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Physical Stability Test Spray 10% Combination of Virgin Coconut Oil (VCO) and Ginger (Zingiber Officinale Rocs.) As a candidate of a substance for the cure of gingivitis

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ABSTRACT

Virgin Coconut Oil (VCO) and ginger (Zingiber officinale Rosc.) have antibacterial and anti-inflammatory activities, making them potential natural alternative therapies for the treatment of gingivitis. Although their biological effectiveness has been proven, the physical stability of this combination spray preparation has not yet been evaluated. The spray formulation was chosen because it is practical, provides even distribution, and minimises contamination. To determine the effect of physical stability testing of a 10% VCO-ginger spray combination as a candidate material for the treatment of gingivitis. Laboratory experimental research was conducted by creating five formulations (F1-F5). Stable formulations were subjected to a cycling test and physical stability evaluation, including organoleptic testing, homogeneity, pH, viscosity, spreadability, and adhesion. Data analysis was performed descriptively. Formulation F5 showed the best physical characteristics with a milky white colour, a distinctive coconut-ginger smell, a homogeneous liquid texture, a pH of 6.019-6.823, a spreadability of 5.0-6.1 cm, an adhesion of 19.27-29.72 seconds, and a viscosity of 346.7-692.8 cP. Formulation F5 has physical performance potential as a candidate for gingivitis therapy, but its emulsion stability is limited under extreme temperature conditions. Optimisation of surfactant concentration is required to prevent viscosity reduction and phase separation during long-term storage.

KEYWORDS Virgin Coconut Oil (VCO); ginger (Zingiber officinale Rocs.); gingivitis, spray physical stability; cycling test.

INTRODUCTION

Indonesian people have a low level of awareness in maintaining the cleanliness of the oral cavity, especially in daily life. Gingivitis cases in the United States as a whole reached 95.6% in people over 18 years old, of which two-thirds were in the category of moderate gingivitis and 3.6% were in the category of severe gingivitis (Carvajal et al., 2016). Based on data from the East Java Health Office in 2022, cases of gingivitis and periodontal disease are the most cases of teeth and mouth in East Java around 226,168 cases after pulp and periapical tissue disease. Gingivitis is an inflammation of the gingiva caused by plaque buildup, without being accompanied by loss of attachment to periodontal tissue (Anggraeni et al., 2022). Healing of gingivitis is carried out by plaque control, either mechanically through scaling and root planing, or chemically using antiseptics such as chlorhexidine (Ambarwati et al., 2024; Angelia et al., 2022). However, long-term use of chlorhexidine causes tooth staining and disruption of the normal balance of the oral cavity. Therefore, alternative natural ingredients are needed that are safe to use and have a more affordable price.

A natural ingredient that has been popular lately and beneficial for human life, especially in dental and oral health, is in the form of coconut processed into Virgin Coconut Oil (VCO) (Jacob, 2016; Salian & Shetty, 2018; Wallace, 2019). VCO or pure coconut oil is a processed product of coconut meat with low temperatures or without heating, so that its important content is maintained, and this is increasingly relevant because Indonesia is one of the largest coconut producers and exporters in the world, accounting for around 53% of total global coconut

exports. The process of making pure coconut oil does not require expensive costs because the raw materials are easy to obtain, the processing is simple, and the use of fuel is minimal so that the chemical and nutritional content is maintained, especially the fatty acids contained in the oil (Mattoasi and Usman, 2022). VCO has the highest phytochemical content such as lauric acid (47-50%), myristic acid (17-18.5%) and palmitic acid (7-9.5%). VCO can be used as an alternative ingredient to chlorhexidine and its content of lauric acid and myritic acid is able to kill porphyromonas gingivalis bacteria. In addition, VCO also has anti-inflammatory effects in the acute and chronic inflammatory phases as evidenced by increased expression of anti-inflammatory cytokines that play a role in the periodontal regeneration process (Thahir et al., 2022). However, the unsaturated fatty acid content in VCO often occurs oxidation which can cause stiffness so that it causes the smell, taste, and texture of VCO to be unpleasant. An alternative that can be done is to combine it with other ingredients that function as antioxidants to limit the oxidation of oxygen from the air, such as ginger (Zingiber officinale Rosc.).

Ginger (Zingiber officinale Rosc.) is one of the spice plants that has long been used by the Indonesian people as a traditional medicine because of its potential active ingredient content which is known to be effective in maintaining healthy teeth and mouth, and is easily obtained at an affordable price. The addition of ginger (Zingiber officinale Rosc) is able to reduce the number of peroxides, while the protease enzyme in ginger functions to inhibit and suppress oxidation because these compounds can protect VCO from direct contact with air. Research by Rostina et al (2022) regarding the combination of VCO and emprit ginger obtained the best quality, namely by adding 150 mL of ginger filtrate to 1000 mL of VCO. Emprit ginger was chosen because of its higher gingerol and shogaol content compared to elephant ginger and red ginger (Wahyani and Fera, 2022). The content of active compounds in ginger is divided into volatile and non-volatile compounds which are the highest compared to other local natural ingredients. Non-volatile components (oleoresins) as a complete picture of the content of ginger consisting of gingerol, shogaol, and zingerone compounds that have antioxidant, anti-inflammatory, analgesic, and anticarcinogenic activities. In addition, ginger also contains anti-inflammatory compounds such as alkaloids, terpenoids, and tannins that are able to inhibit and even kill porphyromonas gingivalis bacteria so that they can support the healing process of gingivitis. A phytochemical test study by Nashiroh et al (2023) proved that ginger (Zingiber officinale Rosc.) contains saponins, alkaloids, phenolics, flavonoids, and triterpenoid compounds that have potential as topical anti-inflammatories.

Previous research by Wisnawati (2025) exploring the effectiveness of a combination spray of VCO and ginger (Zingiber officinale Rosc.) on the number of lymphocyte cells in gingivitis mice showed that this combination can significantly reduce the number of lymphocyte cells, supporting the inflammatory healing process in gingiva. However, the study still did not explore the variety of additives and concentrations so that the results of the spray preparation were thick and did not meet the pH criteria of the oral cavity. VCO oil and ginger (Zingiber officinale Rosc.) remain the main active ingredients with a VCO concentration maintained at 10% to maintain its lauric acid content. Meanwhile, the development of this VCO and ginger spray formulation (Zingiber officinale Rosc.) requires special attention to the selection of additives, such as thickeners, surfactants, preservatives, and solvents to ensure physical, chemical, and biological stability. In the initial formulation, Carbomer 940 was used as a thickener to form a stable gel, but this material has limited stability to pH. Alternatively,

Hydroxypropyl Methylcellulose (HPMC) has been widely studied as a neutral substitute, resulting in a clear gel, its viscosity is stable in the long term with an optimal concentration of around 3-5%. The use of Tween 80 and Span 80 which produce a spray preparation that is still thick so that it can be replaced with PEG (Polyethylene Glycol) 40 and 400 which can help in lowering surface tension, increasing interface fluidity, and increasing the mixing of water and oil (Sahumena and Suryani, 2022). Meanwhile, the use of Methyl Paraben as an antimicrobial preservative is also a concern due to its potential toxicity risk. More modern and safe alternatives such as phenoxyethanol with a concentration of 1% have been developed to improve the oxidative stability and shelf life of the product. In this formulation, synthetic preservative substitutes are a priority to produce products that are safer for consumers (Abidin et al., 2022; Anindhita & Oktaviani, 2020; Annisa et al., 2020).

The use of VCO spray and ginger (Zingiber officinale Rosc.) is a form of innovation as well as an alternative solution. The selection of spray preparations for the oral cavity is increasingly popular compared to other preparations, such as mouthwashes or ointments, due to some of its advantages. The use of sprays is also considered more appropriate in conditions when direct exposure to the inflamed gingival area is required, such as in gingivitis (Agustiani et al., 2022). This is because the spray can reach the sulcus gingival and interdental areas that are not always reached by mouthwash (Adnyani et al., 2023). Mouthwash works on the entire oral cavity but is quickly wasted, so the contact time of the active ingredient becomes very short (Lin and Raman, 2015). While topical gels can indeed provide longer contact time, their application requires direct contact with the inflamed area, risks causing contamination and is impractical for the user if used repeatedly (Almukainzi et al., 2022). Therefore, formulations in the form of spray preparations are considered more practical and safer because contamination with microorganisms can be minimized, which is used by spraying without direct contact with hands like other topical preparations (Cendana et al., 2021). In addition, spray preparations can provide a more even distribution on the surface of the oral cavity, thereby increasing the effectiveness of treatment. Research shows that spray preparations are preferred by users because they provide a fresh sensation and quickly absorb without leaving an uncomfortable residue, making it a better choice in oral cavity care (Darman et al., 2022). The stability of pharmaceutical preparations is a fairly important criterion in a product to determine the characteristics of the properties possessed by the ingredients. Various formulations of spray preparations need to be evaluated for physical stability to ensure product safety and effectiveness. Evaluation of physical stability using cycling tests includes organoleptic tests, homogeneity, pH, viscosity, dispersibility, and adhesion. Therefore, this study aims to continue the development of a combination spray formulation of VCO and ginger (Zingiber officinale Rosc.) by exploring various variations of additives and concentrations and conducting physical stability evaluations. This research is expected to produce a more optimal formulation in terms of effectiveness, stability, and physical characteristics.

The urgency of this research is underscored by the high prevalence of gingivitis and the limitations of current treatments. There is a clear public health need for effective, safe, and affordable alternatives derived from natural sources. While the individual and combined benefits of VCO and ginger are known, their successful translation into a stable pharmaceutical product requires rigorous formulation science. This study addresses this need by systematically

developing and evaluating the physical stability of a VCO-ginger spray, a crucial step before proceeding to efficacy and clinical trials.

The novelty of this research lies in its systematic exploration of various excipient combinations to optimize a VCO-ginger spray formulation for the oral cavity. Unlike previous studies that focused solely on biological activity, this research prioritizes pharmaceutical elegance and stability. It investigates different surfactants (Tween 80, Span 80, PEG 40, PEG 400), thickeners (Carbomer 940, HPMC), humectants (glycerol, propylene glycol), and preservatives (methyl paraben, phenoxyethanol) to identify a formula that is not only stable but also possesses the ideal physical characteristics for an oral spray—appropriate viscosity, pH, spreadability, and adhesion.

Is there an effect of the physical stability test of the 10% spray combination of Virgin Coconut Oil (VCO) and ginger (Zingiber officinale Rocs.) as a candidate ingredient for the cure of gingivitis? The purpose of this study was to determine the effect of the physical stability test of the 10% spray combination of Virgin Coconut Oil (VCO) and ginger (Zingiber officinale Rocs.) as a candidate ingredient for the cure of gingivitis. To know and analyze the results of physical stability tests on various types of spray formulations as candidate ingredients for the cure of gingivitis. The benefit is to contribute science on the formulation of 10% spray formulation in combination of VCO and ginger (Zingiber officinale Rocs.) as anti-inflammatory and antibacterial and to support the development of formulation innovations based on natural ingredients in dentistry. Contributing to the provision of safe and effective natural alternative ingredients in maintaining oral health and supporting the development of innovative products that can be widely used by the public and dental professionals.

METHOD

This study used a laboratory experimental design to formulate and evaluate five combination spray formulations of Virgin Coconut Oil (VCO) and ginger (Zingiber officinale Rocs.). The samples included aged coconut meat, emprit ginger, as well as five spray batches that met the inclusion criteria. The study variables included independent variables in the form of physical stability tests of 10% VCO-ginger spray, bound variables in the form of potential ingredients as candidates for gingivitis curing, and control variables in the form of ingredient concentration, type of excipient, and storage conditions.

The manufacture of active ingredients is carried out through two stages, namely the production of VCO by the wet fermentation method and the manufacture of emprit ginger filtrate. VCO is obtained from 1,000 ml of coconut milk that is processed to produce 65 ml of oil through a gradual separation of cream, blondo, and water. Ginger filtrate is obtained from the extraction of emprit ginger rhizomes that are blended and filtered to produce 150 ml of filtrate. The combination of VCO and ginger filtrate is then mixed, let it sit, and separated to obtain the oil that becomes the active ingredient of the spray. The spray formula is further made in five variations, each containing 10% VCO-ginger with additional functional excipients such as surfactants, gelling agents, humectants, preservatives, and solvents.

The research data was analyzed descriptively by comparing the observation results to the theory and standard of product stability parameters. The results of the evaluation are presented in the form of brief descriptions, tables, and drawings to illustrate the differences in characteristics between formulations. This analysis was used to determine the most stable

formulation based on physical parameters as well as to assess the potential combination of VCO and ginger as candidates for gingivitis curing ingredients. This research is expected to produce a stable herbal spray formulation that is stable, safe, and in accordance with the criteria of modern topical preparations.

RESULT AND DISCUSSION

Physical Stability Evaluation Results of VCO and Ginger Spray

Physical stability tests are carried out with cycling tests to determine the durability of the preparation during storage. The cycling test was carried out for 6 cycles where in one cycle it was put in a 4 degree ± 2 degrees Celsius cooler for 24 hours then stored at a temperature of 40 degrees ± 2 degrees Celsius for 24 hours so that it took 12 days. In each cycle, physical tests will be carried out which include various parameters, such as organoleptis, homogeneity, pH, viscosity, dispersibility, and adhesion. The combination spray preparation of VCO and ginger consists of 5 formulations with various variations in concentrations and additives used.

Uji Organoleptik

Organoleptic testing was performed to assess the initial physical characteristics of VCO and ginger combination spray preparations using the five senses, including the assessment of color, odor, and texture. A good criterion for organoleptic is that the resulting spray preparations are clear or the same as the active substance, not cloudy, and there are no air bubbles (Montella et al., 2024). The results of the organoleptic test in this study can be seen in the following table:

Table 1. Organoleptic Test Results on F1-F5 Before Cycling Test Organoleptic Results

Formula	Day 0		
	Color	**Smell**	**Texture**
F1	Yellowish white	Typical ginger coconut	Liquid separating
F2	Yellowish white	Typical ginger coconut	Liquid separating
F3	Yellowish white	Typical ginger coconut	Liquid separating
F4	Clear yellowish	Typical ginger coconut	Condensed together
F5	Milky white	Typical ginger coconut	Melt fused

Based on table 1, the results of observations before the cycling test were obtained in yellowish white at F1-F3, clear at F4, and milky white at F5. The overall smell is in accordance with the ingredients used, namely the aroma of coconut and ginger. The texture obtained is liquid in F1, F2, F3, F5 formulations and thick in F4 formulas due to variations in ingredients used in the manufacture of spray preparations.

The organoleptic test followed by the cycling test was only on the F5 formulation because of the four formulations, namely F1-F4, it was not included in the spray criteria. In the formulation F1-F3 has a liquid texture, but the liquid separates between oil and water. The F4 formulation has a thick gel-like texture so it is difficult to spray and its spread will be difficult, but this formulation can be used as an innovation as a combination gel of VCO and ginger which has the same benefits as a candidate ingredient for the cure of gingivitis. The F5 formulation is the only formulation that falls into the spray criteria because of its liquid texture and no separation between oil and water so that this formulation can continue to cycle test.

Table 2. Organoleptic Test Results on F5 After Cycling Test

Formula		Hasil Organoleptis					
		Day 3	**Day 5**	**Day 7**	**Day 9**	**Day 11**	**Day 13**
F5	**Color**	Milky white	Milky white	White and clear	White and clear	White and clear	White and clear
	Smell	Typical coconut ginger	Typical coconut ginger	Typical coconut ginger	Typical coconut ginger	Typical coconut ginger	Typical coconut ginger
	Texture	Melt fused	Melt fused	Liquid separating	Liquid separating	Liquid separating	Liquid separating

After the cycling test was carried out, the results were obtained that the F5 formulation showed milky white in the 1st (3rd day) to 2nd cycle (5th day) and clear white in the 3rd cycle (7th day) to 6th (13th day). The smell produced remains the same, which is typical of ginger coconut and does not turn rancid. The texture of the liquid spray fused only until the 2nd cycle of the cycle, the rest of the texture remained liquid but there was a separation between oil and water caused by changes in temperature of extreme heat and cold and lack of concentration of surfactants used in the F5 formulation so that in certain circumstances there was separation.

Homogeneity Test

The homogeneity test aims to find out whether the ingredients in the formulation have been evenly mixed without coarse particles, lumps, or phase separation which is carried out by spraying the preparation on transparent and visually observed preparation glass (Anindhita and Oktaviani, 2020). The results of the homogeneity test in this study can be seen in the following table:

Table 3. Homogeneity Test Results on F1-F5 Before Cycling Test

Formula	Homogeneity Results					
	Day 3	**Day 5**	**Day 7**	**Hi 9th**	**Day 11**	**Day 13**
F5	Homogeneous/ no separation	Homogeneous/ no separation	Not homogeneous/ separation occurs	Not homogeneous/ separation occurs	Not homogeneous/ separation occurs	Not homogeneous/ separation occurs

The results of the homogeneity test after the cycling test on the F5 formulation were obtained that in the observation of the 1st cycle (day 3) and cycle 2 (day 5), the preparation was still in a homogeneous condition and did not show any phase separation. This indicates that in the early stages of storage, the F5 formulation has quite good physical stability. However, from the 3rd cycle (day 7) to the 6th cycle (day 13) there was a significant change where the preparation showed inhomogeneous conditions accompanied by phase separation. This indicates that the F5 formulation has decreased physical stability along with the increase in storage time in cycling test conditions.

Based on the results of organoleptic and homogeneity tests that have been carried out, only the F5 formulation meets the criteria for spray preparations. The F1 to F3 formula shows phase separation from the beginning so that it is unstable both in appearance and homogeneity, while the F4 formula although it appears more stable, the texture is too thick so it does not match the characteristics of the spray. In contrast, the F5 formula has the appropriate color and smell, stable liquid consistency, and even particle distribution without any clumps or phase

separation during storage. Therefore, taking into account the best organoleptic results and homogeneity, only the F5 formulation was continued for physical stability testing which included pH, viscosity, dispersability, and adhesion tests.

pH Test

pH testing is carried out to determine the acidity level of the spray formulation preparation to avoid irritation. The pH value of a good mouthwash preparation is in the range of 5-7, while other journals state that the pH of topical preparations of the oral cavity is around 4.5-10.5 (Fadhilah and Ruswanto, 2024). The results of the pH test in this study can be seen in the following table:

Table 4. pH Test Results on F5 Before and After Cycling Test

Formula	pH Results						
	Before	After					
	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13
F5	6.823	6,395	6,375	6,196	6,135	6,129	6,019

Based on table 5.6, it shows the pH test results on the F5 formulation before and after the cycling test. At the initial observation (day 0), the pH value of the preparation was 6.823 which was still within the physiological pH range of the oral cavity. Along with the storage and treatment of the cycling test, there was a gradual decrease in pH value from the 3rd to the 13th day. In the 1st cycle (day 3) the pH value dropped to 6.395 and in the 2nd cycle (day 5) to 6.375. This decline continued until the 3rd cycle (7th day) with a pH of 6.196, the 4th cycle (9th day) of 6.135, the 5th cycle (11th day) of 6.129, and reached the lowest value in the 6th cycle (13th day) of 6.019. Despite the decrease in pH, all pH results of the spray preparation are still included in the criteria of pH for the oral cavity because it is not too acidic or too alkaline so that it remains safe and does not cause irritation.

Viscosity Test

Viscosity tests on VCO and ginger combination spray formulations were carried out to determine the level of viscosity of the preparation and its stability during storage at extreme temperatures. The viscosity test parameters of a good spray preparation range from 500-5000 cP (Karlina et al., 2024). The results of the viscosity test in this study can be seen in the following table:

Table 5. Viscosity Test Results on F5 Before and After Cycling Test

Formula	Viscosity Results						
	Before	After					
	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13
F5	692.8 cP	616.8 cP	548.0 cP	524.0 cP	380.0 cP	370.0 cP	346.7 cP

Based on the results of table 5.9, it shows the results of the viscosity test on the F5 formulation before and after the cycling test. At the initial observation (day 0), it produced a viscosity of 692.8 cP. Along with the change in the cycle of the cycling test, the viscosity value decreased until the 2nd cycle (day-3) which was still included in the spray viscosity criteria. However, in the 3rd cycle (day 7) the viscosity results decreased and were not included in the

spray criteria due to the separation of the oil and water phases due to extreme temperature storage due to cycling tests.

Dispersion Test

The dispersion test was carried out to evaluate the ability of the spray preparation to spread evenly on the target surface of the application carried out on mica plastic with a certain spraying distance. Good dispersion parameters were obtained from the dispersion of spray preparations ranging from 5-7 cm (Angelia et al., 2022). The results of the dispersion test in this study can be seen in the following table:

Table 6. Dispersion Test Results on F5 Before and After Cycling Test

Formula	Dispersion Results						
	Before	After					
	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13
F5	5,0 cm	5,1 cm	5,3 cm	5,5 cm	5,9 cm	6,0 cm	6,1 cm

Based on table 5.7, it shows the results of the dispersion test on the F5 formulation before and after the cycling test. On day 0 before the cycling test, the dispersion capacity of the spray preparation was obtained at 5.0 cm. Along with the storage time, the dispersion value gradually increased from the 1st cycle (day 3) to the 6th cycle (day 13) with the widest dispersion obtained. This increased dispersibility indicates a decrease in the viscosity of the preparation over time, making the formulation easier to spread when applied. Although it shows an increase in dispersibility in each cycle, the results obtained are still included in the criteria of good dispersibility of the spray.

Adhesive Strength Test

The adhesion test was carried out to measure the ability of the combination of VCO and ginger spray formulations to adhere to the application surface, where a longer adhesion time indicates a more optimal contact effectiveness of the active substance. The parameter of good spray adhesion is that the preparation does not drip for 10 seconds (Banne et al., 2022). The results of the adhesion test in this study can be seen in the following table:

Table 7. Adhesion Test Results on F5 Before and After Cycling Test

Formula	Adhesive Yield						
	Before	After					
	Day 0	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13
F5	29.72 seconds	28.91 seconds	27.85 seconds	27.14 seconds	20.06 seconds	19.87 seconds	19.27 seconds

Based on the results of table 5.8, it shows the results of the adhesion test on the F5 formulation before and after the cycling test. In the initial observation (day 0) before the cycling test, the adhesion of the preparation was recorded at 29.72 seconds. Along with the storage time, the adhesion decreases gradually from the 1st cycle (day 3) to the 6th cycle (day 13) which reaches the lowest value of 19.27 seconds. This is due to the decrease in the bonds between particles in the formulation getting weaker with the storage time and treatment of the cycling test. Despite the decrease in dispersivity value, the results in the F5 formulation are

still within the acceptable range for topical preparations, as the preparations remain able to adhere for sufficient time to provide therapeutic effects.

Summary of Physical Stability Evaluation

After all formulas undergo a physical stability evaluation process through several parameters, the observation results are summarized to facilitate comparison between formulas. The following table presents the suitability of each formula to the physical stability criteria which include organoleptic, homogeneity, pH, viscosity, dispersibility, and adhesion. This summary helps identify the formula that most closely approximates the characteristics of the ideal spray preparation.

Table 8. Summary of Physical Stability Test Results Before Cycling Test

1	Criteria	Formula				
		F1	F2	F3	F4	F5
Organoleptis	Color, smell, texture just like active substances	✓	✓	✓	✓	✓
Homogenites	Homogeneous	×	×	×	✓	✓
pH	Oral pH 5-7	×	×	×	×	✓
Viscosite	Viskositas spray 500-5000 cPs	×	×	×	×	✓
Spreadability	Spray dispersion 5-7 cm	×	×	×	×	✓
Adhesive	Spray adhesion 10 seconds	×	×	×	×	✓

Table description: sign (✓) indicates the formulation meets the parameters of the physical stability evaluation criteria, (×) indicates the formulation does not meet the parameters of the physical stability evaluation criteria

Based on the summary of the results of the physical stability test before the cycling test in Table 5.10, it can be seen that only the formulations F4 and F5 meet most of the parameters of the physical stability evaluation, including organoleptic, homogeneity, pH, viscosity, dispersibility, and adhesion. Meanwhile, the formulations F1, F2, and F3 have not met the set criteria, especially in the homogeneity and viscosity parameters, so it is not feasible to continue the cycling test.

Table 9. Summary of Physical Stability Test Results After Cycling Test

Parameter	Criteria	Siklus Cycling Test	Formula				
			F1	F2	F3	F4	F5
Organoleptis	Color, smell, texture are the same as substances Active	Cycle 1 (Day 3)	×	×	×	×	✓
		Cycle 2 (Day 5)	×	×	×	×	✓
		Cycle 3 (Day 7)	×	×	×	×	×
		Cycle 4 (Day 9)	×	×	×	×	×
		Cycle 5 (Day 11)	×	×	×	×	×
		Cycle 6 (Day 13)	×	×	×	×	×
Homogenites	Homogeneous	Cycle 1 (Day 3)	×	×	×	×	✓
		Cycle 2 (Day 5)	×	×	×	×	✓
		Cycle 3 (Day 7)	×	×	×	×	×
		Cycle 4 (Day 9)	×	×	×	×	×
		Cycle 5 (Day 11)	×	×	×	×	×
		Cycle 6 (Day 13)	×	×	×	×	×
		Cycle 1 (Day 3)	×	×	×	×	✓

Parameter	Criteria	Siklus Cycling Test	Formula				
			F1	F2	F3	F4	F5
pH	Oral pH 5-7	Cycle 2 (Day 5)	×	×	×	×	✓
		Cycle 3 (Day 7)	×	×	×	×	✓
		Cycle 4 (Day 9)	×	×	×	×	✓
		Cycle 5 (Day 11)	×	×	×	×	✓
		Cycle 6 (Day 13)	×	×	×	×	✓
Viscosite	Viskositas spray 500-5000 cPs	Cycle 1 (Day 3)	×	×	×	×	✓
		Cycle 2 (Day 5)	×	×	×	×	✓
		Cycle 3 (Day 7)	×	×	×	×	✓
		Cycle 4 (Day 9)	×	×	×	×	×
		Cycle 5 (Day 11)	×	×	×	×	×
		Siklus 6 (Day 13)	×	×	×	×	×
Spreadability	Spray dispersion 5-7 cm	Siklus 1 (Day 3)	×	×	×	×	✓
		Cycle 2 (Day 5)	×	×	×	×	✓
		Cycle 3 (Day 7)	×	×	×	×	✓
		Cycle 4 (Day 9)	×	×	×	×	✓
		Siklus 5 (Day 11)	×	×	×	×	✓
		Siklus 6 (Day 13)	×	×	×	×	✓
Adhesive	Spray adhesion 10 seconds	Siklus 1 (Day 3)	×	×	×	×	✓
		Cycle 2 (Day 5)	×	×	×	×	✓
		Cycle 3 (Day 7)	×	×	×	×	✓
		Siklus 4 (Day 9)	×	×	×	×	✓
		Siklus 5 (Day 11)	×	×	×	×	✓
		Siklus 6 (Day 13)	×	×	×	×	✓

Table description: sign (✓) indicates the formulation meets the parameters of the physical stability evaluation criteria, (×) indicates the formulation does not meet the parameters of the physical stability evaluation criteria

Based on the results presented in Table 5.11, it is stated that only the F5 formulation was tested using a cycling test because it met the initial stability criteria. The results of cycling tests on F5 showed that the formula was stable in the first two cycles, but began to undergo phase separation in the third cycle so that its stability was not optimal for long-term storage in extreme cold hot conditions. Therefore, this indicates that the F5 formula is the most potent formula compared to other formulas, but still requires further optimization to achieve adequate physical stability.

In the research on the optimization of spray formulas, it was carried out by comparing variations in concentration and type of excipients to determine which type of formula produced the best preparation and evaluation of physical stability. In making formulations, it is necessary to trial various variations in concentrations and ingredients used. The active ingredient is used to provide the pharmacological effect or therapeutic benefit of the preparation, such as the antibacterial, anti-inflammatory, or healing activity that is expected to be achieved in the area

applied. While additives or excipients are used as enhancers of the physical properties of preparations such as stabilizing preparations to suit the purpose of their application. The proper use of excipients will affect the results of the spray preparation so that the optimal formulation can be obtained through the evaluation of various combinations of additives.

The active ingredients used in this study are in the form of Virgin Coconut Oil (VCO) and ginger (Zingiber officinale Rosc.) as the main active substances. VCO is high in lauric acid and myristic acid so it can function as an antibacterial and anti-inflammatory, especially in gingivitis-causing bacteria such as Porphyromonas gingivalis. VCO is obtained from old coconut meat that is processed into pure coconut oil using the wet method. The wet method is carried out by making coconut milk, separating cream and skim, and breaking up coconut milk cream that has been mixed with ginger. Ginger contains volatile (volatile) and non-volatile (non-volatile) compounds that have antimicrobial effects to fight bacteria, fungi, viruses, maintain oral health, and prevent the occurrence of periodontal disease (Ahnafani et al., 2024). The ginger used is in the form of rhizomes which are processed by the filtrate method, namely by smoothing and then letting it sit until it separates between the starch and ginger filtrate.

Additional ingredients used are gelling agents such as Carbomer 940 or HPMC which can increase viscosity and stabilize preparations (Chaerunisaa et al., 2020), humectants such as glycerol or propylene glycol which can prevent moisture loss of products, surfactants such as Tween 80, Span 80, PEG 40, or PEG 400 which function to reduce surface tension, preservatives such as methyl parabel or phenoxyethanol to prevent product spoilage, as well as solvents in the form of aquadest to dissolve combinations of ingredient preparations.

The combination of the active ingredient and the finished additive will be left for 7 days to ensure that the preparation does not separate between oil and water. Preparations that remain stable can be continued for cycling testing, while unstable preparations cannot be continued for cycling tests because they are not included in the indicators of good spray criteria. Stability testing using the cycling test method is one of the simulations of temperature changes (hot and cold) every year or even day to ensure the resistance of the preparation to different storage conditions so that it is effective and safe to use. The testing process was carried out for 6 cycles or the equivalent of 12 days at extreme temperatures (4°C and 40°C) alternately. The physical stability was carried out in the form of cycling tests before and after with the parameters used in the form of organoleptic tests, homogeneity, pH, viscosity, dispersibility, and adhesion.

The homogeneity test is carried out to determine whether the mixture of a preparation is homogeneous or non-homogeneous. Homogeneous means that the ingredients used to make the preparation have been mixed well and evenly without the presence of particle clumps, while non-homogeneous means that the preparation still contains particle clumps or the occurrence of phase separation in the preparation. The results of the homogeneity test showed that before the cycling test was carried out, the F1-F3 formulation was not homogeneous, which could be seen that there was a separation of the oil and water phases, while the F4 and F5 formulations showed homogeneous results. After the cycling test, the F1-F4 formulation was not continued with the cycling test because the previous results did not meet the spray criteria indicators. This is due to extreme temperature changes (temperatures of 4°C and 40°C) that make a preparation less stable. At cold temperatures, emulsifiers in the oil and water phase will be more sensitive to cooling compared to moderate heating so that there will be the formation of ice crystals that can damage the emulsion droplets thereby increasing the size between particles (Dewi et al.,

2015). In addition, it can also be caused by an imbalance in the composition of additives, such as low concentrations of surfactants so that the oil and water phases cannot mix properly. Surfactants function as a material that is able to reduce the surface tension between oil and water so that it becomes an intermediary for mixing two phases of water oil (Ayuningtyas et al., 2021). The homogeneity criterion of a preparation is characterized by the absence of separate particles and evenly distributed components, meaning that the preparation has good physical quality. Therefore, it can be concluded that the combined spray preparation of VCO and ginger formulations F1-F3 does not meet the standards while the F4 and F5 formulations meet the standards. However, in the F5 formulation it is homogeneous until the 2nd cycle, which means that the formula experiences physical instability if stored for a long time.

Based on the results of organoleptic and homogeneity testing, it can be determined that the formulation of F5 is the only suitable preparation to proceed to the next stage of physical evaluation. The formulations of F1 to F3 experience instability in the form of phase separation so that they do not qualify as a spray preparation, while F4 although stable, has a texture that is too thick so that it does not match the expected form of preparation. Meanwhile, F5 exhibits an organoleptic appearance that is consistent in color, smell, and aroma and remains homogeneous during storage. With these considerations, the F5 formulation can be carried out a follow-up test which includes pH, viscosity, dispersability, and adhesion.

The pH test is an important parameter because it is to determine the acid-base level of the preparation. The pH test results on F5 show that the pH value decreases with the cycle change in the cycling test. Day 0 before the cycling test produced the highest pH of 6,823 and then decreased until day 13 produced the lowest pH value of 6,019. The decrease in pH that occurs along with the change of cycles in the cycling test is caused by the presence of substances that are decomposed in the spray preparation during the cycling test process, especially the decomposition of unsaturated fatty acids from the oil phase of the spray. In addition, pH changes are also caused by environmental factors such as poor storage. However, the entire pH value produced by the F5 formulation is still within the safe range for oral cavity preparations, which is around 5-7. A pH value that is too acidic can cause irritation, while a pH value that is too alkaline can trigger the growth of fungi that cause canker sores. Therefore, it can be concluded that the combination of VCO and ginger spray can meet the pH standard of the oral cavity despite the decrease in each cycle, but still falls within the standard pH range of the oral cavity. This shows that the formulated spray has optimal pH quality and is suitable as a natural and safe preparation for oral use.

Viscosity tests are carried out to determine the viscosity of the preparation product. The viscosity results of the F5 formulation were obtained that there was a decrease in viscosity along with the change of cycles in the cycling test. On day 0 before the cycling test, the highest viscosity value was obtained, which was 692.8 cP, then continued to decrease along with the cycle change until the 13th day after the cycling test was obtained a value of 346.7 cP. The decrease in viscosity is thought to occur due to the influence of extreme storage temperature (40°C) which decreases the cohesion force between the base molecules and surfactants. This accelerates the movement of oil globules leading to globule merger and phase separation, which is characterized by the consistency of the preparation becoming thinner. The smaller the viscosity value, the more diluted the preparation will be, so it will affect the larger the dispersion but the smaller the adhesion, and vice versa, the greater the viscosity value, which

means that the preparation will be thicker so that it will affect the smaller the dispersion but the greater or longer adhesion . When the temperature is cold (4 degrees) the water phase will freeze and tend to shrink, so that there is a narrowing of the water phase space and causes oil globules to be close to each other, as a result of which the viscosity of the preparation increases. At a hot temperature (40 degrees), the crystals will melt and will re-spread in the system.

If the recovery speed of the spray is slow, there can be instability of the preparation. In addition, the viscosity value is influenced by the thickening agent, the selected surfactant, the proportion of the dispersed phase and the particle size. If there is an increase in the size of the particle diameter, it will cause the viscosity to decrease (Dewi et al., 2015). However, the results obtained until the 3rd cycle are still within the range of good spray viscosity criteria, namely 500-5000 cP. However, in the 4th cycle, there was a drastic decrease because the preparations were unstable and separated, so further evaluation was needed. Therefore, it can be concluded that the combination of VCO and ginger spray can meet the spray viscosity criteria well up to the third cycle.

A dispersion test is carried out to determine the dispersion ability of the preparation. The dispersion yield in the F5 formulation results in a dispersion value that continues to increase with cycle change. On day 0 before the cycling test, the diameter of the dispersion was obtained of 5.0 cm and continued to increase until the 13th day resulting in the largest dispersion of 6.1 cm. This is because the increase in dispersion is inversely proportional to the viscosity value shown in each formula or form of preparation, which the thicker the preparation, the lower the dispersion will be. On the other hand, the more liquid the preparation, the greater the dispersion so that the surface area in contact with the spray will be wider and the active substances will be properly distributed. Despite this, the results obtained are still within the required range, which is between 5 to 7 cm. Therefore, it can be concluded that the combination of VCO and ginger spray meets the spray dispersion criteria both before the cycling test and after the cycling test even though each cycle test continues to increase in diameter.

An adhesion test is performed to determine the duration of attachment of the preparation when applied to an object. The adhesion results of the F5 formulation showed that there was a decrease in adhesion time as the cycle in the cycle in the cycle test progressed. On day 0 before the cycling test, the longest duration was obtained at 29.72 seconds and then continued to decrease until the 13th day the shortest duration was obtained, which was 19.27 seconds. A decrease in dispersion time can occur due to various factors, one of which is the viscosity of the spray preparation. The higher viscosity is caused by the higher consistency of the preparation so that the adhesion time becomes longer. The longer the adhesion, the thicker the spray preparation will be, the longer the adhesion will be. However, the results obtained are still within the range of the criteria for good spray adhesion, namely attachment of more than 10 seconds. Therefore, it can be concluded that the combination of VCO and ginger spray can meet the spray dispersibility criteria both before and after the cycling test.

Determination of the Best Formulation

The evaluation of the results of the physical stability of the combination of VCO and ginger spray preparations that has been carried out shows that the formulations F1, F2, F3 produce preparations that separate between the oil and water phases so that the formulation cannot be continued with the cycling test because it is not included in the indicators of good spray criteria. The F4 formulation produces a clear and homogeneous colored preparation, but

its thick texture makes it impossible for the formulation to fit into the spray indicator criteria. In this F4 formulation, the cycling test was also not continued because it was not included in the indicator of a good spray criterion. However, the F4 formulation can be used as a new innovation in making a combination gel of VCO and ginger for the cure of gingivitis.

The formulation of F5 before the cycling test produced a good preparation according to the criteria of organoleptic test indicators, homogeneity, pH, viscosity, dispersibility, and adhesion. This formulation also shows phase stability so that there is no separation in the storage room temperature. Therefore, the F5 formulation is suitable for continuing cycling tests to determine the duration of the resistance of the preparation at extreme temperatures. The results obtained from the preparation remain liquid in texture, although in the 3rd cycle there is separation which means that the preparation experiences physical instability if stored for a long time so that later it will need to be repaired again for the concentration and additional ingredients used.

Based on the explanation above, it can be concluded that the formulation of F5 produces preparations with good initial physical stability characteristics in the cycling test method which includes organoleptic, homogeneity, pH, viscosity, dispersibility, and adhesion tests. Therefore, it can be said that F5 formulations with 10% active ingredients and variations in concentration and additives show the most excellent physical stability characteristics compared to other formulations.

CONCLUSION

There is an effect of the addition of 10% active ingredients VCO and ginger as well as various variations in concentrations and additives on the physical characteristics and stability of the resulting spray preparation, especially as seen from the separation between the VCO oil phase and the water phase as well as the results of the physical stability test during the cycling test. The physical quality results of the 10% spray preparation combined with VCO and ginger showed the results of the F5 formulation that met the standards in all test parameters before the cycling test but after the cycling test only the pH, dispersibility, and adhesion parameters met the standard criteria; Meanwhile, the organoleptic, homogeneity, and viscosity parameters partially did not meet the standard test criteria. It is necessary to develop advanced formulas using additives with different concentrations to see the stability of the preparation against these concentrations. It is necessary to perform long-term physical stability testing at room temperature to determine the resistance of the formula to storage under normal conditions for several months, in accordance with pharmaceutical industry standards. It is necessary to develop further research with replicated formulations so that data analysis can be carried out on the test parameters of pH, viscosity, dispersibility, and adhesion so as to strengthen the validity of the research results. Conducting research with the same ingredients in the form of VCO and ginger with gel preparations as a new innovation. Further researchers It is recommended to use different sectors to make new contributions to understanding the dynamics of firm value in different industries. And it is expected to use other factors that can affect the company's value because this research results that that only one of the three independent variables has an influence on the dependent variable, while the other 2 independent variables reject the hypothesis. For companies, this research is expected to be used as a consideration of factors that increase or decrease the value of the company, including debt

policy, independent commissioners, and firm size. Companies need to take strategic steps to enhance and maintain the company's value. For investors, this research is expected to be useful for investors in looking at a company from the perspective of firm value.

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