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Literature Review: Physical Stability Evaluation of Various Natural Extract-Based Preparations

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ABSTRACT

This literature review examines the physical stability of various natural extract-based preparations increasingly used in cosmetic and pharmaceutical formulations. The main problem identified is the high phytochemical variation of the extracts, which can affect physical stability, such as changes in pH, viscosity, homogeneity, color, and texture during storage. The purpose of this study was to analyze physical stability parameters in various dosage forms, such as liquid, semi-solid, and solid, and to evaluate factors influencing their instability, based on selected literature from 2020 to 2025. The method used was a literature review through an online search of national and international journals relevant to the available data. Ten articles were used to support this literature review. The results of the literature review indicate that liquid dosage forms tend to be susceptible to organoleptic and clarity changes, while semi-solid dosage forms are strongly influenced by the stability of polymer matrices and emulsions, while solid dosage forms have the best stability due to their low water content. Based on the results of this literature review, it can be concluded that the physical stability of a preparation is highly dependent on the suitability of the excipients, the characteristics of the extract, and the stability testing method used. This review is expected to serve as a reference in the development of more stable and high-quality natural ingredient extract formulations.

INTRODUCTION

The use of natural ingredient extracts in the development of pharmaceutical and cosmetic preparations continues to increase due to a shift in public preference for products that are safer, more natural, and have fewer side effects. Phytochemical compounds such as flavonoids, tannins, saponins, and terpenoids found in plant extracts are known to have biological activity, so they are widely applied to various forms of preparations (Alfiani et al., 2025). However, plant extract-based formulations often face physical stability challenges due to the natural properties of active compounds that are sensitive to light, oxygen, temperature, and interactions with excipients. This condition makes the evaluation of physical stability an important aspect to ensure the quality and safety of a natural preparation for long-term use.

Natural formulations have a susceptibility to physical changes such as discoloration, aroma, viscosity, and homogeneity. Falahi's research (2024), shows that physical stability is affected by the type *of enhancer* and can be observed through parameters such as organoleptic, viscosity, pH, adhesion, dispersibility, and *freeze-thaw tests* to assess the resistance of the gel to extreme temperature changes. The results showed that gels with certain formulations remained stable without significant changes. Another study by Nasution et al. (2022), showed that variations in extract concentrations affect the stability of the emulsion, such as pH, homogeneity, color, and consistency during four-week storage at room temperature. The results of the test showed that increased concentration of the extract can affect the color and aroma of the preparation, while the stability of the emulsion is determined by the interaction of the active ingredient with the surfactant and the phase of the oil.

In addition, research by Nurrosyidah et al. (2020), shows that the parameters of pH, moisture content, organoleptic, and foam stability are indicators used to determine the physical quality of soap and the effect of adding extracts on its characteristic. In the study of Rahayu et al. (2025), physical stability can be assessed through tests of homogeneity, pH, color, and fineness of particles to ensure comfort of use and safety on the skin during storage. The results of this study show that Chinese betel extract can be formulated stably provided that the mixing process and formulation are carried out properly so that there is no clumping or discoloration.

The study shows that despite the fact that there are many well-formulated natural preparations, physical stability remains a major challenge due to the complex characteristics of the extract. Each type of preparation has different stability parameters, so an evaluation approach is required according to the form of the preparation. In addition, the variation in physical stability test methods in each study shows the need for a study that can summarize the parameters and results of physical stability evaluation of various types of biological extract preparations.

Based on this background, the literature review or *review* of this article aims to analyze and compare the results of research on the physical stability of various preparations made from plant extracts, with a focus on the stability test parameters and factors that affect the physical changes of preparations during storage. The results of this literature review are expected to provide an overview of how natural ingredient extracts affect the physical stability of formulations and become a reference for researchers in developing stable and high-quality herbal preparations.

METHOD

This literature review was prepared using *a systematic literature review approach* by following the PRISMA flow which can be seen in Figure 1. Article searches are conducted through *Google, Google Scholar,* and *Publish or Perish* using keywords such as "physical stability of extract preparations", "*herbal formulation satbility*", "physical stability of preparations", and "physical stability". The publication range is limited from 2020-2025 to ensure relevant and up-to-date data. Articles were selected based on criteria, namely using extracts of natural ingredients as active components, formulating pharmaceutical or cosmetic preparations, and reporting the results of physical stability tests such as pH, viscosity, organoleptis, homogeneity, dispersibility, and others. Based on the articles that were successfully found, a total of 10 articles were obtained that were suitable for analysis. The data from each article was taken including the physical stability parameters and the results of physical changes. All data is then analyzed descriptively to compare or identify factors that affect it.

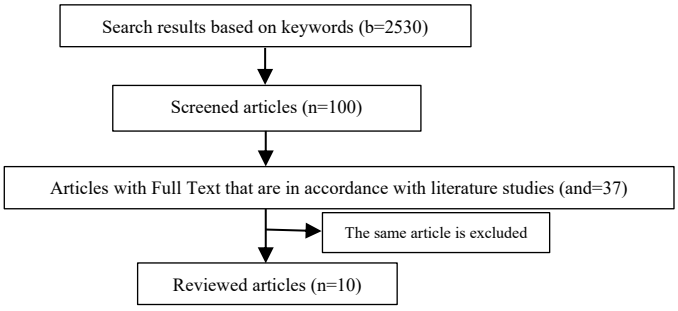

Figure 1. Prism Flow Diagram

RESULTS AND DISCUSSION

General Characteristics of Natural Ingredient Extract Preparations

Natural Materials

Preparations formulated using extracts of natural ingredients generally contain a variety of secondary metabolites such as flavonoids, alkaloids, tannins, saponins, triterpenoids, polyphenols, and essential oils. These compounds play a role in biological activities such as antibacterial, antioxidant, or anti-inflammatory (Khairunnisa et al., 2025). Flavonoids and polyphenols are natural compounds that are easily oxidized, so their color can fade or darken during storage. In the study of Alif et al. (2024), stated that celery syrup has a yellowish-green color that remains stable during storage, this shows only a slight oxidation reaction in its polyphenol compounds.

Table 1. Results of Literature Review (review) Evaluation of Physical Stability Test on Natural Ingredient-based Extract Preparations

Yes	Stability Test Parameters	Test Results	References
1	Physical stability test parameters: • Organoleptic test • Clarity test • Homogeneity test • pH Test • Viscosity test	Celery leaf infusion syrup is stable with a homogeneous liquid form, distinctive aroma, yellowish-green in color, average pH of 5.27, and viscosity of 3.8 cP	(Alif et al., 2024)
2	Physical stability test parameters: Test: • Organoleptic test • pH Test • Dispersion test • Viscosity test • Cycling *test*	Preparation of essence sheet mask with 05, 3%, 5%, and 7% acid extract shows good physical stability.	(Ulfa et al., 2022)
3	Physical stability test parameters: Test: • Organoleptic test • Homogeneity test • pH Test • Cycling test	Yield extract of the princess rope plant (Cassytha filiformis L.) has a pH of 6.4-6.2 and a viscosity of 2530-1610 cPs. All formulas undergo syneresis, but F1 formulations show the best stability.	(Setiawan et al., 2023)
4	Physical stability test parameters: • Organoleptic test • Homogeneity test • pH Test • Dispersion test • Adhesion test • Stability test	The cream preparation shows stable physical properties with a typical banana aroma, namely green color, semi-solid texture, pH 5.04, dispersion power of 3.43, and adhesion of 30.55 seconds.	(Lumentut et al., 2020)
5	Physical stability test parameters: • Organoleptic test • pH Test • Homogeneity test • Viscosity test • Dispersion test	Kapuk randu leaf extract with concentrations of 3%, 6%, and 9% was successfully formulated into a clay mask with good physical stability, without significant changes in organoleptis, pH, homogeneity, drying time, dispersibility, and viscosity.	(Pradana et al., 2025)
6	Physical stability test parameters: • Organoleptic test • Homogeneity test • Dispersion test • Adhesion test • pH Test • Viscosity test	Bitter melon gel shows that bitter melon powder affects color homogeneity, adhesion, and viscosity, while bitter melon ethanol extract affects dispersibility and viscosity during storage	(Rianti et al., 2020)
7	Physical stability test parameters: • Organoleptic test • Homogeneity test • pH Test • Viscosity test • Foam height test	Red pomegranate extract toothpaste is most stable on the formula F2 (CMC Na 1.5%), with a thick texture, creamy warn, pH 7.98, viscosity 42,530 cPs, foam height 6.67 cm, and stable at temperatures of 4-40 ^{oC}	(Kresnawati & Mutmainah, 2023)
8	Physical stability test parameters: • Organoleptic test • pH Test • Homogeneity test • Viscosity test • Hedonic test	Garlic extract syrup has a pH of 5.05, a type weight of 1.23 g/ml, a viscosity of 8.40 cPs, and is declared stable as an altermintic preparation.	(Zainal et al., 2024)

9	Physical stability test parameters: • *Cycling test* • Organoleptic test • pH Test • Dispersion test • Adhesion test	Avocado seed starch emulgel at concentrations of 2%, 6%, and 8% proved to be stable before and after *cycling tests*, meeting all parameters of organoleptic, homogeneity, pH, dispersability, and adhesion	(Korengkeng et al., 2022)
10	Physical stability test parameters: • Organoleptic test • pH Test • Homogeneity test • Dispersion test • Foam power test • Viscosity test • Skin irritation test • Stability in storage • Inhibition test	Facial wash of chitolod leaf extract at concentrations of 15% and 20% shows a stable, homogeneous pH, appropriate viscosity, does not cause irritation, remains stable after *cycling tests*, and has an inhibition against *Staphylococcus aureus*.	(Basir et al., 2024)

Saponins and alkaloids are known to affect the pH and stability of the foam as can be seen in some preparations containing plant extracts with high levels of saponins in Table 1. Tannins are known to cause deposition or clumping in liquid preparations (Dwiputri et al., 2025). Physical stability is also greatly affected by the form of the extract used. Research by Rianti et al. (2020), shows that powdered extracts such as bitter melon gel tend to be more difficult to disperse and cause inuniformity, in contrast to liquid extracts that are easier to mix. Therefore, it can be known that the phytochemical characteristics of natural ingredient extracts play a role in determining the success of formulation and stability, as well as influencing the selection of excipients such as *gelling agents, emulsifiers, humectants*, and buffers.

Physical Stability Test Parameters on Various Preparations

Physical stability evaluation is usually carried out with a number of parameters, each of which is able to describe the resistance of the preparation to storage. These parameters may differ depending on the form of the preparation, but there are several commonly used parameters, such as organoleptic, homogeneity, pH, viscosity, dispersibility, adhesion, foam stability, emulsion and particle type, and *Freeze-Thaw/Cycling Test.*

Organoleptis

Organoleptic tests are examinations through color, smell, shape, and texture. Organoleptic functions to ensure that there is no degradation or physical contamination. Discoloration can indicate an oxidation, impurity, or degradation reaction of the product (Sakiroff et al., 2022).

Homogeneity

Homogeneity can indicate whether the active ingredient and excipients are evenly distributed. Good homogeneity is used to ensure homogeneously stable consistency during storage (Kholili et al., 2025).

pH

pH is an important indicator in the stability of natural ingredient extract preparations because pH is able to affect the stability of the active compound, the degree of irritation, and the compatibility between excipients. Many secondary metabolite compounds such as flavonoids, tannins, and saponins are easily degraded at extreme pH. Therefore, topical preparations are generally formulated in the pH range of 4.5-6.5 to match the physiological pH of the skin and prevent irritation (Wahyudi et al., 2025).

Viscosity

Viscosity indicates the level of viscosity of a preparation and plays a major role in ease of use, physical appearance, and stability of internal structures. A decrease in viscosity is often a sign that the preparation is undergoing degradation, syneresis, or the formation of a free water phase. Meanwhile, high viscosity can make preparations difficult to remove from the container and difficult to even on the skin (Pratiwi et al., 2023).

Spreadability

The dispersion test describes the ability of the preparation to spread on the surface of the skin when lightly pressured. This parameter greatly affects the comfort of use, absorption ability, and delivery efficiency of the active ingredients. The dispersion power is greatly influenced by the viscosity, the higher the viscosity, the

smaller the dispersion. Preparations with too large dispersion tend to be too liquid and less sticky (Tungadi et al., 2023).

Adhesive

Adhesion is the ability of the preparation to stick to the skin for a certain amount of time. This parameter is especially important for preparations that require longer contact times, such as antibacterial gels, anti-inflammatory creams, and emulgels. Adhesion is affected by the viscosity and structure of the gelling polymer. The high adhesion allows the active ingredient to last longer, thus increasing its effectiveness. However, too high a stickiness can make the preparation feel sticky and uncomfortable (Tungadi et al., 2023).

Foam Stability

Foam stability is a parameter in cleaning preparations such as liquid soaps, solid soaps, and facial washes. The foam comes from the ability of surfactants or saponins to form a thin film layer that holds air bubbles. The stability of the foam is affected by the type of surfactant, the pH concentration, and the presence of oils or hydrophobic compounds that can damage the structure of the foam. Cleansing preparations should have enough lather but not excessively, as too high a lather can dry out the skin. Good foam stability indicates that the composition of the surfactant is balanced and the structure of the preparation does not undergo phase separation (Kresnawati & Mutmainah, 2023).

Emulsion Type and Particle Size

In emulsion preparations such as creams and lotions, the physical stability is greatly influenced by the type of emulsion (O/W or W/O) and the particle size of the oil globule. O/W emulsions are typically easier to wash off and suitable for oily skin, while W/O is more suitable for dry skin. The small and uniform particle size is able to increase stability because it reduces the risk of coalescence (incorporation of oil globules). If the particle size increases during storage, this indicates instability that can lead to creaming or phase separation (Rusli et al., 2022).

Freeze-Thaw/Cycling Test

Freese-thaw/cycling test is an acceleration simulation method to evaluate the stability of preparations against extreme temperature fluctuations. Repeated cycles can lead to expansion, shrinkage, crystallization, cracking of gel structures, or phase separation. If the preparation remains stable after several cycles, then it can be predicted that the preparation is stable under normal storage conditions (Hafifah et al., 2025).

Physical Stability by Extract Preparation Type

The physical stability of natural ingredient extract-based is greatly influenced by the form of the preparation, as each form has different formulation characteristics, water content, and active ingredient interactions. The physical stability of preparations is categorized into liquid, semi-solid, and solid preparations.

Liquid Preparations

Liquid preparations have a high moisture content so they are more susceptible to organoleptic changes, clarity, precipitation, and pH changes. The phenolic, flavonoid or tannin components in extracts can react with certain excipients or ions, causing cloudiness or discoloration. Therefore, the stability of liquid preparations is highly dependent on pH regulation, the use of preservatives, chelating agents, and viscosity control to keep them homogeneous (Panaungi & Hasma, 2022).

Semi Solid Preparations

Semi-solid preparations have a more complex matrix structure (polymer or emulsion) so they are more sensitive to temperature fluctuations. Gels are known to be prone to changes in viscosity or syneresis if the polymer matrix is disrupted, while creams and emulgels are prone to creaming or phase separation if the size of the globule or the type of emulsion changes. The physical stability of semi-solids can be assessed through tests of viscosity, dispersibility, adhesion, pH, and its response to acceleration tests such as cycling tests (Korengkeng et al., 2022).

Solid Preparations

Solid preparations are more stable because they have a low moisture content, so the risk of physical changes due to hydrolysis or microbial growth is minimal. In soap preparations, stability is affected by the moisture content or structure of the surfactant, as well as the ability to retain foam. Meanwhile, mineral-based clay mask products tend to be stable and are only affected by changes in viscosity or color due to the addition of extracts (Pradana et al., 2025).

CONCLUSION

Based on a review of the literature on different types of preparations based on natural ingredient extracts, it can be concluded that physical stability is greatly influenced by the form of the preparation, the phytochemical characteristics of the extract, and the excipients used. Liquid preparations tend to be susceptible to changes in pH, color, and clarity, so they require pH regulation and the use of proper stabilizers. Semi-solid preparations such as gels, creams, emulgels, and toothpastes are more sensitive to temperature fluctuations and viscosity changes, but they can be stable when the polymer matrix or emulsion is strong and compatible with the extract. Solid preparations such as soap, powder, and clay masks, show the best physical stability due to their low moisture content. Based on this, it can be seen that each form of physical preparation has its own challenges and advantages, but physical stability can be achieved through the selection of the right excipients, parameter control, and evaluation using stability tests.

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