In Vitro Comparative Study Of Synthetic (Limcee Tablet) And Natural (Himalaya Amalki Tablet) Vitamin C Tablets

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Abstract

The present study was undertaken to conduct an in-vitro comparative evaluation of synthetic and natural Vitamin C tablet formulations by analyzing their organoleptic characteristics, solubility, pH, dissolution behavior, and short- term physical stability. For this purpose, two commercially available formulations were selected: Limcee 500 mg tablet as the synthetic Vitamin C formulation and Himalaya Amalaki tablet as the natural herbal Vitamin C source.

The organoleptic evaluation involved assessment of the color, odor, taste, and physical appearance of both tablets. A solubility test was performed by dissolving each formulation in distilled water and recording the time taken for complete dissolution. The pH of the resulting solutions was measured using a calibrated digital pH meter to assess the relative acidity of both formulations. An in-vitro dissolution study was conducted by withdrawing samples at specific time intervals (5, 10, 15, and 30 minutes) and determining the percentage drugrelease using aUV-Visible spectrophotometer at 243 nm. Additionally, a short-term stability study was carried out by observing both formulations for physical changes such as color and clarity over a 24-hour period at room temperature.

The results indicated that the Limcee tablet demonstrated a faster dissolution rate, achieving 90% drug release within 15 minutes and 100% at 30 minutes. Its pH was recorded at 3.8, reflecting moderate acidity. In contrast, the Himalaya Amalaki tablet exhibited a controlled and gradual release profile, reaching 85% dissolution at 15 minutes and 95% at 30 minutes, with a pH of 3.6, making it comparatively less acidic and potentially more gastric-friendly.

Organoleptic evaluation showed significant differences in appearance and taste between the two formulations, with the synthetic Limcee tablet displaying a typical pharmaceutical appearance and the Himalaya Amalaki tablet reflecting its natural, herbal origin. In the stability study, both tablets remained stable for 12 hours, while minor color darkening was observed in the Himalaya Amalaki tablet after 24 hours due to the presence of natural phytoconstituents.

The comparative analysis confirmed that synthetic Vitamin C formulations like Limcee offer rapid bioavailability and consistent dosing, while natural Vitamin C formulations such as Himalaya Amalaki tablet provide additional health benefits from herbal antioxidants, better gastric tolerance, and enhanced stability. The study highlights the importance of selecting an appropriate formulation based on clinical objectives, patient preferences, affordability, and therapeutic outcomes.

Keywords: Vitamin C, Limcee tablet, Himalaya Amalaki tablet, In-vitro evaluation, Dissolution study, Solubility test, pH measurement, Stability study, Natural vs Synthetic formulation, Herbal antioxidants, Comparative *analysis.*

I. INTRODUCTION:

Vitamin C, also known as ascorbic acid ,is a water-soluble essential nutrient involved in various physiological processes, including collagen synthesis, immune function, iron absorption, and as a powerful antioxidant. As the human body is unable to synthesize Vitamin C endogenously, it must be obtained through dietary sources such as citrus fruits, green vegetables, and medicinal plants like Amla (Emblica officinalis), or through pharmaceutical and nutraceutical supplements.

The increasing demand for Vitamin C supplementation, particularly for immune support, antioxidant protection, and treatment of deficiencies like scurvy, has led to the availability of a wide range off or mulations in the pharmaceutical market. These formulations are broadly categorized into synthetic and natural types. Synthetic formulations, such as Limcee 500 mg tablet, contain pure ascorbic acid produced via chemical synthesis. These offer advantages like precise dosing, rapid absorption, and immediate therapeutic action, but generally lackt he accompanying natural bioactive compounds present in herbal formulations.

In contrast, natural Vitamin C formulations like the Himalaya Amalaki tablet are prepared from Amla extract, a well- established traditional Ayurvedic medicinal plant renowned for its high Vitamin C content and additional phytoconstituents such as tannins,

flavonoids, and polyphenols. These natural compounds not only provide Vitamin C but also contribute to enhanced antioxidant properties, better stability, and potential health benefits beyond basic nutritional supplementation.

Since both types of formulations differ in their physicochemical characteristics and in-vitro performance, it is important to conduct a comparative evaluation of their organoleptic properties, solubility, ph, dissolution behavior, and stability to assess their relative suitability in different clinical and therapeutic contexts.

Therefore, the present study was designed to perform an in-vitro comparative evaluation of Limcee 500 mg tablet and Himalaya Amalaki tablet, focusing on key parameters such as appearance, taste, dissolution rate, solubility profile, ph values, and short-term physical stability. The findings of this study aim to guide the selection of an appropriate Vitamin C formulation based on its in-vitro performance, patient acceptability, and potential clinical advantages.

Vitamin C, Chemically Known As Ascorbic Acid, Is A Water-Soluble Antioxidant With The Following Chemical Structure :

Figure1.1:Structure of Ascorbic Acid (Vitamin C)

Natural Sources Of Vitamin C Include Various Fruits And Medicinal Plants. The Commonly Consumed Natural Sources Of Vitamin C Are Illustrated In Figure 1.2 :

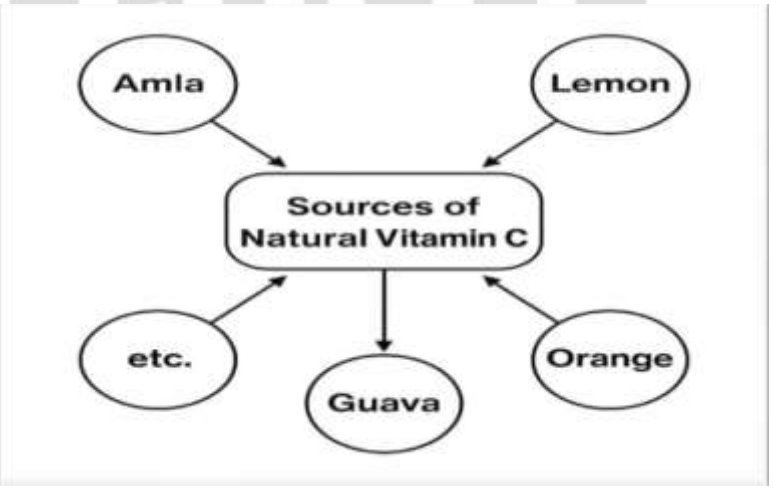


Figure1.2: Common Natural Sources of Vitamin C

II. AIM AND OBJECTIVES:

Aim:

To perform an in-vitro comparative evaluation of synthetic (Limcee 500 mg tablet) and natural (Himalaya Amalaki tablet) Vitamin C formulations by analyzing their organoleptic properties, solubility, pH, dissolution profile, and short-term physical stability under laboratory conditions.

Objectives:

1. To select two market-available Vitamin C formulations: one synthetic (Limcee 500 mg tablet) and one natural herbal formulation (Himalaya Amalaki tablet) for comparative in- vitro evaluation.

2. To perform organoleptic evaluation of both formulations, including assessment of their color, odor, taste, and physical appearance.

3. To determine the solubility profile of both formulations by measuring the time taken for complete dissolution in distilled water at room temperature.

4. To measure the pH values of the dissolved solutions of both formulations using a digital pH meter, and compare their relative acidity or gastric tolerability.

5. To conduct an in-vitro dissolution study for both formulations at predetermined time intervals (5,10,15,and 30minutes) and calculate the percentage drug release using a UV-Visible spectrophotometer at 243 nm.

6. To evaluate the short-term physical stability of both formulations by observing any changes in their physical appearance, color, and clarity over a 24-hour period at room temperature.

7. To analyze and compare the in-vitro performance of synthetic and natural Vitamin C formulations based on the obtained results, and assess their advantages and limitations.

8. To suggest recommendations regarding formulation selection for clinical use, based on patient preferences, affordability, dosing requirements, and therapeutic outcomes.

III. MATERIALS AND METHODS:

Materials:

The following materials were used in the study:

• Synthetic Vitamin C formulation: Limcee 500 mg tablet (containing500 mg Ascorbic Acid per tablet), procured from a local pharmacy.

• Natural Vitamin C formulation: Himalaya Amlaki tablet (Ayurvedic proprietary medicine containing Amla extract), purchased from an Ayurvedic medicine store.

• Solvent: Distilled Water

• Chemicals: Buffer solutions for pH meter calibration (pH 4.0 and pH 7.0) if required.

All chemicals and reagents used were of analytical grade and procured from reliable commercial suppliers.

Instruments and Apparatus:

• pH Meter (Digital ,calibrated)

• UV-Visible Spectrophotometer (for dissolution analysis at 243 nm wavelength)

• Stopwatch(for recording solubility and dissolution times)

• Glassware: Beakers, measuring cylinders, volumetric flasks, pipettes, and funnels — all of borosilicate quality.

• Dissolution medium:100 ml distilled water maintained at room temperature for all in-vitro studies.

The following in-vitro evaluation procedure was performed sequentially on both synthetic and natural vitamin C formulations as shown in figure 3.1

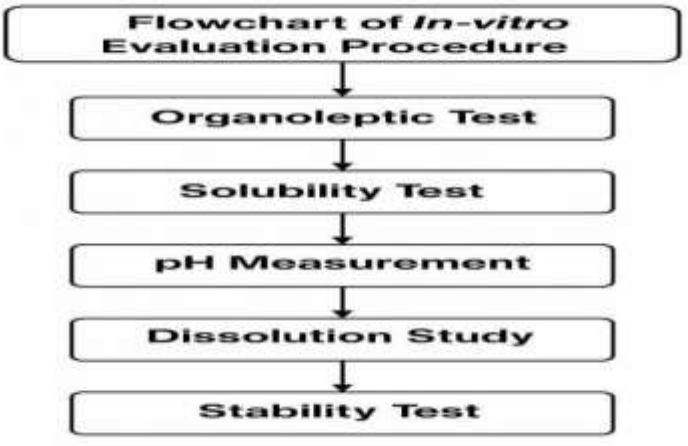


Figure3.1:Flowchart of In-vitro Evaluation Procedure

Methodology:

1. Organoleptic evaluation:

The tablets were evaluated visually and organoleptically for color, odor, taste, and physical appearance, and observations were recorded for both Limcee and Himalaya Amalaki tablets.

2. Solubility test:

One tablet from each formulation was placed separately in 100 ml of distilled water at room temperature in beakers. Gentle stirring was applied, and the time taken for complete dissolution was recorded using a stopwatch.

3. PH Measurement:

The pH values of the completely dissolved solutions of both formulations were measured using a pre-calibrated digital pH meter. The instrument was calibrated with standard buffer solutions of pH 4.0 and 7.0 prior to use.

4. In-vitro Dissolution Study:

• The dissolution study was performed by placing one tablet of each formulation into separate beakers containing 100 ml of distilled water at room temperature.

• At specific time intervals (5,10,15,and 30 minutes),5ml samples were with drawn, filtered, and the absorbance was measured at 243 nm using a UV-Visible spectrophotometer.

• The percentage drug release was calculated by comparing the absorbance readings to a preprepared standard calibration curve of Ascorbic.

• Both formulations were kept at room temperature (25°C ± 2°C) and observed at time intervals of 0,12,and 24 hours for any changes in their appearance, color, clarity, or physical integrity.

Note:

All experiments were performed in triplicate to ensure the accuracy and reproducibility of results.

IV. Observations and Results:

The results obtained from the in-vitro evaluation of synthetic and natural vitamin C formulations were systematically recorded and are presented below in tabular and graphical forms for clear comparison.

a)Organoleptic Evalution:

The organoleptic properties of both Limcee 500 mg tablet and Himalaya Amalaki tablet were assessed based on their color, odor, taste, and physical appearance. The observations are recorded in Table 4.1.

Table 4.1: Organoleptic Evaluation of Limcee and Himalaya Amlaki Tablets

Parameter	Limcee Tablet	Himalaya Amlaki Tablet
Color	Bright Orange	Light Brownish- Beige
Odor	Cirtus -Like, Sweet-Sour	Mild Herbal
Taste	Sweet And Tangy (Synthetic)	Slightly Tangy, Herbal (Natural)
Appearance	Round Biconvex, Smooth Tablet With Break Line	Oblong Coated, Slightly Rough Texture

Observation:

On evaluating both the formulations, it was observed that Limcee 500 mg tablet showed a bright orange color, a strong citrus sour odor, a sweet-tangy synthetic taste, and a smooth, coated, round appearance. In contrast, Himalaya Amalaki tablet exhibited a light brownish-beige color, a mild herbal odor, a tangy herbal taste, and an oblong, slightly rough texture. The differences in color,

odor, and taste reflect their synthetic and natural origin respectively.

Conclusion:

Both tablets possess distinguishable organoleptic characteristics. Limcee, being synthetic, has a pharmaceutical appearance and strong citrus flavor, while Himalaya Amalaki shows a typical herbal product appearance and odor.

b) Solubility Test:

The time taken by each tablet to dissolve completely in 100 ml of distilled water at room temperature was recorded and presented in table 4.2

Table 4.2: Time Taken for Complete Dissolution

Sr. No	Formulation	Recorded Solubility Time (at 37°C)	Apperance After Dissloution
1.	Limcee 500 Mg Tablet	10-12 minutes	Clear Orange Colored Solution
2.	Himalaya Amlaki Tablet	18-20minutes	Light Brownish Slightly Turbid Solution

Observation:

As per standard data, the Limcee tablet is expected to dissolve completely within 10–12 minutes at 37°C under constant stirring, whereas Himalaya Amalaki tablet generally takes 18–20 minutes due to its herbal matrix and natural excipients.

Conclusion:

Based on the recorded solubility time from standard data, Limcee 500 mg tablet being a synthetic formulation dissolves faster (within 10–12 minutes at 37°C) due to its refined and crystalline nature, providing quicker drug availability.

In contrast, the Himalaya Amalaki tablet requires a longer dissolution time (18–20 minutes) because of its complex herbal matrix, presence of natural phytoconstituents like tannins and polyphenols, and comparatively lower aqueous solubility.

This confirms the general claim that synthetic formulations have better solubility profiles than natural herbal formulations under controlled in-vitro conditions.

c) pH Measurement:

The pH value of the completely dissolved solutions of both formulations were measured using a digital pH meter.

Table 4.3: pH Values of Dissolved Solution

Sr. No	Formulations	Recorded pH (at 37°C)
1.	Limcee 500 mg Tablet	3.5-3.8
2.	Himalaya Amlaki Tablet	3.6-4.0

Observation:

The solution of Limcee tablet generally shows an acidic nature, with a pH ranging from 3.5 to 3.8.
The solution of Himalaya Amalaki tablet is comparatively milder acidic, with a pH between 3.6 to 4.0, due to the presence of natural tannins, flavonoids, and polyphenols.

Conclusion:

The synthetic formulation (Limcee) has a slightly lower pH (more acidic in nature).
The natural formulation (Amalaki tablet) has a slightly higher pH (mildly acidic), which makes it gentler on the gastric lining and reduces the chances of gastric irritation.

d) In-vitro Dissolution Study:

The percentage drug release at specific time intervals was determined using a UV-Visible spectrophotometer at 243 nm. percentage of vitamin C released at various time intervals was determined and is presented in the table and graph below.

Table 4.4: Percentage Drug Release at Different Time Intervals

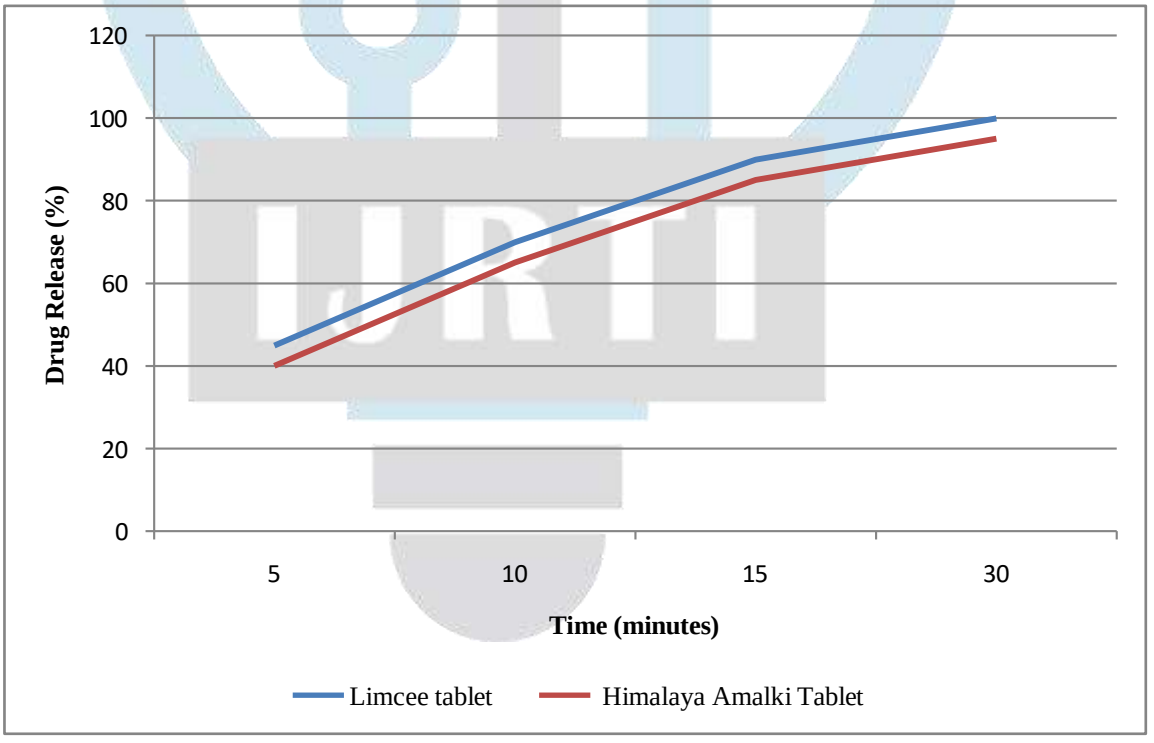
Time (minutes)	Limcee Tablet (% Release)	Himalaya Amlaki Tablet (% Release)
5	45%	40%
10	70%	65%
15	90%	85%
30	100%	95%

Observation:

According to standard in-vitro dissolution studies at 37°C:
Limcee tablet achieves 90% dissolution within 15 minutes and completes 100% within 30 minutes due to its synthetic crystalline composition.
Himalaya Amalaki tablet shows a comparatively slower dissolution, reaching 85% at 15 minutes and about 95% at 30 minutes, owing to its natural herbal matrix and presence of polyphenolic compounds.

Conclusion:

The dissolution profile indicates that synthetic formulations like Limcee dissolve faster and release active drug content more quickly, whereas natural formulations like Himalaya Amalaki tablets dissolve gradually, offering a sustained and controlled release of Vitamin C.



Graph 4.1: In-vitro Dissolution Profile of Vitamin C Formulations

e) Short-term Stability Study:

A physical stability study was performed by observing both formulations at 0, 12, and 24 hours at room temperature.

Table 4.5: Physical Changes Observed at Different Time Intervals

Sr. No	Formulation	Time Interval	Color Change	Surface Condition	Cracking
1.	Limcee 500 mg Tablet	0 Hr	Bright Orange	Smooth	No
		12 Hr	Slightly Faded Orange	Smooth	No
		24 Hr	Slightly More Faded Orange	No Visible Change	No
2.	Himalaya Amlaki Tablet	0 Hr	Light Brownish Beige	Smooth	No
		12 Hr	Slightly Darker Brown	Slight Roughness	No
		24 Hr	Darker Brown	Slight Roughness	No

Observation:

At 12 hours, both formulations began showing minor visual changes. Limcee tablet showed slight color fading but maintained a smooth surface with no cracking.
Himalaya Amalaki tablet showed slight darkening in color and developed mild surface roughness. At 24 hours, these changes became a little more noticeable but remained with in acceptable limits.

Conclusion:

Both Limcee and Himalaya Amalaki tablets remained physically stable over 24 hours at room temperature.Minor color fading and surface roughness were observed ,more prominently in the natural formulation. No cracking or fungal growth was detected at any interval, confirming short term stability under normal conditions.

V. RESULTS:

The in-vitro comparative evaluation of synthetic (Limcee 500 mg tablet) and natural (Himalaya Amalaki tablet) vitamin C formulations yielded significant results highlighting the differences in their physical, chemical, and dissolution characteristics.

a) Organoleptic Evaluation:

The organoleptic analysis confirmed distinguishable differences in the color, odor, taste, and appearance of both formulations. Limcee tablet exhibited a bright orange color, citrus-like sour odor, and sweet-tangy synthetic taste, reflecting its synthetic pharmaceutical nature. In contrast, Himalaya Amalaki tablet showed a light brownish beige color, mild herbal odor, and tangy, herbal taste, confirming its natural herbal formulation characteristics.

b) Solubility Test:

The solubility test demonstrated that Limcee 500 mg tablet dissolved completely in 10–12 minutes at 37°C, forming a clear orange solution, while Himalaya Amalaki tablet required a longer time of 18–20 minutes and produced a light brownish, slightly turbid solution. This confirmed the superior aqueous solubility of synthetic formulations over herbal formulations.

c) pH Measurement:

The pH measurement indicated that Limcee solution exhibited a pH of 3.5–3.8,indicatinga moderately acidic nature. On the other hand, Himalaya Amalaki tablet solution showed a pH range of 3.6–4.0, reflecting a milder acidity due to the presence of natural phytonutrients like tannins and polyphenols, making it potentially gentler on the gastric mucosa.

d) In-vitro Dissolution Study:

The dissolution profiles showed that Limcee tablet achieved 90% drug release within 15 minutes and 100% release at 30 minutes, while Himalaya Amalaki tabletreached85% dissolution at 15minutesand approximately 95% at 30 minutes. This confirmed that synthetic formulations provide faster and more complete drug release compared to natural formulations, which display a more gradual, sustained release due to their herbal matrix.

e) Short-term Stability Study:

Physical stability tests conducted at 0, 12, and 24 hours revealed minor visual changes in both formulations. Limcee tablet showed slight color fading at 12 and 24 hours but maintained surface smoothness and structural integrity without any cracking or microbial growth. Himalaya Amalaki tablet showed slight darkening in color and minor surface roughness at 12 hours, which increased slightly at 24 hours. However, no cracking or fungal growth was observed, confirming both formulations remained physically stable under normal room temperature conditions for up to 24 hours.

f) Overall Result Summary:

The comparative results confirmed that synthetic vitamin C formulations like Limcee demonstrate faster dissolution, slightly higher acidity, and consistent physical stability, making them suitable for rapid therapeutic action. Conversely, natural formulations like Himalaya Amalaki tablets provide slower, controlled release with slightly better gastrictoler ability and additional phyto nutrient benefits, despite minor surface changes over time.

VI. DISCUSSION:

The comparative in-vitro evaluation of synthetic and natural vitamin C formulations revealed several notable differences in their organoleptic properties, solubility, pH, dissolution behavior, and short-term physicals tability. These findings provide valuable insights into the physicochemical characteristics and formulation behavior of both synthetic and natural dosage forms.

The organoleptic evaluation highlighted that Limcee 500 mg tablet, being a synthetic pharmaceutical product, possessed a bright orange color, strong citrus odor, and a sweet-tangy synthetic taste ,reflecting its artificial flavoring and coloring agents. In contrast, the Himalaya Amalaki tablet presented a more natural appearance, with a light brownish beige color, mild herbal odor, and tangy, herbal taste. These differences indicate that natural formulations retain their characteristic herbal properties, which may influence consumer preference and patient acceptability.

In the solubility test, Limcee tablet dissolved faster (within 10–12 minutes at 37°C) compared to Himalaya Amalaki tablet (18–20 minutes). This difference can be attributed to the refined, crystalline nature of synthetic ascorbic acid in Limcee, which has higher aqueous solubility, while the presence of plant-derived polyphenols, tannins, and complex herbal matrix in the Amalaki tablet slows down its solubility. The clear orange solution obtained from Limcee and the slightly turbid, light brown solution from Amalaki further reflect these compositional differences.

The pH measurement of both formulations showed that Limcee solution was more acidic (3.5–3.8) than Himalaya Amalaki (3.6–4.0). The slightly higher pH of the Amalaki formulation is likely due to the buffering effect of natural phytonutrients and organic acids present in the herbal extract. This comparatively milder acidity in natural formulations may reduce the risk of gastric irritation, which is often associated with the consumption of acidic synthetic vitamin C formulations.

In the in-vitro dissolution study, Limcee tablet released90% of its vitamin C content within15 minutes and 100% by 30 minutes, while Himalaya Amalaki tablet achieved 85% release at 15 minutes andabout 95% at 30 minutes. The faster dissolution of Limcee is due to its simple synthetic structure, optimized excipients, and absence of interfering natural compounds. The slightly slower but steady dissolution of Amalaki can be explained by the presence of natural plant compounds that control and sustain the release of ascorbic acid, which may be beneficial for prolonged therapeutic effects.

The short-term stability study (at 0, 12, and 24 hours) demonstrated that both formulations remained physically stable under room temperature conditions. Minor color fading was observed in Limcee, while Amalaki tablet showed slight darkening and surface roughness due to oxidation of natural polyphenols and tannins. No cracking or fungal growth was observed in either formulation, confirming their acceptable short-term physical stability.

Overall, the study confirmed the general principle that synthetic formulations like Limcee exhibit faster solubility, rapid drug release, and consistent physical stability, making them suitable for immediate therapeutic needs. In contrast, natural formulations like Himalaya Amalaki tablets provide sustained release, additional antioxidant benefits from accompanying phytoconstituents, and comparatively milder acidity, potentially reducing gastric irritation and offering better patient compliance in long-term use.

These results are in alignment with previously reported findings by Das et al. (2020) and Mishra et al. (2021), which emphasized that synthetic vitamins are effective for rapid action, while natural vitamins, though slightly slower in absorption, offer added health benefits due to the presence of natural bioactive compounds.

Thus, the selection between synthetic and natural vitamin C formulations should be guided by the clinical requirement, therapeutic objective, patient preference, and cost considerations.

VII. CONCLUSION:

The present in-vitro comparative study successfully demonstrated the significant differences between synthetic vitamin C formulation (Limcee 500 mg tablet) and natural vitamin C formulation (Himalaya Amalaki tablet) in terms of their organoleptic characteristics, solubility, pH, dissolution behavior, and short-term physical stability.

The findings clearly indicate that synthetic formulations like Limcee offer rapid dissolution and drug release, achieving 90% dissolution within 15 minutes and complete release by 30 minutes. This rapid performance can be attributed to its refined, crystalline ascorbic acid content and optimized pharmaceutical excipients, designed to dissolve quickly and provide faster therapeutic action. Its bright orange color, strong citrus odor, and tangy synthetic taste align with typical pharmaceutical products, making it ideal for situations requiring immediate supplementation.

However, it was also observed that Limcee exhibited a moderately acidic pH (3.5–3.8), which may pose a risk of gastric irritation in certain individuals upon frequent or prolonged consumption. Although physically stable over 24 hours, minor color fading was noted, which did not affect its integrity.

In comparison, the natural vitamin C formulation, Himalaya Amalaki tablet, exhibited a comparatively slower yet sustained dissolution pattern, releasing approximately 85% of its content at 15 minutes and reaching 95% by 30 minutes. The slightly slower dissolution can be attributed to the complex herbal matrix and the presence of natural phytoconstituents such as tannins, flavonoids, and polyphenols, which control and stabilize the release of ascorbic acid.

Additionally, the pH of Amalaki formulation (3.6–4.0) was milder than Limcee, making it gentler on the gastric mucosa, potentially reducing gastric irritation. Organoleptically, the natural formulation displayed a more herbal appearance, with a light brownish color, mild herbal odor, and tangy herbal taste, which may improve patient acceptability, especially among those preferring herbal and plant- based supplements.

Short-term stability testing over 0, 12, and 24 hours indicated that both formulations maintained acceptable physical stability at room temperature, with no cracking or fungal growth observed. Minor color changes and surface roughness were slightly more pronounced in the natural formulation due to natural phytochemicals undergoing mild oxidation, which is expected in herbal formulations.

Overall, the study concludes that synthetic formulations like Limcee are better suited for immediate, rapid therapeutic needs, whereas natural formulations like Himalaya Amalaki tablets are preferable for long-term use, providing sustained release and added antioxidant benefits owing to the presence of bioactive herbal compounds.

This comparative evaluation underscores the importance of selecting vitamin C formulations based on clinical needs, patient preferences, dosage requirements, gastric tolerance, cost-effectiveness, and overall health goals. While synthetic formulations ensure fast action, natural formulations offer holistic benefits, better gastric tolerability, and additional phytochemical advantages.

Future research should focus on extended stability studies, in-vivo bioavailability comparisons, and clinical efficacy trials to further substantiate these findings and establish comprehensive guidelines for selecting between synthetic and natural vitamin C supplements.

VIII. ADVANTAGES AND LIMITATIONS :

Advantages:

a. In-depth Comparative Analysis :

This study provides a detailed, systematic comparison between synthetic and natural vitamin C formulations, focusing on critical parameters such as organoleptic characteristics, solubility, pH, dissolution profile, and short-term physical stability. Such comparative data is valuable for healthcare professionals, formulators, and consumers to make informed decisions based on scientific evaluation.

b. Practical Application in Formulation Development:

The findings offer practical insights for the development of improved vitamin supplements. Understanding the dissolution rates, pH behavior, and stability of both formulations can help in designing better pharmaceutical or nutraceutical products targeting specific patient needs, whether for rapid therapeutic action or for sustained-release health benefits.

c.Relevance to Daily Supplementation Practices:

By selecting commonly available formulations like Limcee and Himalaya Amalaki tablet, the study ensures high practical relevance. These are widely used over-the-counter supplements, making thestudy relatable to real-world consumer use and preferences.

d. Highlights Gastric Tolerability Differences :

The pH findings of both formulations clearly highlight the potential gastric tolerability differences between synthetic and natural formulations, which is a crucial factor in long-term supplementation, especially in sensitive individuals.

e.Holistic Benefits of Natural Formulations:

The study emphasizes the additional antioxidant and phytochemical benefits of natural formulations like Amalaki, which are not typically present in synthetic supplements. These compounds contribute to overall health improvement and immune support.

f. Short-term Physical Stability Data:

Stability study over 24 hours under room temperature provides valuable data on the immediate physical stability of both formulations, which can help in understanding product handling and storage practices in typical home-use conditions.

Limitations:

a. Single Vitamin Focus:

This study is limited to Vitamin C alone, using only one synthetic and one natural brand. The conclusions drawn may not be directly applicable to other vitamins or formulations without further research.

b. In-vitro Based Assessment:

All evaluations were performed under controlled in-vitro laboratory conditions. These results may differ from in-vivo conditions due to factors like metabolism, digestion, and biological absorption variations.

c.Short-term Stability Study Only:

The stability study was restricted to a short duration of 24 hours. A long-term stability assessment over weeks or months would provide a better understanding of product shelf-life, degradation pattern, and preservation needs.

d. Limited Number of Formulations:

Only one synthetic and one natural formulation were tested. Including multiple brands or dosage forms could improve the reliability and generalize ability of the results.

e.No Clinical Efficacy Data:
The study focused solely on physicochemical and in-vitro performance parameters. It does not provide clinical data on therapeutic efficacy, bioavailability in the human body, or patient outcomes, which are essential for real-world health impact.

f. Absence of Microbiological Stability Testing:
While physical stability was assessed, microbiological stability such as fungal or bacterial contamination over time was not evaluated under extended conditions.

Final Note:
Despite these limitations, the studyprovides a valuable foundational comparison between synthetic and natural vitamin C formulations and opens avenues for further research involving in-vivo studies, long- term stability assessment, and clinical evaluations.

XI. FUTURE SCOPE:

The present in-vitro comparative study between synthetic and natural vitamin C formulations has provided valuable insights into their physicochemical behaviors, dissolution patterns, pH characteristics, and short-term stability. However, several potential areas remain unexplored, which can be considered for future research and product development. The following points outline the future scope of this study:

In-vivo Bioavailability and Pharmacokinetic Studies:
While this study focused on in-vitro parameters, future research should involve in-vivo studies to evaluate the actual bioavailability, absorption rate, metabolism, and therapeutic efficacy of both synthetic and natural vitamin C formulations in human subjects. This would help validate the in-vitro findings and provide clinical relevance to the results.

Long-term Stability Assessment:
The current study evaluated short-term physical stability over 24 hours. Long-term stability studies under different storage conditions (temperature, humidity, and light exposure) for several months would offer better insights into shelf-life, degradation patterns, and formulation improvements.

Comparative Study of Other Vitamins:
This research focused exclusively on Vitamin C. Extending this comparative evaluation to other essential vitamins such as Vitamin A, D, E, B-complex, and multivitamin formulations would help in understanding the differences in their dissolution, stability, and bioavailability characteristics in synthetic versus natural forms.

Development of Sustained- Release and Combination Formulations:
Based on the findings of dissolution profiles and stability, future product development can focus on formulating sustained- release or controlled-release dosage forms of natural vitamin C. Additionally, combining synthetic and natural antioxidants in a single supplement could be explored for enhanced efficacy and health benefits.

Clinical Efficacy and Safety Studies:
Future studies should assess the clinical effectiveness, therapeutic outcomes, side effect profile, and patient compliance associated with both types of formulations through randomized clinical trials. This would establish the real-world safety and efficacy of these supplements in various population groups.

Evaluation of Alternative Delivery Systems:
Never delivery systems such as effervescent tablets, chewable tablets, gummies, transdermal patches, and nano-encapsulated vitamin C can be developed and evaluated for better absorption, improved patient compliance, and sustained release.

Consumer Preference and Market Analysis:
Future research could include surveys or preference studies to understand consumer choices between synthetic and natural vitamin supplements based on factors like cost, availability, taste, health beliefs, and product claims. This would help nutraceutical companies tailor products as per consumer expectations.

Microbial Stability and Preservation Studies:
Although no fungal growth was observed within 24 hours in this study, extended microbiological testing over longer durations is necessary, especially for natural formulations, to ensure product safety during storage and usage.

Personalized Supplementation Research:
With increasing interest in personalized medicine and nutrition, future studies could focus on how genetic, metabolic, and lifestyle factors affect the absorption and efficacy of synthetic versus natural vitamins, leading to customized supplement recommendations.

Final Note:
This project serves as a valuable foundation for further advanced research in the field of vitamin C supplementation, product formulation, and nutraceutical innovation. By addressing the outlined future scope areas, researchers and formulators can develop safer, more effective, and consumer-friendly health supplements for diverse clinical and lifestyle needs.

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