation variables and physical characteristics.

In addition to the evaluated physical and rheological properties, the stability of the formulation was further assessed through centrifugation testing. All formulations exhibited phase separation, indicated by the presence of a small amount of oil on the surface of the paste. This finding suggests that the formulations exhibited limited physical stability under the accelerated test conditions. The instability may be associated with the incorporation of Jatropha curcas sap and red betel leaf extract into a vaselin album base, which could reduce the ability of the system to remain homogeneous under high centrifugal force. Furthermore, the increased ZnO concentration may have contributed to changes in the internal structure of the paste, affecting its stability. These results suggest that the current formulation requires further optimization, particularly with respect to the composition of the base and the addition of suitable stabilizing agents.

4. CONCLUSION

The present study showed that increasing ZnO concentration affected the physical characteristics of the paste formulations, particularly viscosity. All formulations showed pH, spreadability, and adhesion values within the acceptable range. However, phase separation was observed during centrifugation testing, indicating limited physical stability under accelerated conditions. Among the tested formulations, F1 and F2 showed better physical characteristics than Formula 3. Further optimization of the formulation is required to improve its physical stability.

5. ACKNOWLEDGMENT

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