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COMPARATIVE QUALITY EVALUATION OF COMMERCIAL VITAMIN C SUPPLEMENTS USING UV–VISIBLE SPECTROPHOTOMETRY

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ABSTRACT
Vitamin C (ascorbic acid) is an essential water-soluble vitamin widely used as a nutritional supplement due to its antioxidant properties and its role in collagen synthesis and immune function. Since numerous vitamin C formulations are available in the pharmaceutical market, evaluation of their quality is important to ensure safety and therapeutic effectiveness. The present study aimed to compare the quality of different commercially available vitamin C tablets using UV–Visible spectrophotometric analysis and standard pharmaceutical quality control tests. Five brands of vitamin C tablets containing 250 mg of ascorbic acid were evaluated for weight variation, hardness, friability, and assay determination. Quantitative estimation of ascorbic acid was performed using UV–Visible spectrophotometry at 295 nm. The calibration curve showed a linear relationship between concentration and absorbance with an R^2 value close to 0.999. The assay results indicated that the vitamin C content ranged from 95.89% to 99.51% of the labeled amount. Most brands complied with pharmacopeial limits for weight variation and friability, although minor variations were observed in hardness and mechanical properties. The results suggest that the tested vitamin C supplements generally meet acceptable quality standards. Continuous post-market evaluation is necessary to ensure consistency, safety, and efficacy of pharmaceutical supplements.

KEYWORDS: *Vitamin C, Ascorbic acid, UV–Visible spectrophotometry, Tablet quality control, Pharmaceutical analysis*

1. INTRODUCTION

Vitamins are essential micronutrients that play important roles in metabolic reactions and physiological processes. Among these nutrients, vitamin C (ascorbic acid) is a water-soluble vitamin that functions as a powerful antioxidant and is essential for collagen synthesis, wound healing, and immune response.

Unlike many animals, humans cannot synthesize vitamin C due to the absence of the enzyme L-gulonolactone oxidase. Therefore, it must be obtained through dietary sources such as citrus fruits, vegetables, or pharmaceutical supplements. Vitamin C deficiency may lead to scurvy, fatigue, and impaired immune function.

In recent years, vitamin supplements have become widely available in the pharmaceutical market. These products are consumed not only to prevent vitamin deficiency but also to support overall health. However, variations in manufacturing practices, formulation ingredients, and storage conditions may influence the quality and potency of these supplements.

Quality control evaluation of pharmaceutical tablets is essential to ensure uniformity of dosage units and therapeutic effectiveness. Tests such as weight variation, hardness, friability, and drug content analysis are routinely used to assess the quality of tablet formulations.

UV–Visible spectrophotometry is a commonly used analytical technique for the quantitative estimation of pharmaceutical compounds. Ascorbic acid shows characteristic absorption in the ultraviolet region, making UV spectrophotometric analysis a simple and reliable method for determining its concentration in tablet formulations.

The present study was conducted to evaluate and compare the quality of commercially available vitamin C tablets using UV–Visible spectrophotometry and standard tablet evaluation tests.

2. MATERIALS AND METHODS

The quality analysis of Ascorbic acid was studied through the determination of weight variation, friability, and hardness, UV–Visible spectrophotometer. The study was performed by doing these various test procedures, which are the key factor analysing the quality of the different brands of tablets.

All experimental data were expressed as mean ± standard deviation (SD) for triplicate measurements (n = 3). Statistical analysis was performed to evaluate variation among different brands. One-way ANOVA was considered for comparison, and results were interpreted at a significance level of $p < 0.05$.

2.1 Sample Collection

Five different brands of vitamin C tablets containing 250 mg of ascorbic acid were purchased from local pharmacies. Each brand was coded as Brand A, Brand B, Brand C, Brand D, and Brand E to avoid bias during analysis. The products were finely checked for their physical appearance, the name of the manufacturer, batch number, manufacture date, expiry date, manufacturing license number, and D.A.R number before purchasing. The physical appearances of different brands were also shown in Table 1.

Table 1: Physical Appearance Tablets of Different Brands

Brand	Colour	Shape and Others
Ceevit 250mg Brand A	Orange	Round, uncoated
VC 250mg Brand B	Orange	Round, uncoated
Nutrivit C Brand C	Pale-Yellow	Oval, uncoated
Cecon Brand D	Orange	Round, uncoated
VascoBrand E	Orange	Unusual, Uncoated

2.2 Chemicals and Reagents

- Standard ascorbic acid
- Distilled water

All reagents used were of analytical grade.

2.3 Instruments

The following instruments were used during the experiment:

- UV–Visible spectrophotometer
- Analytical digital balance
- Tablet hardness tester
- Friability tester
- Mortar and pestle

2.4 Weight Variation Test

Twenty tablets from each brand were randomly selected and weighed individually using a digital analytical balance. The average weight and percentage deviation from the mean weight were calculated and compared with pharmacopeial limits.

The formula of percent (%) of weight variation: Percentage (%) weight variation= (average weight – individual weight)/ individual weight x 100 %

2.5 Hardness Test

Tablet hardness was measured using a tablet hardness tester. Ten tablets from each brand were analyzed and the average crushing strength was recorded in kilograms force (kg-f).

2.6 Friability Test

Friability testing was performed using a friability tester. Tablets were rotated at a fixed speed for a specific number of revolutions, and the percentage weight loss was calculated.

Percentage (%) friability= {(Initial weight- Final weight)/ Initial weight} x100

2.7 Preparation of Standard Solution

A standard solution of ascorbic acid was prepared by dissolving 25 mg of pure ascorbic acid in distilled water and diluting to a known volume.

2.8 Preparation of Sample Solution

Tablets from each brand were powdered using a mortar and pestle. A quantity equivalent to 25 mg of ascorbic acid was dissolved in distilled water, filtered, and diluted appropriately for spectrophotometric analysis.

2.9 UV–Visible Spectrophotometric Analysis

The absorbance of standard and sample solutions was measured using a UV–Visible spectrophotometer at 295 nm, which corresponds to the maximum absorption wavelength of ascorbic acid.

3. RESULTS

3.1 Weight Variation of Tablets

The weight of 12 different brands of Ascorbic Acid tablets was determined with the help of an electronic balance and the observed results have been included in the table below (Mean values ± SD, n=10).

Table 2: Average Weight of Different Brands of Ascorbic Acid Tablets

Brand	Average Weight (mg)	Weight variation limit
Ceevit 250mg Brand A	907	±1.2
VC 250mg Brand B	744	±1.5
Nutrivit C Brand C	819	±1.3
Cecon Brand D	835	±1.1
VascoBrand E	817	±1.4

3.2 Hardness and Friability

Hardness is one of the most important physical features for evaluating tablet. [6] It may affect tablet friability, disintegration time and bioavailability. Too hard tablets may result in a decrease in the release of the drug. A digital hardness tester was used to measure the hardness of 12 different brands (Mean values ± SD, n=10).

Brand	Hardness (kg-f)	Friability (%)	Limit
Ceevit 250mg Brand A	14.8	0.15	<1%
VC 250mg Brand B	11.8	0.04	<1%
Nutrivit C Brand C	2.6	1.15	<1%
Cecon Brand D	18.2	0.06	<1%
VascoBrand E	3.4	0.09	<1%

The hardness of the evaluated vitamin C tablets ranged from 2.6 to 18.2 kg-f, indicating significant variation in mechanical strength among different brands. Generally, acceptable tablet hardness lies within the range of 2–8 kg-f depending on formulation requirements.

In the present study, Brand D exhibited the highest hardness (18.2 kg-f), followed by Brand A (14.8 kg-f) and Brand B (11.8 kg-f), indicating that these tablets were comparatively harder than the typical acceptable range. Excessive hardness may negatively influence tablet disintegration and drug release profile.

On the other hand, Brand C (2.6 kg-f) and Brand E (3.4 kg-f) showed lower hardness values, which fall within or near the acceptable range, suggesting adequate crushing strength.

The variation in hardness among brands may be attributed to differences in granulation techniques, compression force, and excipient composition used during tablet manufacturing.

Friability testing showed that the percentage weight loss ranged from 0.04% to 1.15%. Most brands complied with the pharmacopeial limit of not more than 1% (NMT 1%), indicating good mechanical stability.

However, Brand C exhibited a friability value of 1.15%, exceeding the acceptable limit, suggesting that the tablets may be more prone to mechanical damage during handling, packaging, and transportation.

3.3 Calibration Data of Ascorbic Acid

The values of Abs. (absorbance) were plotted against respective concentrations (Figure 2). The conc. (concentration) showed linearity when the curve was plotted indicating it obeyed beers law. The linear equation was $A = 0.061C + 0.002$ and the regression coefficient R^2 was also 0.999

Concentration (µg/mL)	Absorbance
2	0.118
4	0.243
6	0.366
8	0.491
10	0.614

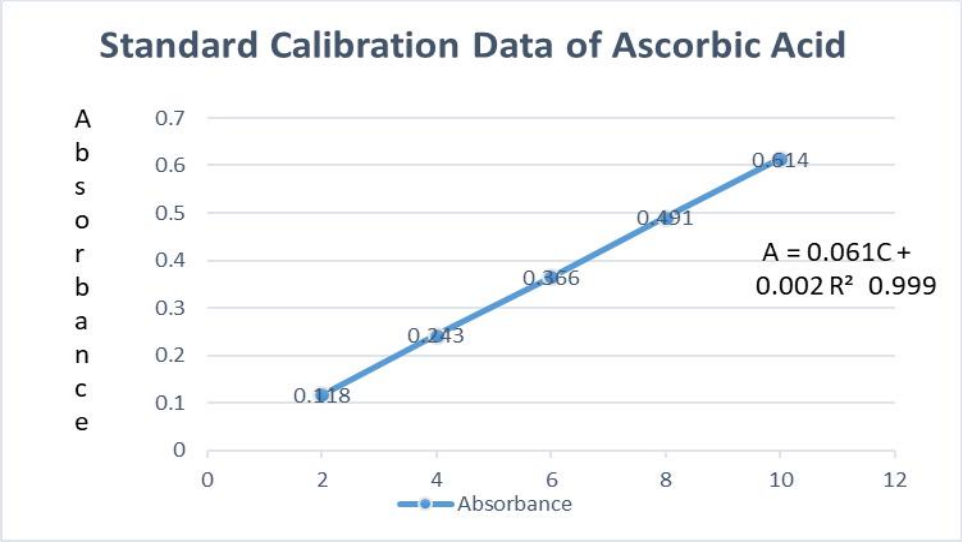

Figure 1: UV Standard Calibration Curve of Ascorbic Acid at 295.4 nm

3.4 Assay Determination of Ascorbic Acid Tablets

Brand	Vitamin C Content (%) Assay	SD
Ceevit 250mg Brand A	97.40	±0.5
VC 250mg Brand B	98.31	±0.4
Nutrivit C Brand C	99.51	±0.3
Cecon Brand D	98.31	±0.4
VascoBrand E	95.89	±0.6

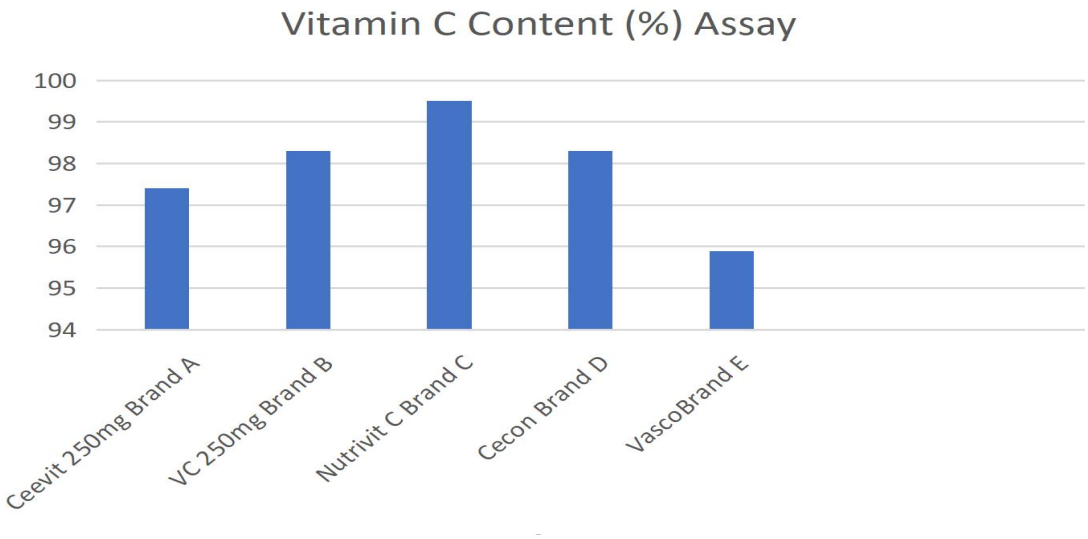

Figure 2: Comparative Assay Profile of Ascorbic Acid Tablets of Different Brands

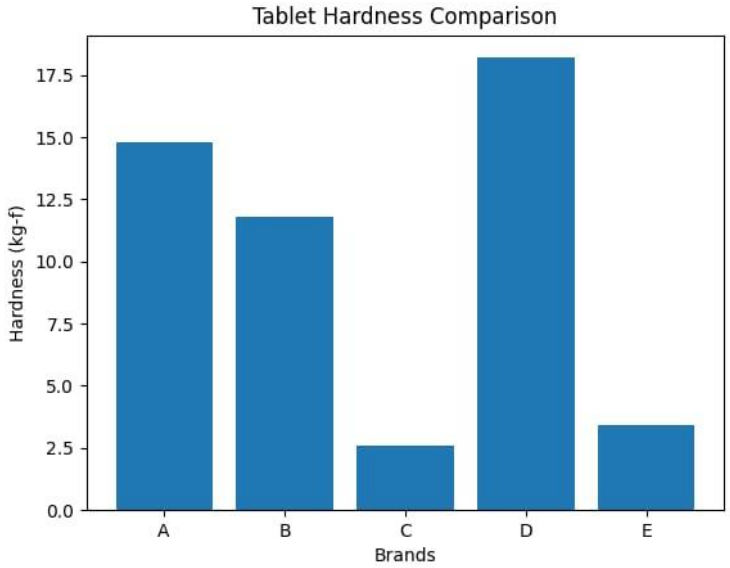

Figure 3. Comparative Hardness of Ascorbic Acid Tablets of Different Brands

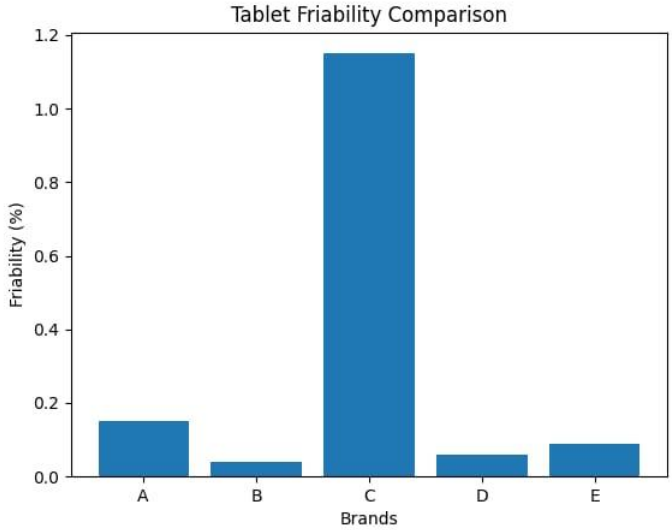

Figure 4. Comparative friability of Ascorbic Acid Tablets of Different Brands

3.5 Comparative Graphical Analysis

The comparative evaluation of different brands was further illustrated using graphical representation.

The vitamin C content of all brands was within acceptable pharmacopeial limits, with Brand C showing the highest content while Brand E showed the lowest.

Tablet hardness varied significantly among brands, indicating differences in compression force during manufacturing.

Friability results showed that most brands complied with acceptable limits (<1%), except Brand C which slightly exceeded the limit, indicating lower mechanical strength.

4. RESULTS

The calibration curve of ascorbic acid showed a strong linear relationship between concentration and absorbance at 295 nm, with a regression coefficient (R^2) of 0.999, indicating excellent method reliability. (Figure 1)

Weight variation results demonstrated that all tested brands complied with pharmacopeial limits, confirming uniformity in tablet formulation.

Significant variation was observed in hardness values, ranging from 2.6 to 18.2 kg-f. This variation indicates differences in compression force and formulation characteristics among brands.

Friability testing revealed that most brands exhibited acceptable mechanical resistance (<1%). However, Brand C showed a friability value slightly above the acceptable limit, suggesting reduced mechanical strength.

The assay results indicated that vitamin C content ranged from 95.89% to 99.51% of the labelled claim. All brands complied with acceptable limits, confirming adequate drug content.

Graphical representation (Figures 2–4) further highlights inter-brand variability in pharmaceutical quality parameters.

5. DISCUSSION

The evaluation of pharmaceutical tablet formulations is important to ensure compliance with quality standards. In this study, several quality control parameters were investigated to assess the characteristics of commercially available vitamin C tablets.

The weight variation results indicated that all tested brands met pharmacopeial requirements, suggesting uniformity in tablet manufacturing. Uniform weight distribution is essential because it ensures consistent drug dosage in individual tablets.

Hardness testing revealed variations in tablet mechanical strength. Tablets with higher hardness values are generally more resistant to mechanical damage during handling and transportation. However, excessively hard tablets may affect disintegration and drug release.

Friability values for most brands were below the acceptable limit of 1%, indicating good mechanical stability. One brand showed slightly higher friability, which may be due to formulation differences or manufacturing conditions.

The present study highlights the importance of post-market quality evaluation of pharmaceutical supplements. The UV–Visible spectrophotometric method demonstrated excellent linearity and reliability for the quantification of ascorbic acid. Uniformity in weight variation confirms consistency in manufacturing processes across brands. However, variations observed in hardness values indicate differences in compression pressure and excipient composition, which may influence tablet disintegration and drug release.

Friability results suggest that most formulations possess adequate mechanical strength, although one brand exceeded acceptable limits, indicating potential handling issues during transportation and storage.

The assay results confirmed that all brands contained vitamin C within pharmacopeial limits, ensuring therapeutic efficacy. The minor variations observed may be attributed to formulation differences and storage conditions.

Overall, the findings emphasize the necessity of continuous quality monitoring to ensure the safety, efficacy, and consistency of pharmaceutical products available in the market.

6. CONCLUSION

The present study evaluated the quality of commercially available vitamin C tablets using UV–Visible spectrophotometry and standard pharmaceutical tests. The results demonstrated that most brands complied with pharmacopeial standards for weight variation, hardness, friability, and drug content.

The spectrophotometric method proved to be simple, accurate, and reliable for determining vitamin C content in tablet formulations. Although minor variations were observed among brands, the overall quality of the evaluated products was satisfactory.

Regular post-market quality monitoring of vitamin supplements is recommended to ensure product safety, consistency, and therapeutic effectiveness.

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