EVALUATION OF THE QUALITY CONTROL PARAMETERS OF SIX BRANDS OF ESOMEPRAZOLE (40 MG) TABLETS AVAILABLE IN BANGLADESH

By

Sakin Bin Nasir
18146039
Purabi Chakraborty
21146020

A thesis submitted to the Department of Pharmacy in partial fulfillment of the requirements for the degree of
Bachelor of Pharmacy

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at BRAC University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

Student's Full Name & Signature:

Sakin Bin Nasir	**Purabi Chakraborty**
18146039	21146020

Approval

The thesis titled "Evaluation of the quality control parameters of six brands of esomeprazole (40 mg) tablets available in Bangladesh," submitted by

1. Sakin Bin Nasir (18146039)
2. Purabi Chakraborty (21146020)

Of Spring, 2025 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Pharmacy.

Examining Committee:

Supervisor:

_____

Mohd. Raeed Jamiruddin, PhD
Associate Professor
School of Pharmacy

Approved By:

Acting Chairperson:

_____

Raushanara Akter, PhD
Acting Chairperson and Professor, School of Pharmacy
BRAC University

Acting Dean:

_____

Dr. A F M Yusuf Haider
Acting Dean, School of Pharmacy
BRAC University

Ethics Statement

This study does not involve any human or animal trail.

Abstract

This study evaluated the quality control parameters of six brands of Esomeprazole 40 mg tablets marketed in Bangladesh. Here to assess their compliance with USP standards. Weight variation, hardness, friability, disintegration, and dissolution tests were performed on randomly selected samples from each brand. All brands complied with weight variation specifications (±5% deviation) and demonstrated excellent friability performance (<1% weight loss). Furthermore, hardness values ranged from 11.384 to 17.553 kg. This value exceeds conventional ranges due to the enteric coating requirements of Esomeprazole. However, critical concerns emerged in functional tests of disintegration. Two brands failed to disintegrate within 45 minutes. It may occur due to an overcoated material for enteric coating. During this study, no tablet brands achieved the required 75-80% drug release in dissolution testing. It may occur due to failure to maintain the standard laboratory procedure during lab work.

Keywords: Esomeprazole, Quality Control, Dissolution, Disintegration, Pharmaceutical Quality

Dedication

We dedicate this work to our beloved parents, friends, and respected faculty members, who have helped a lot to make our undergraduate journey successful.

Acknowledgement

We would like to convey my deepest gratitude and pleasure to our project supervisor Dr. Mohd. Raeed Jamiruddin (Associate Professor, School of Pharmacy, BRAC University) for his constant guidance and continuous encouragement to make this work successful.

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List of Acronyms

USP	United States Pharmacopeia
BP	British Pharmacopeia
GSF	Gastric Simulated Fluid
ISF	Intestinal Simulated Fluid
SD	Standard Deviation
ESP	Esomeprazole

Chapter 1

Introduction

1.1 General

Evaluating the quality control parameters of different brands of tablets is important for ensuring the safety and efficacy of the treatment as well as for ensuring public trust in pharmaceuticals (Yadav et al., 2024). The most widely used dosage form is tablets, the quality of which directly affects treatment outcome. Different manufacturing processes, excipients, and raw materials used across different brands can contribute to differences in the physical and chemical properties. These properties impact the drug's release and absorption and overall effectiveness (Yadav et al., 2024). Quality control tests like weight variation, hardness, friability, disintegration, dissolution, and assay tests are necessary to ensure that all the pills contain the right quantity of active pharmaceutical ingredient (API) and that they are up to pharmacopeial standards (Hassan, 2023). These parameters provide uniformity, mechanical strength as well as proper drug release profiles, which are essential in ensuring that the desired therapeutic effect is attained with reduced chances of toxicity or treatment failure (Hassan, 2023). For example, excessive change in weight or poor dissolution which may lead to adverse effect or uneven therapeutic outcomes (Hassan, 2023). Moreover, relative quality evaluation helps detect bad or fake products, which are more prevalent in regions with weak regulatory oversight. These products can be of poor quality in terms of safety or efficacy (Dash, 2024). Frequent inspections help the regulators to control the pharmaceutical market and safeguard consumers (Dash, 2024). We can use the measurement of quality-control parameters in the brands to identify the interchangeability and bioequivalency between them. This makes clinicians assured that they can use such innovator brands instead of generics without negatively affecting patient care (Dash, 2024). Moreover, continuous quality assessment

encourages pharmaceutical companies to follow Good Manufacturing Practices (GMP) and maintain consistency in their production (Dash, 2024; Yadav et al., 2024).

1.2 Gastroesophageal Reflux Disease

GERD is a comparatively widespread chronic disorder when the contents of the stomach and other substances are refluxed into the esophagus (Richter & Rubenstein, 2018). It has a severe impact on the health of individuals and contributes to raising the national healthcare expenditures. Globally, GERD occurs in populations between 10 to 30 percent in adults and the rate is on the rise in the Western and Asian population (Richter & Rubenstein, 2018). Since GERD is a chronic disease that may cause a host of complications, it significantly influences quality of life and drives up the cost of healthcare (Richter & Rubenstein, 2018). The pathogenesis of GERD is multifactorial. Behind this factor it involves an imbalance between aggressive factors such as gastric acid, pepsin, bile acids and defensive mechanisms of the esophagus (Richter & Rubenstein, 2018). Other important reasons are anatomical alterations, which are hiatal hernias, incompetent lower esophageal sphincter (LES), weak esophageal motility, sluggish stomach emptying, and duodenal refluxing (Bertin et al., 2025). Furthermore, one of the modifiable risk factors is obesity, particularly abdominal obesity, and other risk factors are the advancement of age, male, smoking, alcohol, and some eating habits (Bertin et al., 2025). Genetic causes are also very important. The heritability is approximated to be about 31% and scientists have also associated various genes with increased risk (Argyrou et al., 2018). GERD also occurs in various types with non-erosive reflux disease (NERD) being the most prevalent type and erosive reflux disease (ERD) (Savarino et al., 2017). The disease can progress to complications such as erosive esophagitis, Barrett's esophagus, esophageal strictures, and, rarely, esophageal adenocarcinoma (Savarino et al., 2017). An effective

prevention and management of GERD requires a solid understanding of all these risk factors and interaction of these factors on a biological level (Savarino et al., 2017).

1.3 Symptoms

The gastroesophageal reflux disease (GERD) is usually characterized by the common symptoms of heartburn which is a burning feeling in the chest and the regurgitations of the acid, which is the coming back of the stomach contents in the mouth or the throat (Savarino et al., 2017). Extraesophageal or atypical symptoms are also common and they involve chest pain, persistent cough, bronchial asthma, hoarseness, sore throat, laryngitis, dental erosions, and feeling that a lump is lodged in the throat (globus) (Savarino et al., 2017). Other less frequent symptoms are dysphagia (trouble in swallowing), nausea, bloating, belching, hiccups, and vomiting (Chhabra & Ingole, 2022; Savarino et al., 2017). These may be single or combined symptoms and their prevalence or locality is not necessarily associated with the extent of esophageal damage (Chhabra & Ingole, 2022).

1.4 Treatment

Management of GERD is a complex process and it focuses on alleviating the symptoms, curing esophageal damage and preventing complications (Kröner et al., 2021). First-line management focuses on lifestyle change, such as weight reduction, head-of-bed elevation, and late meals or trigger foods avoidance. After that the main focus is on pharmacologic treatment, whereby proton pump inhibitors (PPIs) are the most effective and best prescribed drugs in erosive as well as non-erosive GERD (Kröner et al., 2021). PPIs inhibit gastrointestinal acid secretions and are normally administered as an introductory dose of 4 to 8 weeks (Kröner et al., 2021).

The dosage schedule may be altered depending on the response and the minimum dose prescribed should be used to sustain treatment (Kröner et al., 2021). Furthermore, in patients who have not fully responded to PPIs, the next possible options are to optimize the use of PPIs, to use potassium-competitive acid blockers (PCABs) like vonoprazan or to add adjunctive agents including H2-receptor antagonists prokinetics, alginates, or baclofen (Arabpour et al., 2023; Hossa & Małecka-Wojciesko, 2025). Baclofen especially can be useful in patients with no acid reflux or continuing symptoms (Arabpour et al., 2023). On the other hand, refractory cases or when long-term medication is undesirable there's a option of surgical interventions. For example, laparoscopic fundoplication or magnetic sphincter augmentation are considered for these cases (Rosen et al., 2025).

1.5 Esomeprazole

Esomeprazole is a very popular drug in the treatment of acid reflux diseases like gastroesophageal reflux disease (GERD), peptic ulcers, and disorders related to Helicobacter pylori infection (Hou et al., 2020). It comes in different formulations, like the standard and immediate release formulations (Hou et al., 2020). And it is commonly prescribed as an oral dose of 20 or 40mg daily in erosive esophagitis (Hou et al., 2020). Esomeprazole also effectively treated patients with Zollinger-Ellison syndrome (Hou et al., 2020).

1.5.1 Chemistry

Esomeprazole is the S-enantiomer of omeprazole and belongs to the class of chiral sulfoxides that are important in pharmaceutical chemistry due to their biological activity and stereoselectivity. Its chemical formula is C17H19N3O3S (Table 1). And molecular weight of approximately 345.4 g/mol (Table 1). The IUPAC name of esomeprazole is 6-methoxy-2-[(S)-(4-methoxy-3,5-dimethyl-2-pyridinyl)methylsulfinyl]-1H-benzimidazole (Table 1). The

molecule has a benzimidazole ring which is bound by a sulfinyl (S=O) bond to a substituted pyridine ring and the S configuration of the sulfur atom is a differentiator between esomeprazole and its R-enantiomer (Yu, n.d.).

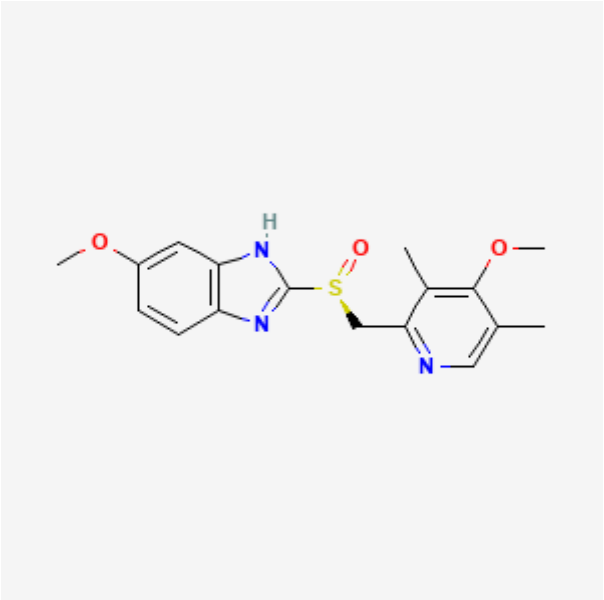

Figure 1: Structure of Esomeprazole (PubChem, n.d.)

Table 1: Characteristics of Esomeprazole (PubChem, n.d.)

Chemical Names	6-methoxy-2-[(S)-(4-methoxy-3,5-dimethyl-2-pyridinyl)methylsulfinyl]-1H-benzimidazole
Molecular Formula	C17H19N3O3S
Relative Molecular Mass	345.4 g/mol
Melting Point	155 °C
Boiling point	600.0±60.0 °C(Predicted)
Appearance	White to off-white or pale beige to brown powder or solid
Enantiomers	It is an enantiomer of a (S)-omeprazole.
Solubility	DMF: 30 mg/ml,DMSO: 20 mg/ml,Ethanol: 10 mg/ml,PBS (pH 7.2): 10 mg/ml

1.5.2 Synthesis

Synthesis of esomeprazole in industries has the aim of attaining a high level of enantiomeric purity, with asymmetric oxidation of the respective sulfide precursor frequently being used (Yu, n.d.). They can be transition metal catalysis (e.g., titanium, iron), bio-enzyme catalysis, and oxaziridine oxidation, with each having its own benefits regarding yield, selectivity, and environmental impact (Nishiguchi et al., 2018). Esomeprazole is usually prepared as magnesium or sodium salt to increase its stability as the free base cannot withstand acidic environments and breaks down very easily in acidic environments (Nishiguchi et al., 2018). Esomeeprazole is commonly combined with enteric-coated preparations in the pharmaceutical preparations to allow gastric protection and enhance delivery of the drug (Nishiguchi et al., 2018).

1.5.3 Mechanism of Action

Esomeprazole is a proton pump inhibitor (PPI). It acts primarily by irreversibly inhibiting the gastric H+/K+ ATPase enzyme (Saccar, 2009). This specific enzyme find in the parietal cells of the stomach and known as proton pump (Saccar, 2009). Esomeprazole is absorbed after administration by mouth and it is concentrated in the acidic environment of the parietal cell canaliculi (Saccar, 2009). After administration it is converted to its active form sulfenamide (Saccar, 2009). This active metabolite covalently binds to cysteine residues on the H+/K+ ATPase (Saccar, 2009). It's leading to irreversible inactivation of the enzyme and blocking the final step of gastric acid secretion. This results in a marked and sustained reduction in gastric acidity, providing symptomatic relief in acid-related disorders such as GERD and peptic ulcers (Saccar, 2009). Beyond acid suppression, esomeprazole also exhibits antioxidant and anti-inflammatory effects (El-Dessouki et al., 2025). It reduces oxidative stress by enhancing antioxidant factors like glutathione and superoxide dismutase. And it inactivates inflammatory

signaling pathways such as p38 MAPK and NF-κB (El-Dessouki et al., 2025). This pathway contributes to mucosal protection and healing in stress-related gastric injury. These additional actions may help explain its protective effects in various gastrointestinal and extra-gastrointestinal conditions (El-Dessouki et al., 2025).

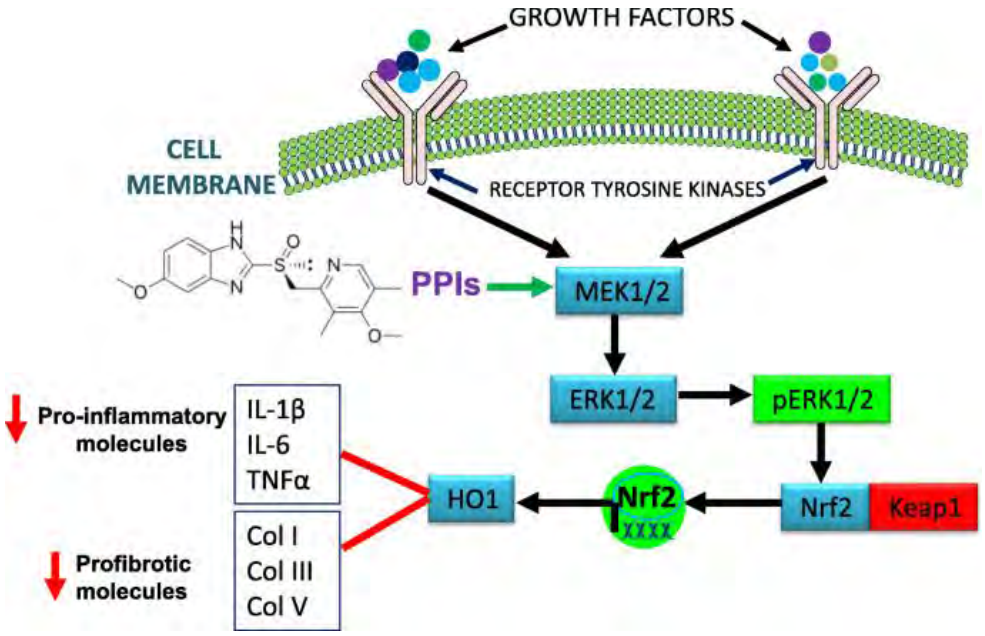

Figure 2: Esomeprazole antioxidant and anti-inflammatory effects (Ebrahimpour et al., 2021)

1.5.4 Side Effects

Esomeprazole is a widely used proton pump inhibitor which is generally well tolerated but can cause side effects. Common side effects include headache, abdominal pain, diarrhea, nausea, constipation, and respiratory infections (Gold et al., 2007). More severe risks have been observed which include kidney damage, nephrogenic anemia and rebound acid hypersecretion, particularly when taken chronically (Gold et al., 2007; Wang et al., 2025). In older adults, gastrointestinal issues and hyponatremia are more frequent. Children may experience vomiting, acute kidney injury, and rare allergic reactions (Wang et al., 2025). Moreover, long-term use for women and the elderly is also associated with an increased risk of osteoporosis and bone

fractures (Wang et al., 2025). Following this there's a documented a report about case of esomeprazole induced chest pain with electrocardiogram (ECG) changes (Radas et al., 2020). But this is considered an unexpected and rare adverse reaction (Radas et al., 2020).

1.5.5 Contradictions

As a proton pump inhibitor, esomeprazole may have contraindications that interact with other drugs and bring about clinically significant contradictions. Interacting most significantly and documented with is the clopidogrel, an antiplatelet agent (Youssef et al., 2025). Esomeprazole acts on the enzyme CYP2C19 that is required in the transformation of clopidogrel into its active form (Youssef et al., 2025). This effect can diminish the efficacy of clopidogrels thus increasing the probability of cardiovascular events and thus their use should be avoided or other PPIs such as pantoprazole or rabeprazole should be used instead (Youssef et al., 2025). Furthermore, esomeprazole has the potential to increase or decrease the absorption of drugs with a pH-dependent bioavailability, including ketoconazole and digoxin (Miyaue et al., 2024). And may affect the pharmacokinetics of drugs, including apixaban and levodopa, potentially diminishing their efficacy (Miyaue et al., 2024).

1.5.6 Esomeprazole Consumption Statistics in Bangladesh

In Bangladesh, Esomeprazole is one of the most commonly used medicines for reducing stomach acid. And it is widely prescribed for conditions such as gastric ulcers, acid reflux, and gastroesophageal reflux disease (GERD) (Rashid et al., 2022). This medicine is available under many different brand names and is produced by different pharmaceutical companies in this country (Rashid et al., 2022). Several drug-utilization and outpatient prescription surveys of Bangladesh hospitals and cities indicate the presence of esomeprazole as the most frequently prescribed PPI (Islam et al, 2017). Following this, one study found esomeprazole accounted for roughly one-third of PPI prescriptions (Islam, 2017). Although the uptake is high, published

audits and utilisation reviews indicate the potential over-use and non-optimal indicators of PPIs in Bangladesh. This highlights the importance of supervising and guideline-based prescribing to have rational use of esomeprazole (Sa & Kmm, 2024).

1.6 Quality Control

In the production of pharmaceuticals, quality control is essential for the product's safety, effectiveness, and uniformity. The raw materials, such as API, excipients, and the final product, are used for production and marketing if they pass all of the tests conducted by the quality control department. The raw ingredients and final product will remain preserved until the quality control department issues a pass. Physical and chemical testing, dissolution testing, microbial testing, and stability testing are among the tests carried out in quality control. Evaluation of Raw Materials Explain the importance of quality control in ensuring that raw materials are suitable for pharmaceutical production.

1.6.1 In Process Quality Control

The in-process quality control (IPQC) process is a very important part of manufacturing processes in the pharmaceutical industry to guarantee products attain the pre-established safety, efficacy, and quality requirements at every production level. In contrast to end-product testing, IPQC is a process of ongoing monitoring and assessment of materials, intermediate products and processes with the aim of realizing trends in real-time (Chavan et al., 2018). It assists in consistency, reduction of deviation, and avoidance of expensive batch failures. Common IPQC standards are variation in weight of tablets, hardness, friability, disintegration test, pH checks, viscosity tests and environmental control in manufacturing departments (Chavan et al., 2018; Ganesh et al., 2022). IPQC helps in the improvement of operational efficiency by identifying and fixing the problems in real time, which decreases the likelihood of producing defected products in the market. It also assures Good Manufacturing Practices (GMP) and regulatory

requirements by the agencies like the FDA and EMA. Finally, IPQC safeguards patient safety because it ensures that each batch that is produced is within the quality specifications throughout its production (Chavan et al., 2018).

1.6.2 Quality Control Parameters of Solid Dosage Forms

In order to maintain the safety, efficacy and consistency of pharmaceutical products, quality control (QC) of solid dosage forms is mandatory. These parameters are used to ensure that the quality of tablets or capsules is as per the specifications before they are released to the market (Tawde et al., 2024). The major QC tests are organoleptic test (color, odor, appearance) and weight change, as it is used to check that the drug content is equal in each unit (Tawde et al., 2024). Hardness test and friability test determine mechanical strength in order to withstand handling and packaging (Tawde et al., 2024). Disintegration time is used to determine how fast a dosage form disintegrates under physiological conditions and dissolution testing is used to determine the rate and the level of drug release which directly affects bioavailability (Tawde et al., 2024). Standardization of the content is used to achieve precise dosing especially of a strong drug. Other tests include moisture content, thickness, and microbial limits whereby these tests continue to ensure stability and safety of a product. Together, these QC parameters ensure uniform therapeutic actions and adherence to Good Manufacturing Practices (GMP) of the solid dosage forms (Tawde et al., 2024).

1.6.3 Weight Variation

For a solid dosage form (tablets and capsules) to ensure dose consistency and product uniformity, a weight variation test is one of the essential quality control metrics. In this test, a predetermined number of units typically 20 tablets or capsules are selected at random and weighed (Ganesh et al., 2022). The weight of each unit is then compared to the average weight once the mean weight has been determined. The variance should fall within the pharmacopeial

(USP, BP) limitations, which are dependent on the tablet's average weight. Significant variances may be indication of poor die filling, incorrect powder flow, or compression issues (Ganesh et al., 2022). The test provides assurance that every unit provides the correct dosage. And ensures that the product is safe, effective, and meets the requirement of regulations (Ganesh et al., 2022). According to the United States Pharmacopeia (USP), for tablets weighing less than 130 mg, the permitted deviation is ±10%. For those weighing 130–324 mg, the allowable limit is ±7.5% (Table 2). And for tablets weighing more than 324 mg, the acceptable deviation is ±5% from the average weight (Table 2).

Table 2: Weight variation tolerance for tablets according usp guidelines (Tawde et al., 2024)

Average weight of the tablet	Percentage of difference
130 mg or less	±10%
From 130 mg through 324 mg	±7.5%
More than 324 mg	±5%

1.6.4 Hardness Test

The hardness test is an important quality control (QC) test on solid dosage forms (tablets) in order to be able to guarantee that the solid dosage form has sufficient mechanical strength to be handled, packaged and shipped without breaking or crumbling (Narlawar et al., 2024). During the test a controlled force is applied to a tablet until it fractures. Breaking force is measured typically in newtons or kiloponds (Narlawar et al., 2024). Modern hardness testers can simultaneously measure thickness, diameter, and hardness (Narlawar et al., 2024). The

orientation of the tablet during testing should be standardized and at least six tablets are usually tested to obtain a reliable average. Acceptable hardness values vary depending on the tablet type and intended use. Excessive hardness can negatively impact disintegration and dissolution. So, the test is essential for balancing mechanical strength with optimal drug release characteristics (Narlawar et al., 2024). In practice, most formulations follow commonly accepted ranges according to USP. Where uncoated tablets generally require a hardness of 4–8 kgf and film-coated tablets typically need 6–10 kgf (Table 3).

Table 3: USP Acceptance Criteria of Hardness test (Navya Sri & Reddy, 2023)

Tablet Type	Typical Hardness
Uncoated Tablets	4-8 kg (40-80 N)
Flim-coated Tablets	6-10 kg (60-80 N)
Chewable Tablets	12-20 kg (120-200 N)
Effervescent Tablets	Very low hardness

1.6.5 Friability Test

The friability test is a quality control test that is necessary on solid dosage forms especially on tablets to determine how well they survive mechanical pressure during manufacturing, packaging and transportation (Daria et al., 2022). This test is conducted by placing a given amount of pre-weighed tablets in a rotating drum (friabilator) and moving the tablets through repeated rolling and dropping, usually 100 revolutions at 25 rpm (Daria et al., 2022). After the test, tablets are dedusted and reweighed to determine the percentage of weight loss. Result reflects the extent of chipping, crumbling, or breaking. According to pharmacopeial standards such as the USP and BP, a maximum weight loss of 1% is generally considered acceptable

(Daria et al., 2022). Friability values above this threshold suggest poor mechanical strength (Daria et al., 2022). This may compromise product quality and patient safety. The test is crucial for ensuring that tablets maintain their integrity throughout their shelf life and deliver the intended therapeutic effect (Daria et al., 2022).

1.6.6 Disintegration Test

The disintegration test is another fundamental quality control procedure for solid pharmaceutical dosage forms, such as tablets and capsules. Its primary purpose is to determine the time required for a dosage form to break down into smaller fragments under standardized conditions. This process ensures the active pharmaceutical ingredient becomes available for dissolution and subsequent absorption in the body (Silva et al., 2018). The test is typically performed using a basket-rack assembly, where tablets are repeatedly immersed in a liquid medium at 37 ± 0.5°C (Silva et al., 2018). During the test, the basket rises and falls at a regulated frequency. This allows the medium to flow through the tablets and cause disintegration (Silva et al., 2018). The endpoint is reached when no palpable core remains and all fragments pass through the mesh screen (Silva et al., 2018). This test ensures batch-to-batch consistency and product performance (Silva et al., 2018). Furthermore, for the uncoated tablet the disintegration time is 15 minutes, for coated one is 30 minutes, for film coated tablet is 30 minutes and for enteric coated, it is 60 minutes or 1 hour (Silva et al., 2018).

1.6.7 Dissolution Test

Dissolution test is a quality control process that is critical to test the rate and extent of active pharmaceutical ingredient (API) release out of solid dosage forms. This test is operated under specified dissolution medium with standardized conditions and temperature (usually 37°C) (Barsagade et al., 2021). The amount of drug released into the medium is measured at defined time intervals using UV-Vis spectrophotometry or HPLC (Barsagade et al., 2021; Zaborenko

et al., 2019). This test mimics the drugs release in the gastrointestinal tract and is necessary in forecasting in vivo drug performance. It assures consistency of batches to batches and regulatory acceptance. This test also helps predict the drug's bioavailability (Zaborenko et al., 2019). Furthermore, dissolution profiles are essential for establishing in vitro-in vivo correlations. Regulatory agencies require dissolution testing for product development, quality control and for bioequivalence studies (Zaborenko et al., 2019). USP applies a three-stage acceptance system of dissolution test (Stage S1, S2, and S3) (Table 4). In Stage S1, all six units tested must release not less than Q + 5%. If this requirement is not met then testing proceeds to S2. In S2 the average of 12 units tablets value must be at least Q and with no unit falling below Q − 15%. If still not compliant then stage S3 is performed. In stage 3, evaluate 24 units total tablets. Here, strict criteria determine compliance based on both group averages and minimum individual results (Table 4).

Table 4: BP, USP, PhEur, JP and PhInt acceptance criteria for dissolution test of tablet (Navya Sri & Reddy, 2023)

Level	Sample tested	Acceptance criteria
S1	6	Each value is not less than Q + 5%
S2	6	Average value of the 12 dosage units (S1 + S2) is equal to or greater than Q and no unit is less than Q-15%
S3	12	Average value of 24 dosage units (S1 + S2 + S3) is equal to or greater than Q; not more than 2 units are less than Q - 15%; no unit is less than Q - 25%.

1.7 The Significance of the Study

Over the past few years, the gastrointestinal diseases like peptic ulcer disease, gastroesophageal reflux disease (GERD) and acid-related complications have become more common in our country. Because of the shifting lifestyle habits, stress, improper food habits and increasing exposure to environmental triggers. Despite the fact that they may be difficult to control, they are very curable with proper medication. Proton pump inhibitors (PPIs) are one of the most common therapeutic agents, and the pharmaceutical industry in Bangladesh is very competitive, with a wide range of companies that manufacture and offer formulations of various brands of PPI. Esomeprazole is an effective and popular PPI whose usage is prescribed frequently because of the high acid-suppressive effect and a positive safety profile. Due to a wide range of prescription of esomeprazole 20 mg and 40 mg tablets offered by several manufacturers, there is a need to carry out a comparative assessment of the quality control parameters to guarantee the reliability of products, their therapeutic results, and patient safety. The pharmaceutical products should be of the highest standard and show consistent quality, safety and effectiveness without causing any side effects. Hence, it is important to evaluate the main quality control features, including the variation of weights, hardness, thickness, friability, disintegration period, dissolution trend, and potency, to identify whether the various brands being marketed adhere to pharmacopeial requirements. This kind of comparative study can help create the differences between brands and create the superior formulations in terms of manufacturing, stability, and therapeutic guarantees.

1.8 Aims and objectives of the study

The aim of this study is to evaluate and compare the quality control parameters of different marketed brands of Esomeprazole tablets available in Bangladesh. And the objective of this study will be to critically compare the quality control parameters of different marketed brands

of Esomeprazole tablets in Bangladesh to see to what extent they can comply with pharmacopeial standards. Here testing basic physical and mechanical properties including weight changes, hardness, and thickness as well as friability to ensure that all the tablets remain homogenous and healthy. It also be looking into the disintegration time of individual brands to ensure their applicability in releasing drugs. Dissolution testing will also be done to compare drug release profiles and ensure that each formulation is within the required bioavailability standards. Lastly, potency evaluation ensures that all tablets contain the correct amount of the active pharmaceutical ingredient. Here use the comparison of these parameters of various brands in order to identify any difference in quality and which products demonstrate the highest level of reliability, safety, and therapeutic efficiency.

Chapter 2

Methodology

2.1 Samples

Tablet selection for testing and reference standard collection of Esomeprazole 40 mg. In Bangladesh, several brands of Esomeprazole are available. Among them, 5 brands were selected randomly and collected from different medicine shops in Dhaka (Table 5). To maintain a transparent process we use code name for this brand.

Table 5: Different brands along with their manufacturer names

Tablet	Code name
Esomeprazole 40 mg	ESP-1
Esomeprazole 40 mg	ESP-2
Esomeprazole 40 mg	ESP-3
Esomeprazole 40 mg	ESP-4
Esomeprazole 40 mg	ESP-5
Esomeprazole 40 mg	ESP-6

2.2 Reagents & solvents

Simulated Gastric Fluid (GSF) and Simulated Intestinal Fluid (ISF) are used in dissolution media. To prepare GSF (pH 1.2), 8.3 mL of concentrated hydrochloric acid is carefully added to about 1000 mL of distilled water with continuous stirring. And for ISF (pH 6.8), 1 g of

potassium dihydrogen phosphate (KH_2PO_4) is dissolved in approximately 1000 mL of purified water, followed by the addition of 8.5g sodium chloride to obtain the desired buffer capacity.

Table 6: List of Reagents & solvents used throughout this project

Potassium Dihydrogen Phosphate	Use to make ISF buffer solution for the dissolution test.
Dipotassium Hydrogen Phosphate	Use to make ISF buffer solution for the dissolution test.
Sodium Chloride Hydrogen	Use to make buffer solution for the dissolution test.
Hydrochloric Acid (0.1N HCL)	Use to make GSF buffer solution for the dissolution test.
Distilled Water	Use to make ISF, GSF buffer solution for the dissolution test. Also use to do the disintegration test.

2.3 List of Apparatus/ Glassware's

Table 7: List of Apparatus/ Glassware's used throughout this project

Container	Stop watch
Test tubes	Measuring Cylinders
Volumetric Flasks	Pipettes
Beakers	Glass rod
Droppers	Filter paper

2.4 Weight Variation

2.4.1 Method

A total of 10 tablets were randomly selected from each brand and weighed individually using an analytical balance. The average weight of the tablets was calculated and the percentage deviation of each tablet from the mean weight was determined.

2.4.2 Instrument

Analytical Balance, Model-FH 200

Figure 2: Precision scale FH-200

2.4.3 Calculation

$$\text{Weight variation } = \frac{Tablet\ weight - Average\ weight}{\text{Average weight}} \times 100$$

2.5 Hardness Test

2.3.1 Method

Randomly selected tablets were taken and each tablet was placed diametrically between the instrument's jaws. A steadily increasing force was applied until the tablet fractured, and the breaking force was automatically displayed in Newton. The procedure was repeated for all tablets, and calculated the average hardness.

2.3.2 Instrument

Model: Wincom YD-1

Figure 3: Tablet hardness tester

2.4 Disintegration test

2.4.1 Method

The disintegration test was operated at 37 ± 0.5°C, which simulates physiological body temperature. Six tablets were placed individually in each tube of the basket rack. The rack is immersed in 600 mL of ISF solution as the immersion fluid. The basket was allowed to move up and down at the standard frequency of 29–32 cycles per minute. Each tablet was observed throughout the run, and the endpoint was recorded when no residue remained on the screen except fragments of insoluble coating. The total disintegration time for all six units was documented to ensure compliance with USP acceptance criteria.

2.4.2 Instrument

Model: BJ-2

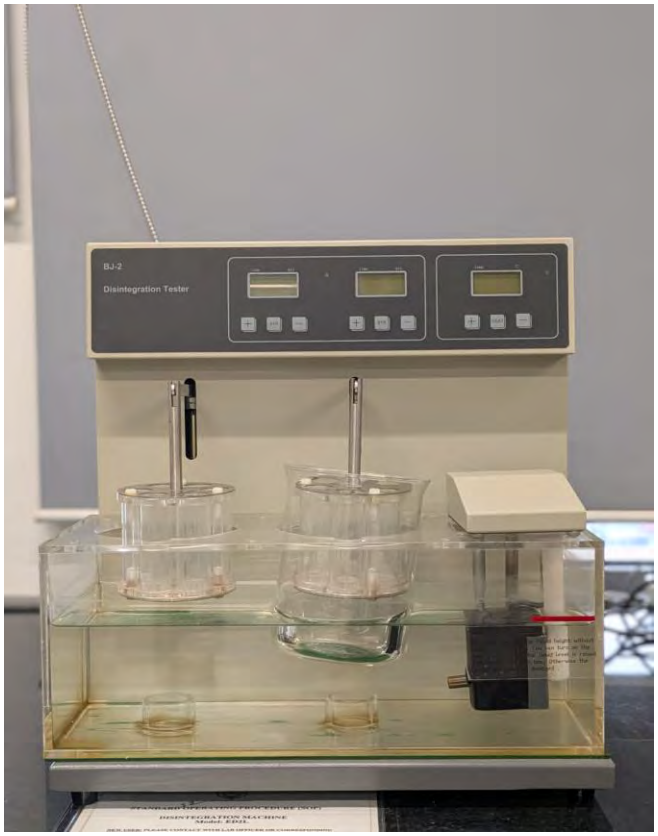

Figure 4: Tablet disintegration tester

2.5 Dissolution Test

2.5.1 Method

The test is performed at a controlled temperature of 37 ± 0.5°C and the typical agitation speed of the instrument was 75 rpm. A specified dissolution medium (GSF and ISF) is used at a 900 mL. Samples are withdrawn at predetermined intervals, filtered, and analyzed using UV-Vis at 300 nm.

2.5.2 Instrument

Model: Logan UDT-804

Figure 7: Tablet dissolution tester

2.5.3 Calculation

$$\%\ of\ drug\ release = \frac{Absorbance(a) \times Dilution\ factor \times 900}{1000}$$

Dilution factor = 50

2.6 Friability

2.6.1 Method

Tablets from each brand which are chosen for the test had a unit weight about less than 650 mg. So, for the friability test, the total tablet weight needs close to 6.5 g. A randomly chosen tablet from each brand was weighed and placed to the friability drum of a friability tester (Electro lab EF-2). For this test, the drum was adjusted to rotate at 25 rpm, for about 4 minutes with a total of 100 rotations. After this, the tablet needed to be removed from the drum, dusted and finally weighed. For each brand the mean percentage of weight loss was noted.

2.6.2 Instrument

Model: Electro lab EF-2

Figure 8: Tablet friability tester

Chapter 3

Result

3.1 Weight Variation

The percentage of variation of 6 different brands of Esomeprazole (40mg) tablets are given below.

3.1.1 ESP-1 40 mg Tablet

Table 8: Weight variation of ESP-1 40 mg tablet

Number of tablets	Weight of individual tablets (g)	Average weight (g)	Individual weight Variation (%)	Highest weight variation (%)	Lowest Weight variation (%)
1	0.260	0.2663	-2.37%	2.89%	-2.37%
2	0.263		-1.24%		
3	0.274		2.89%		
4	0.268		0.64%		
5	0.269		1.01%		
6	0.269		1.01%		
7	0.268		0.64%		
8	0.262		-1.62%		
9	0.265		-0.49%		
10	0.265		-0.49%		

The standard deviation of individual weights is 0.004111.

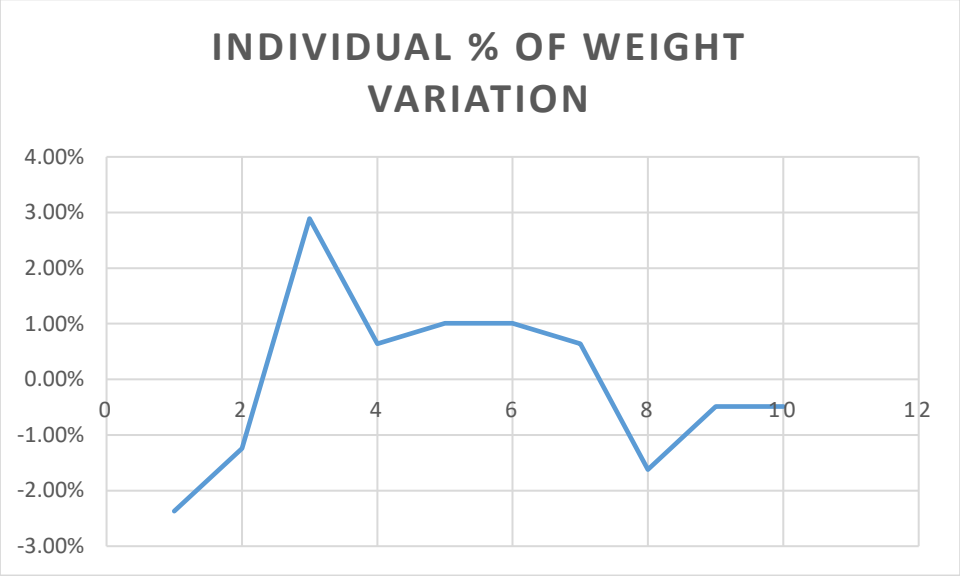

Figure 9: Individual weight variation percentage of (ESP-1 40 mg).

The x-axis indicates the number of the tablets used for test and the y- axis indicate the percentage of weight variation detected for each marketed tablet.

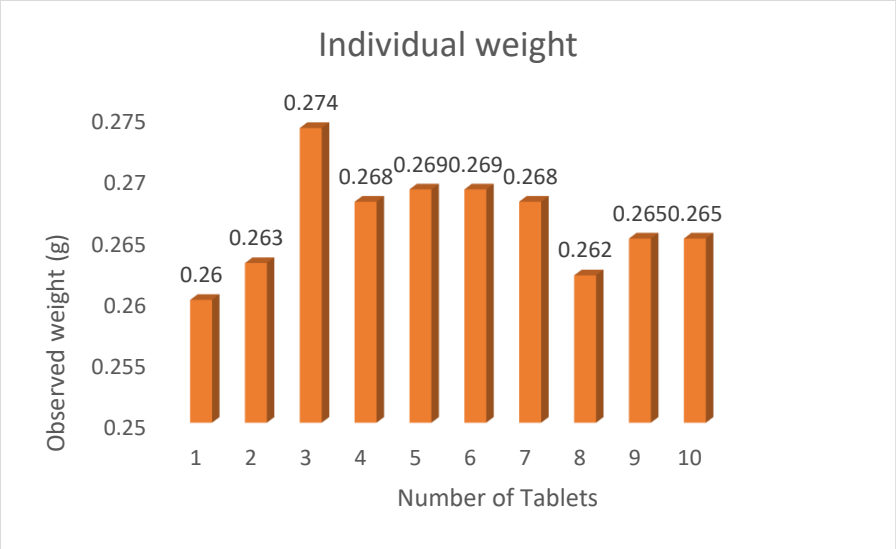

Figure 10: Weight of individual tablet (ESP-1 40mg).

The X-axis indicate the numbers of tablet used for test and the Y- axis indicate weight variation of individual tablet.

3.1.2 ESP-2 40 mg Tablet

Table 9: Weight variation of ESP-2 40 mg tablets

Number of tablets	Weight of individual tablets (g)	Average weight (g)	Individual weight Variation (%)	Highest weight variation (%)	Lowest Weight variation (%)
1	0.267	0.2593 g	2.97%	4.48%	-2.43%
2	0.256		-1.27%		
3	0.255		-1.66%		
4	0.268		3.36%		
5	0.254		-2.05%		
6	0.253		-2.43%		
7	0.255		-1.66%		
8	0.271		4.48%		
9	0.255		-1.66%		
10	0.259		-0.12%		

The standard deviation of individual weights is 0.006717.

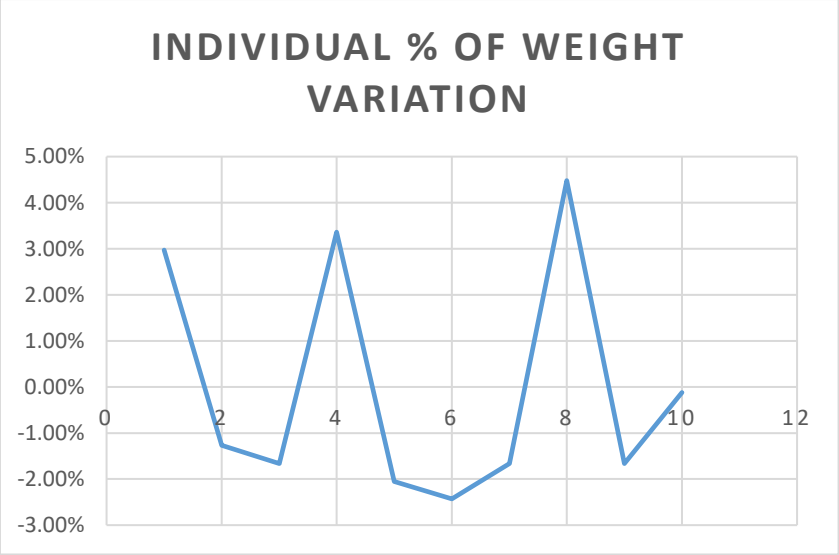

Figure 11: Individual weight variation percentage of ESP-2 40 mg tablets.

The x-axis indicates the number of the tablets used for test and the y- axis indicate the percentage of weight variation detected for each marketed tablet.

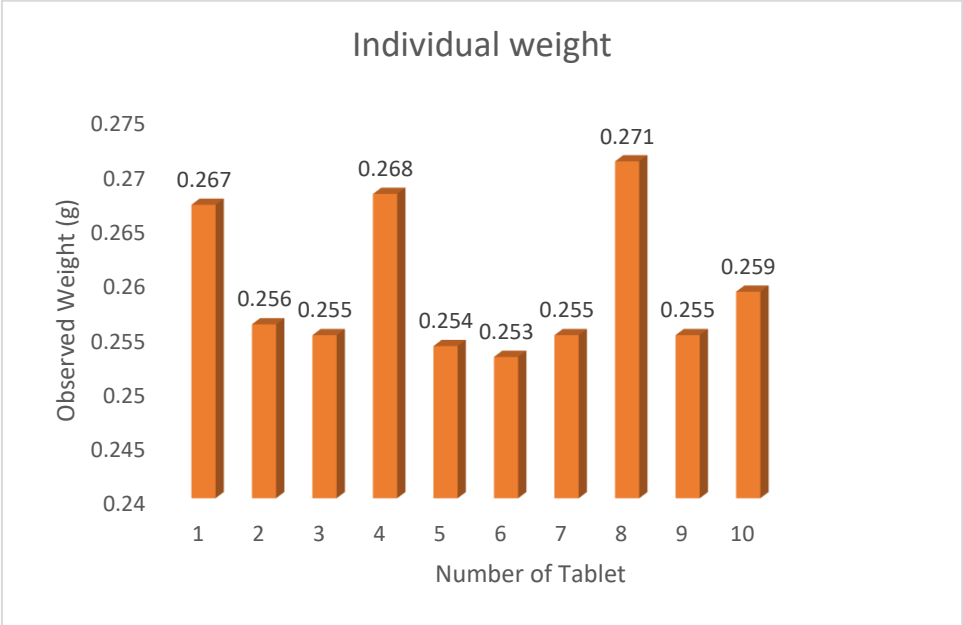

Figure 12: Weight of individual tablet (ESP-2 40mg).

The X-axis indicates the numbers of tablet used for test and the Y- axis indicate weight variation of individual tablet.

3.1.3 ESP-3 40 mg Tablet

Table 10: Weight variation of ESP-3 40 mg tablets

Number of tablets	Weight of individual tablets (g)	Average weight (g)	Individual weight Variation (%)	Highest weight variation (%)	Lowest Weight variation (%)
1	0.363	0.3669 g	1.06%	1.41%	-2.15%
2	0.366		-0.25%		
3	0.368		0.30%		
4	0.359		-2.15%		
5	0.371		1.13%		
6	0.363		-1.06%		
7	0.369		0.57%		
8	0.372		1.41%		
9	0.368		0.30%		
10	0.370		0.85%		

The standard deviation of individual weights is 0.004122.

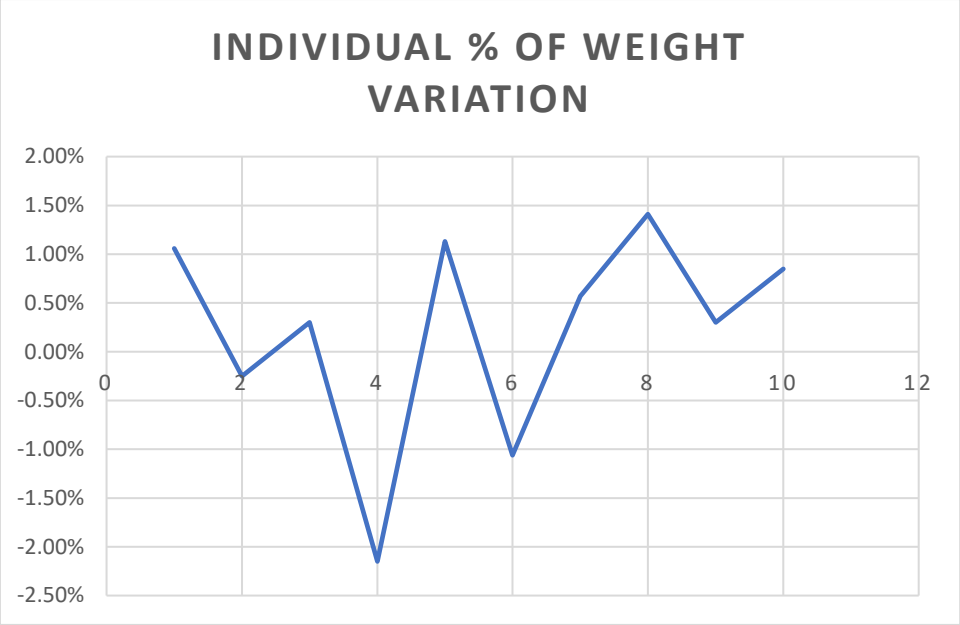

Figure 13: Individual weight variation percentage of ESP-3 40 mg tablets.

The x-axis indicates the number of the tablets used for test and the y- axis indicate the percentage of weight variation detected for each marketed tablet.

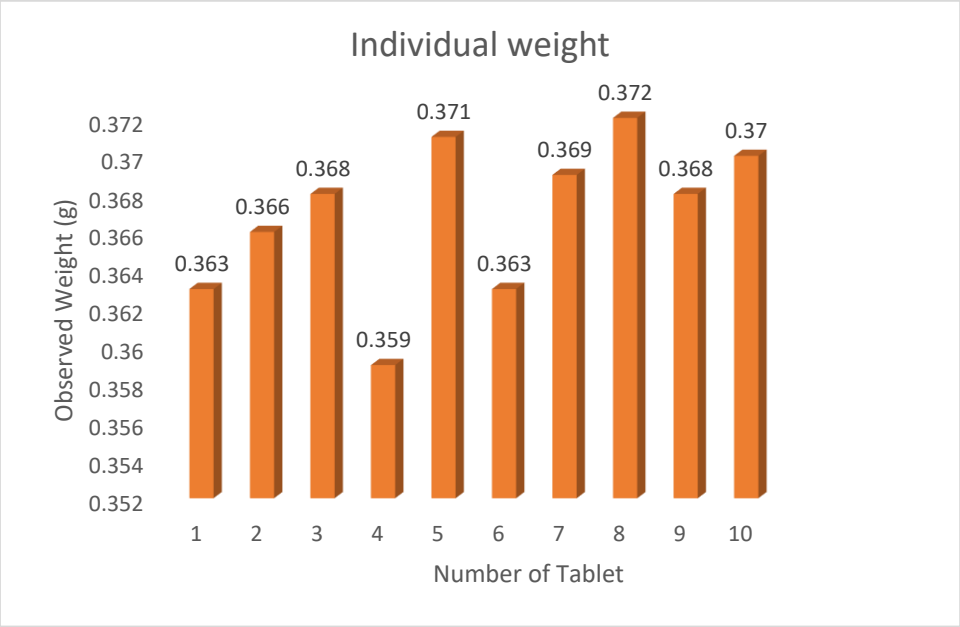

Figure 14: Weight of individual tablet (ESP-3 40mg).

The X-axis indicates the number of tablet used for test and the Y- axis indicate weight variation of individual tablet.

3.1.4 ESP-4 40 mg Tablet

Table 11: Weight variation of ESP-4 40 mg tablets

Number of tablets	Weight of individual tablets (g)	Average weight (g)	Individual weight Variation (%)	Highest weight variation (%)	Lowest Weight variation (%)
1	0.238	0.2401 g	-0.92%	3.71%	-4.21%
2	0.235		-2.17%		
3	0.249		3.71%		
4	0.244		1.62%		
5	0.246		2.46%		
6	0.246		2.46%		
7	0.236		-1.71%		
8	0.230		-4.21%		
9	0.240		-0.04%		
10	0.237		-1.29%		

Standard deviation of individual tablet weight is 0.00599

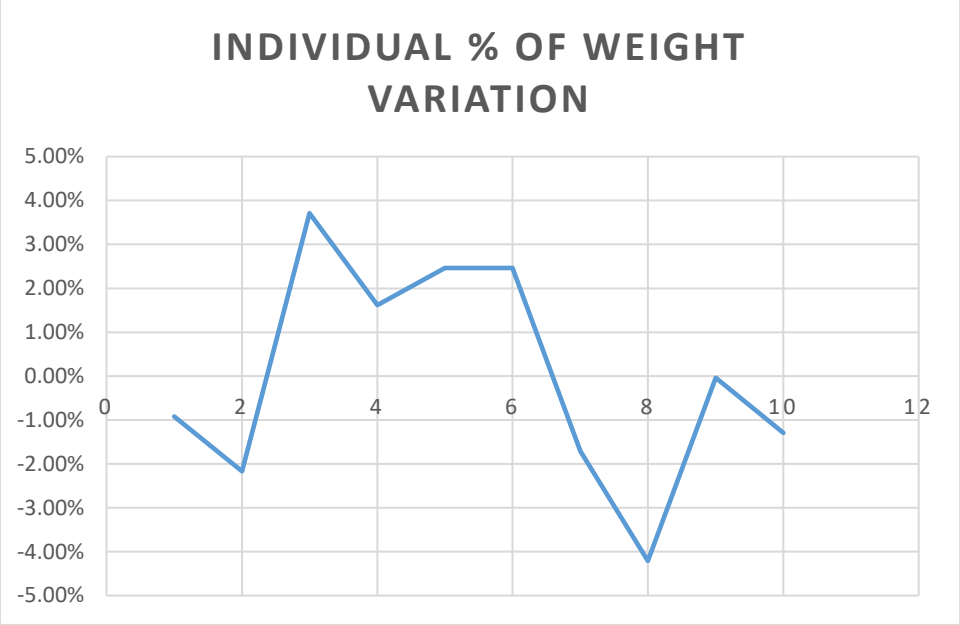

Figure 15: Individual weight variation percentage of ESP-4 40 mg tablets.

The x-axis indicates the number of the tablets used for test and the y- axis indicate the percentage of weight variation detected for each marketed tablet.

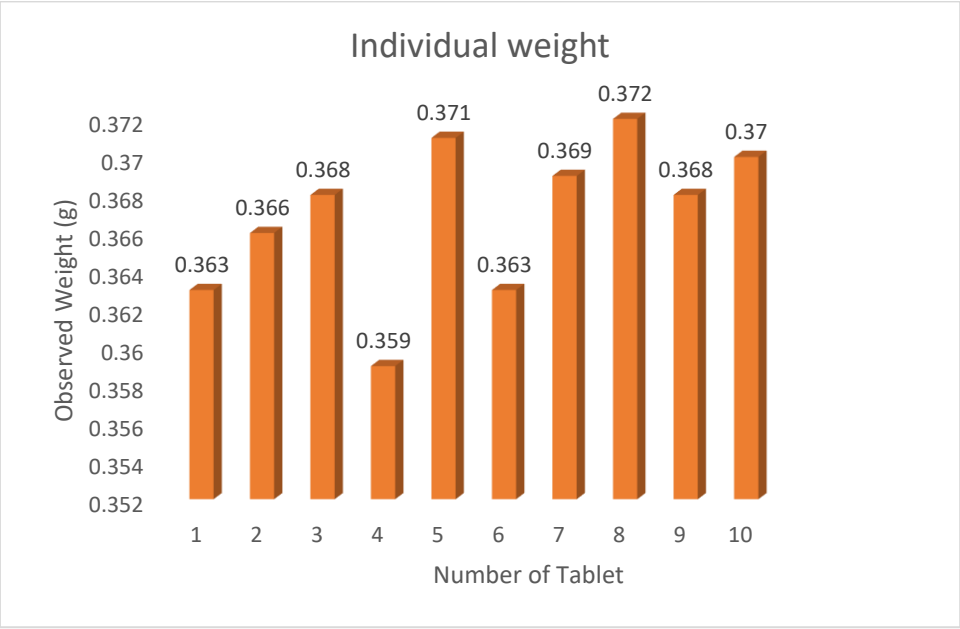

Figure 16: Weight of individual tablet (ESP-4 40mg).

The X-axis indicates the number of tablet used for test and the Y- axis indicate weight variation of individual tablet.

3.1.5 ESP-5 40 mg Tablet

Table 12: Weight variation of ESP-5 40 mg tablets

Number of tablets	Weight of individual tablets (g)	Average weight (g)	Individual weight Variation (%)	Highest weight variation (%)	Lowest Weight variation (%)
1	0.337	0.3327 g	1.29%	3.99%	-2.31%
2	0.325		-2.31%		
3	0.346		3.99%		
4	0.331		-0.51%		
5	0.339		1.87%		
6	0.326		-2.01%		
7	0.327		-1.71%		
8	0.331		-0.51%		
9	0.329		-1.11%		
10	0.336		0.99%		

Standard deviation of individual tablet weight is 0.006684

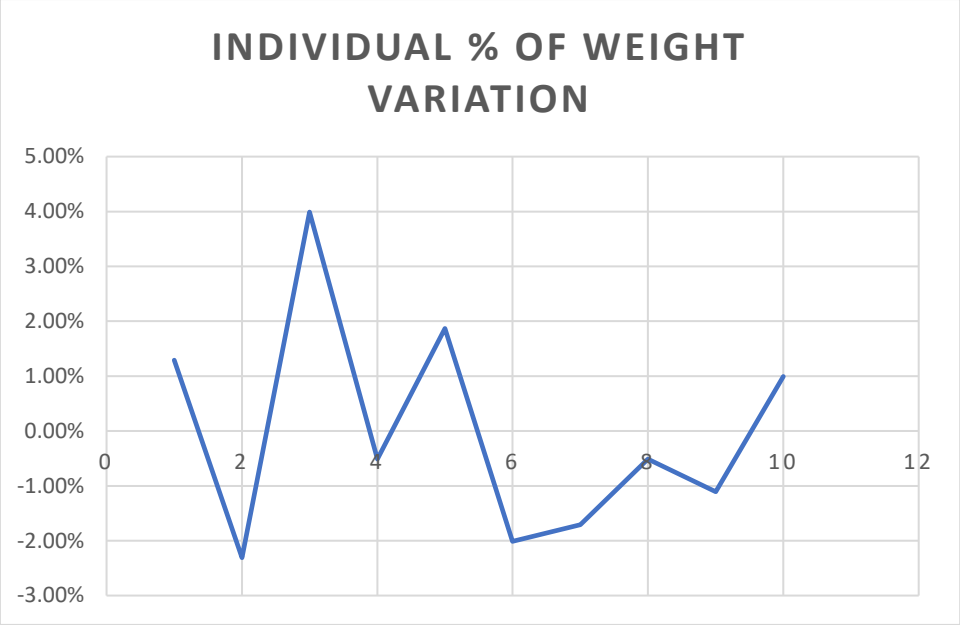

Figure 17: Individual weight variation percentage of ESP-5 40 mg tablets.

The x-axis indicates the number of the tablets used for test and the y- axis indicate the percentage of weight variation detected for each marketed tablet.

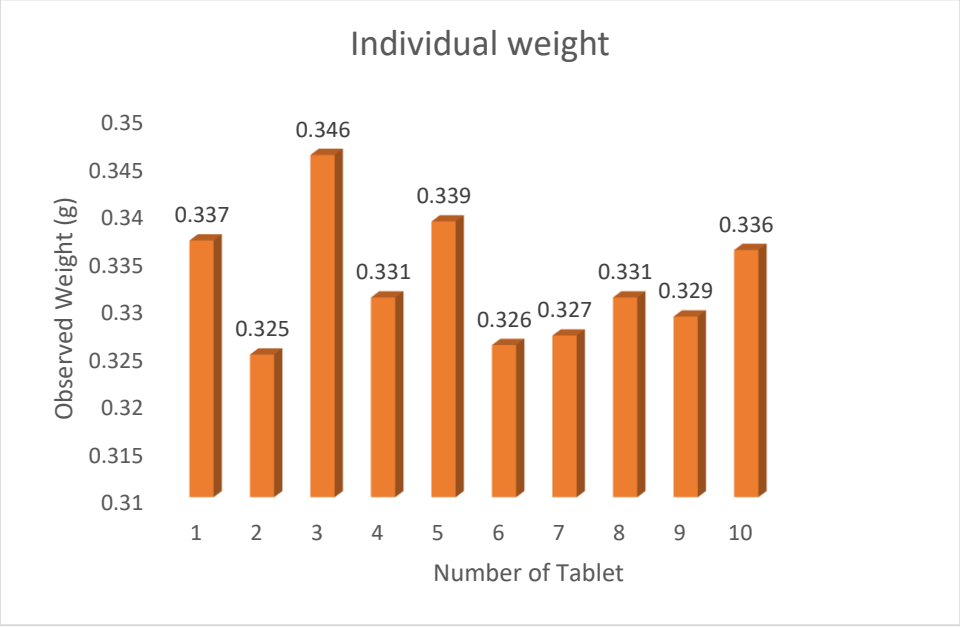

Figure 18: Weight of individual tablet (ESP-5 40mg).

The X-axis indicates the number of tablet used for test and the Y- axis indicate weight variation of individual tablet.

3.1.6 ESP-6 40 mg Tablet

Table 13: Weight variation of ESP-6 40 mg tablets

Number of tablets	Weight of individual tablets (g)	Average weight (g)	Individual weight Variation (%)	Highest weight variation (%)	Lowest Weight variation (%)
1	0.343	0.3384 g	1.36%	2.25%	4.85%
2	0.322		-4.85%		
3	0.346		2.25%		
4	0.344		1.65%		
5	0.339		0.18%		
6	0.346		2.25%		
7	0.336		-0.71%		
8	0.331		-2.19%		
9	0.340		0.47%		
10	0.337		-0.41%		

Standard deviation of individual tablet weight is 0.007471

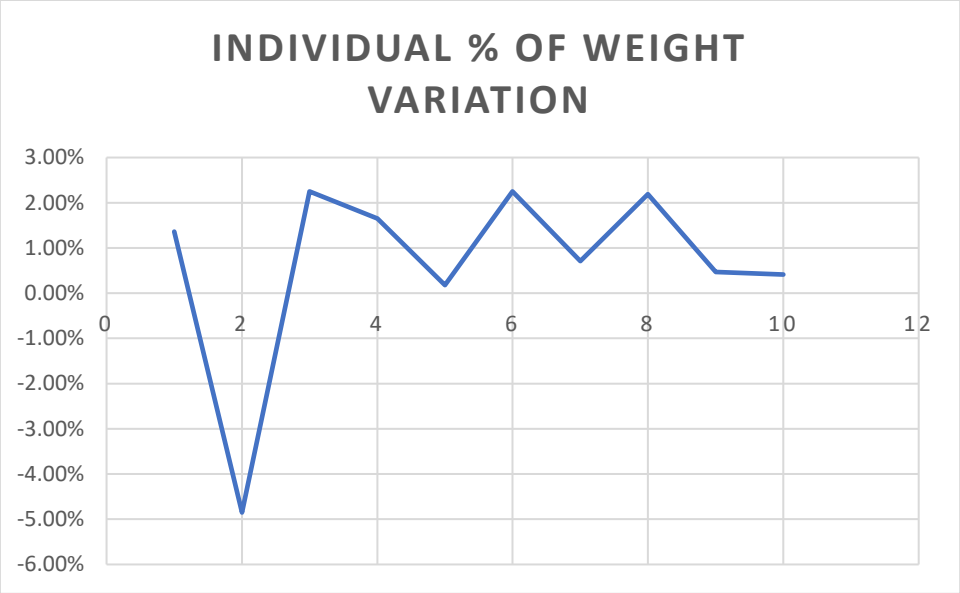

Figure 19: Individual weight variation percentage of ESP-6 40 mg tablets.

The x-axis indicates the number of the tablets used for test and the y- axis indicate the percentage of weight variation detected for each marketed tablet.

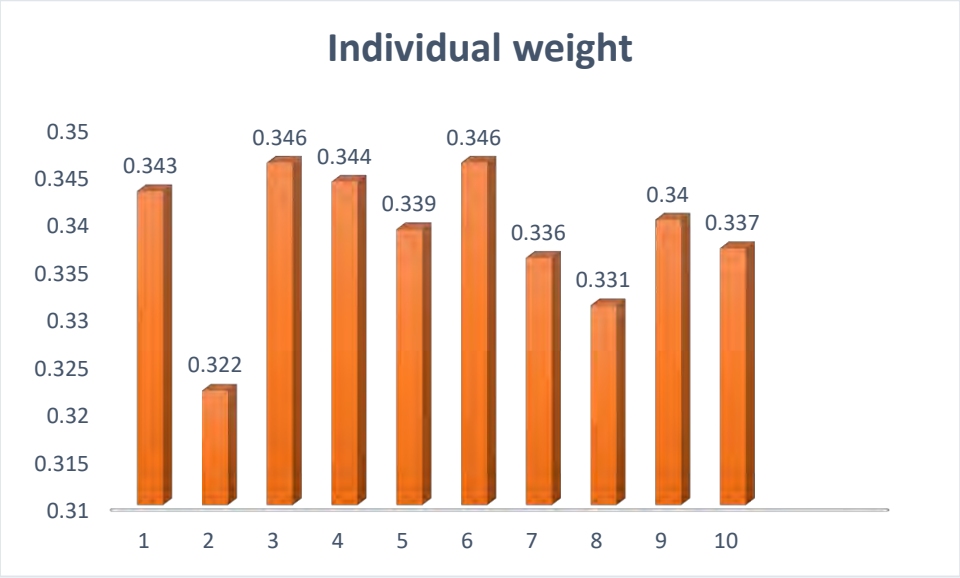

Figure 20: Weight of individual tablet (ESP-6 40mg).

The X-axis indicates the number of tablet used for test and the Y- axis indicate weight variation of individual tablet.

3.1.7 Standard deviation of weight variation

Table 14: Standard deviation of weight variation

Tablet	Standard deviation of weight variation
ESP-1	0.004111
ESP-2	0.006717
ESP-3	0.004122
ESP-4	0.00599
ESP-5	0.006684
ESP-6	0.007471

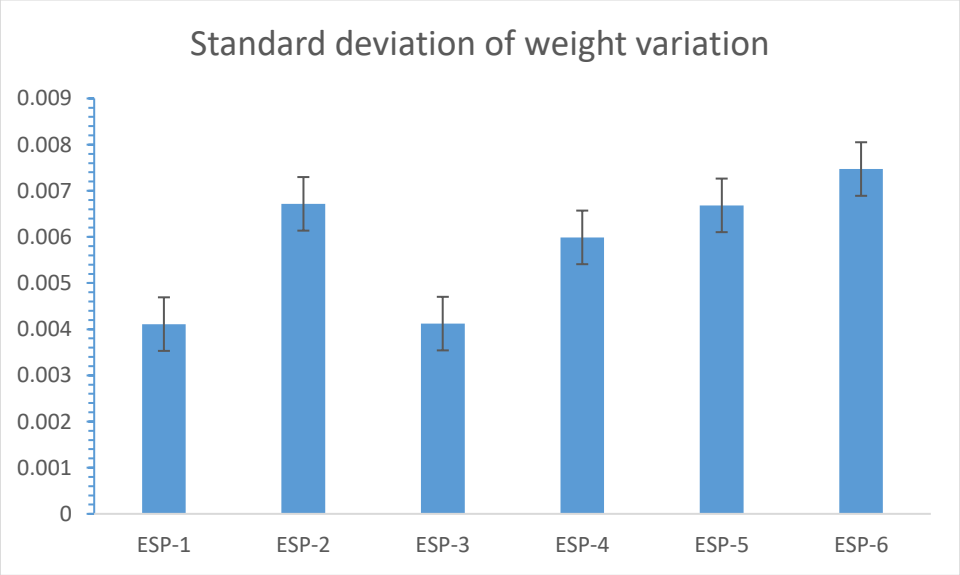

Figure 21: Standard deviation of weight variation

3.2 Hardness Test

3.2.1 ESP-1 40 mg Tablet

Table 15: Hardness test of ESP-1 40 mg.

Number of tablets	Hardness (Kg)	Average (kg)
1	9.05	12.092
2	13.03	
3	11.34	
4	11.50	
5	13.87	
6	11.11	
7	10.37	
8	14.35	
9	13.57	
10	12.72	

The standard deviation of tablet's hardness value is 1.6937

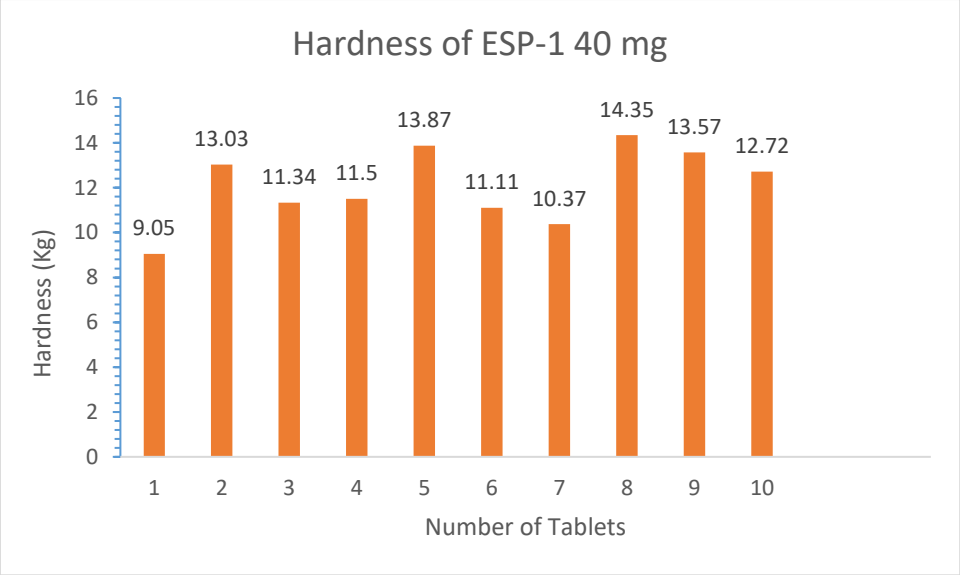

Figure 22: Hardness of ESP-1 40 mg.

X-axis represent numbers of tablet used in experiment. Y- axis shows the hardness value of the tablets.

3.2.2 ESP-2 40 mg Tablet

Table 16: Hardness test of ESP-2 40 mg

Number of tablets	Hardness (Kg)	Average (kg)
1	11.69	11.384
2	11.47	
3	10.13	
4	10.90	
5	11.63	
6	12.62	
7	12.87	
8	11.91	
9	11.44	
10	9.18	

The standard deviation of the tablet's hardness value is 1.097555

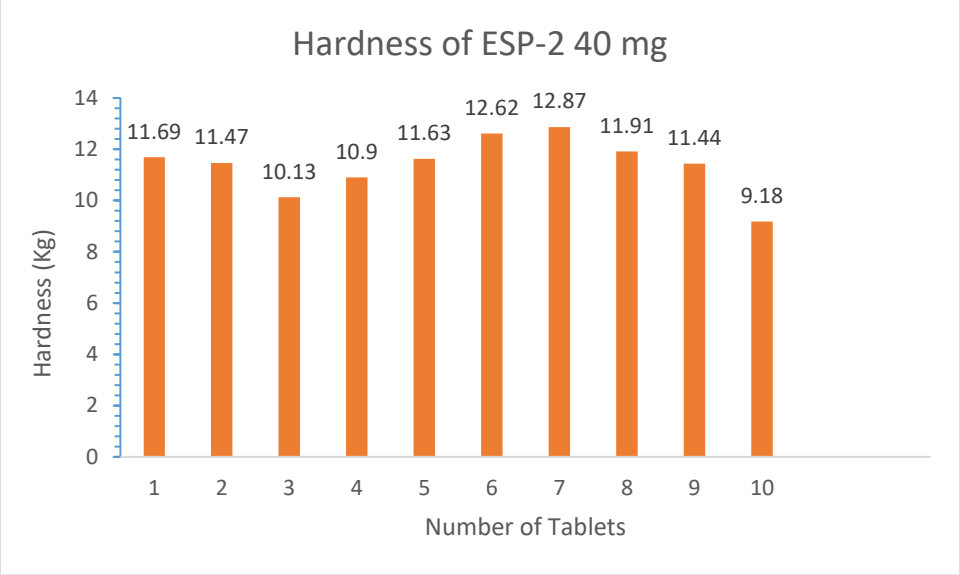

Figure 23: Hardness of ESP-2 40 mg.

X-axis represent numbers of tablet used in experiment. Y- axis shows the hardness value of the tablets.

3.2.3 ESP-3 40 mg Tablet

Table 17: Hardness test of ESP-3 40 mg

Number of tablets	Hardness (Kg)	Average (kg)
1	16.43	10.521
2	14.21	
3	19.05	
4	15.61	
5	17.74	
6	18.86	
7	15.96	
8	16.96	
9	18.18	
10	16.53	

The standard deviation of the tablet's hardness value is 1.524803

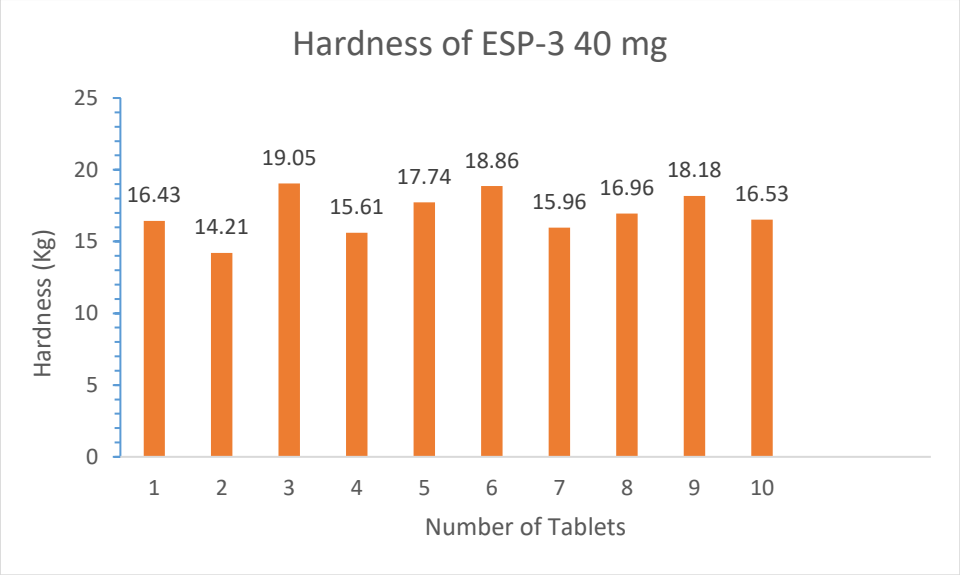

Figure 24: Hardness of ESP-3 40 mg.

X-axis represent numbers of tablet used in experiment. Y- axis shows the hardness value of the tablets.

3.2.4 ESP-4 40 mg Tablet

Table 18: Hardness test of ESP-4 40 mg

Number of tablets	Hardness (Kg)	Average (kg)
1	12.86	12.763
2	12.46	
3	15.28	
4	13.79	
5	12.02	
6	11.91	
7	12.68	
8	12.54	
9	11.66	
10	12.40	

The standard deviation of the tablet's hardness value is 1.063318

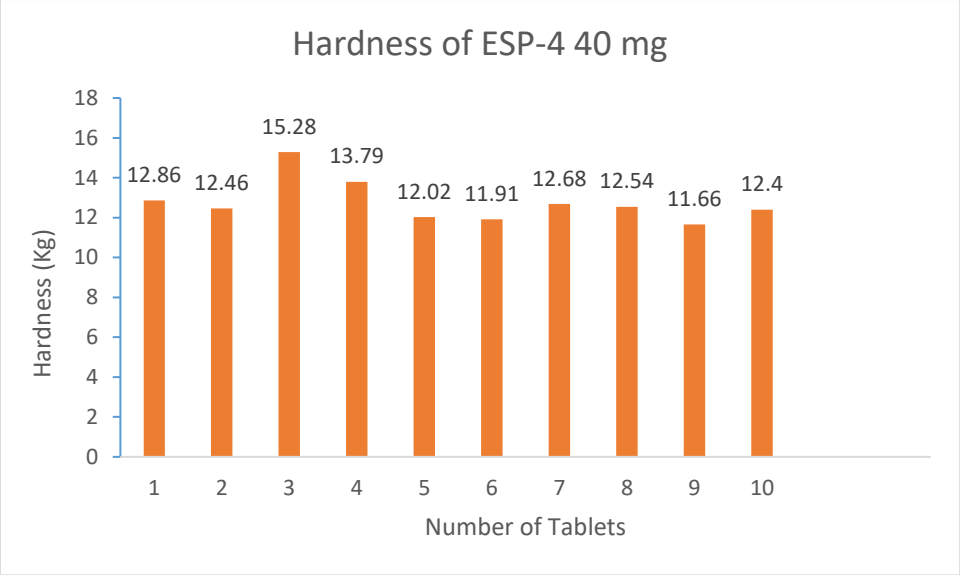

Figure 25: Hardness of ESP-4 40 mg

X-axis represent numbers of tablet used in experiment. Y- axis shows the hardness value of the tablets.

3.2.5 ESP-5 40 mg Tablet

Table 19: Hardness test of ESP-5 40 mg

Number of tablets	Hardness (Kg)	Average (kg)
1	15.11	13.837
2	13.90	
3	15.28	
4	13.79	
5	14.48	
6	11.91	
7	11.40	
8	12.54	
9	17.79	
10	12.17	

The standard deviation of the tablet's hardness value is 1.939702

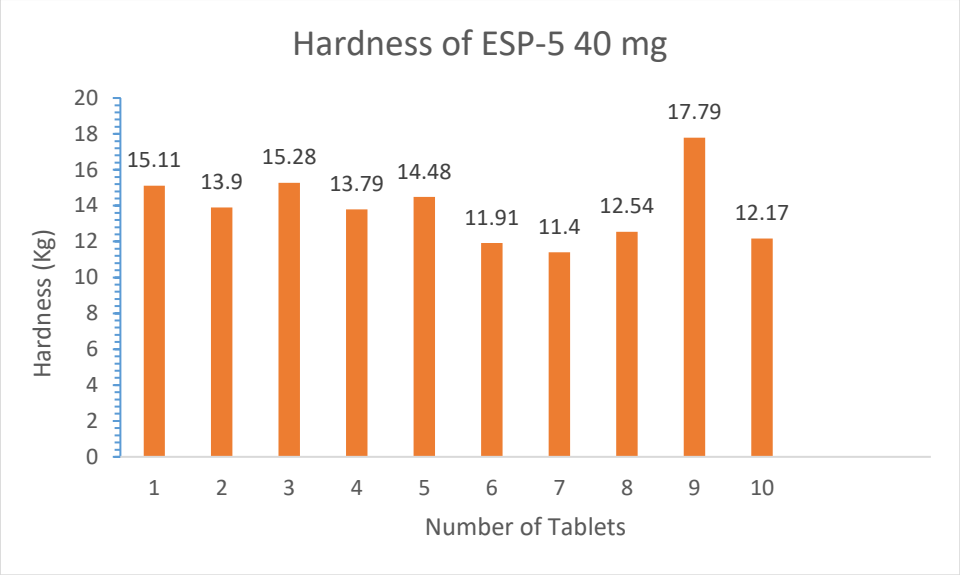

Figure 26: Hardness of ESP-5 40 mg

X-axis represent numbers of tablet used in experiment. Y- axis shows the hardness value of the tablets.

3.2.6 ESP-6 40 mg Tablet

Table 20: Hardness test of ESP-6 40 mg

Number of tablets	Hardness (Kg)	Average (kg)
1	14.11	13.071
2	13.90	
3	12.55	
4	13.79	
5	12.18	
6	11.91	
7	14.03	
8	12.54	
9	13.45	
10	12.25	

The standard deviation of the tablet's hardness value is 0.86386

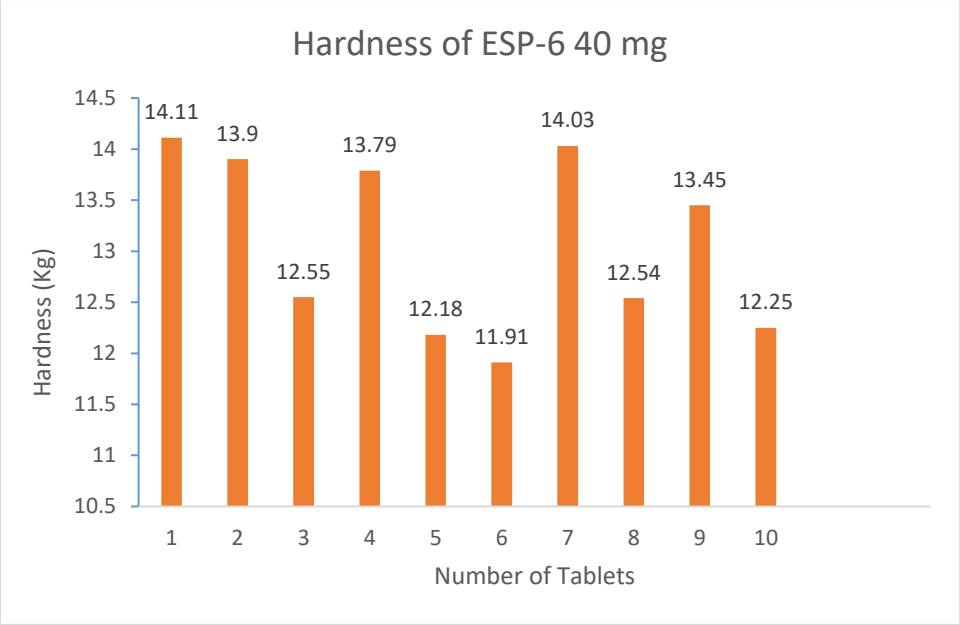

Figure 27: Hardness of ESP-6 40 mg

X-axis represent numbers of tablet used in experiment. Y- axis shows the hardness value of the tablets.

3.2.7 Average Hardness in Kg

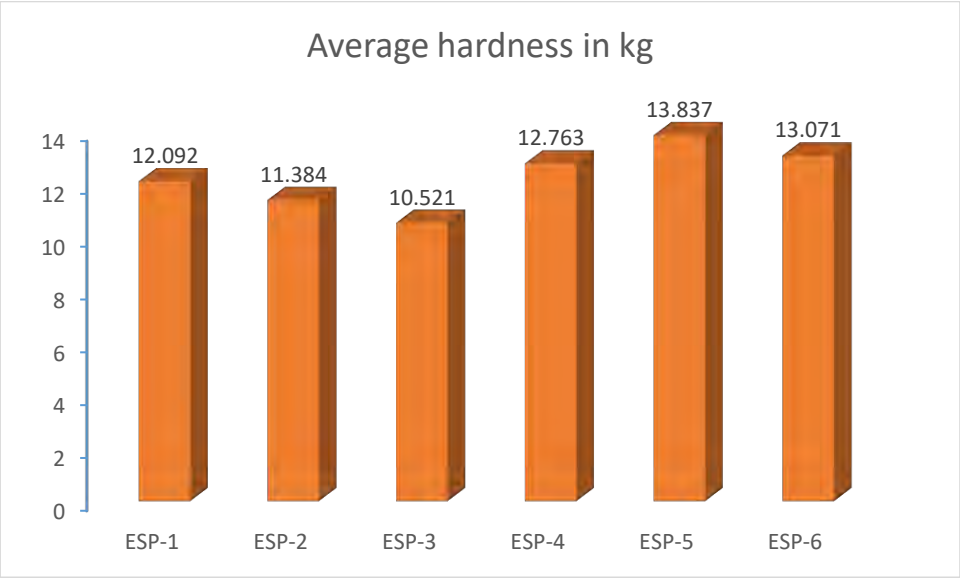

Figure 28: Average hardness of different brand tablets

3.2.8 Standard deviation of Hardness

Table 21: Standard deviation of Hardness

Tablet	Standard deviation of Hardness
ESP-1	1.6963
ESP-2	1.097555
ESP-3	1.524803
ESP-4	1.063318
ESP-5	1.939702
ESP-6	0.86386

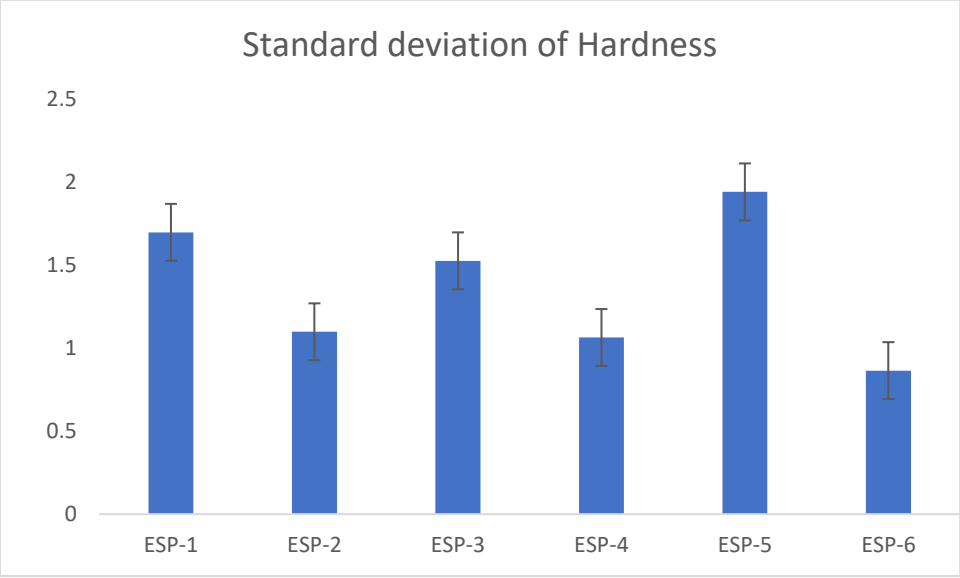

Figure 29: Standard deviation of Hardness

3.3 Friability Test

Table 22: Friability test result

Brand name	Before test	After test
ESP-1	2.654 g	2.652 g
ESP-2	2.595 g	2.595 g
ESP-3	3.653 g	3.652 g
ESP-4	2.393 g	2.393 g
ESP-5	3.330 g	3.330 g
ESP-6	2.714 g	2.714 g

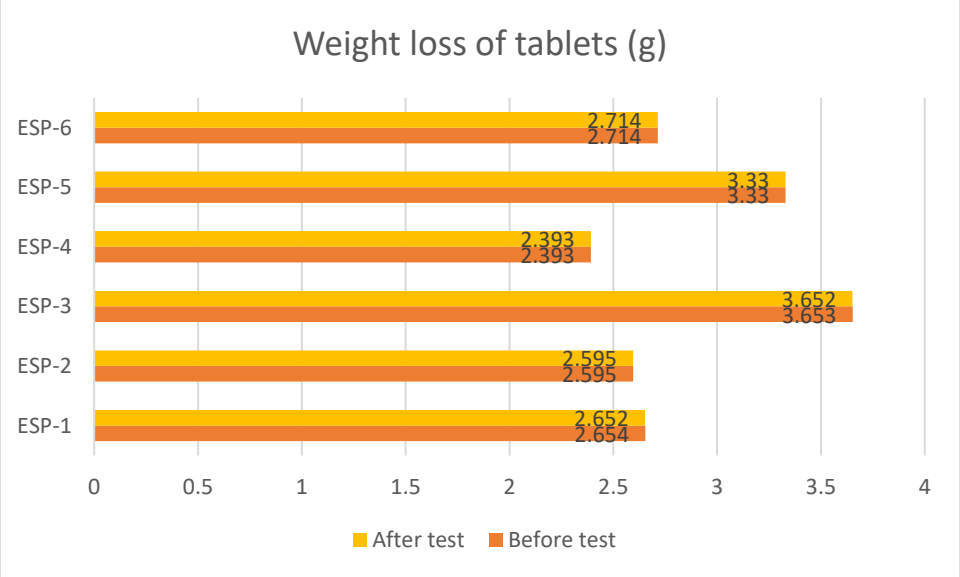

Figure 30: Weight loss tablets of different brands Esomoprazole

The graph shows weight loss of different brand of montelukast by comparing the initial weight and the final weight after test.

3.4 Disintegration Test

Table 23: Disintegration test result of different brands of Esomeprazole

Brand Name	Disintegration time (minutes)
ESP-1	19 min 24 sec.
ESP-2	25 min 40 sec
ESP-3	45 min + (Failed)
ESP-4	19 min. 25 sec.
ESP-5	45 min + (Failed)
ESP-6	24 min 5 sec

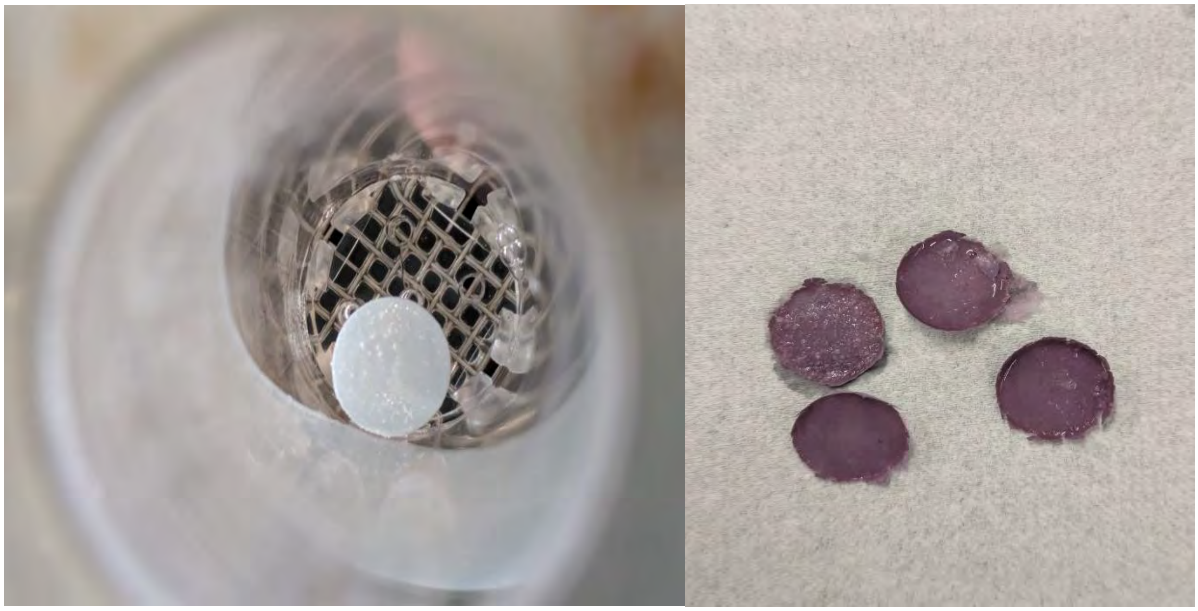

Figure 29: ESP-3 and ESP-5 disintegration test failed observation

3.5 Dissolution Test

3.5.1 ESP-1 40 mg Tablet (GSF Solution)

Table 24: ESP-1 40 mg GSF solution dissolution test absorbance data.

Time	Absorbance	% Drug Release
5	0.007	0.315%
10	0.008	0.36%
15	0.003	0.135%
20	0.009	0.405%
25	0.016	0.72%
30	0.020	0.90%

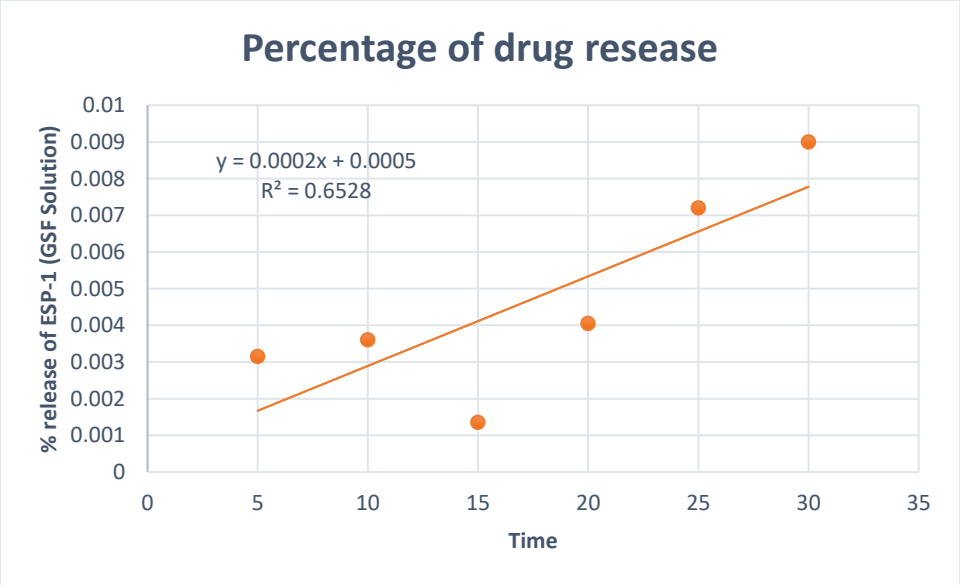

Figure 31: Drug release percentage of ESP-1 40 mg tablet in GSF solution

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.2 ESP-1 40 mg Tablet (ISF Solution)

Table 25: ESP-1 40 mg ISF solution (30 min) dissolution test absorbance data.

Time	Absorbance	% Drug Release
5	0.008	0.36%
10	0.008	0.36%
15	0.003	0.135%
20	0.004	0.18%
25	0.005	0.225%
30	0.007	0.315%

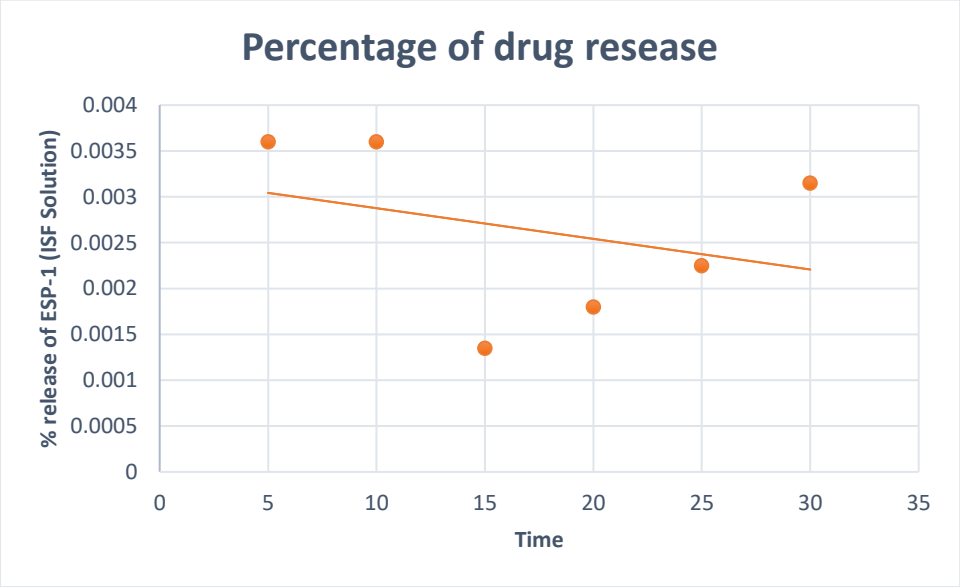

Figure 32: Drug release percentage of ESP-1 40 mg tablet in ISF solution (30 min)

Table 26: ESP-1 40 mg ISF solution (after 60 min) dissolution test absorbance data.

Time	Absorbance	% Drug Release
5	0.018	0.81%
10	0.022	0.99%
15	0.024	1.08%
20	0.013	0.585%
25	0.013	0.585%
30	0.017	0.765%

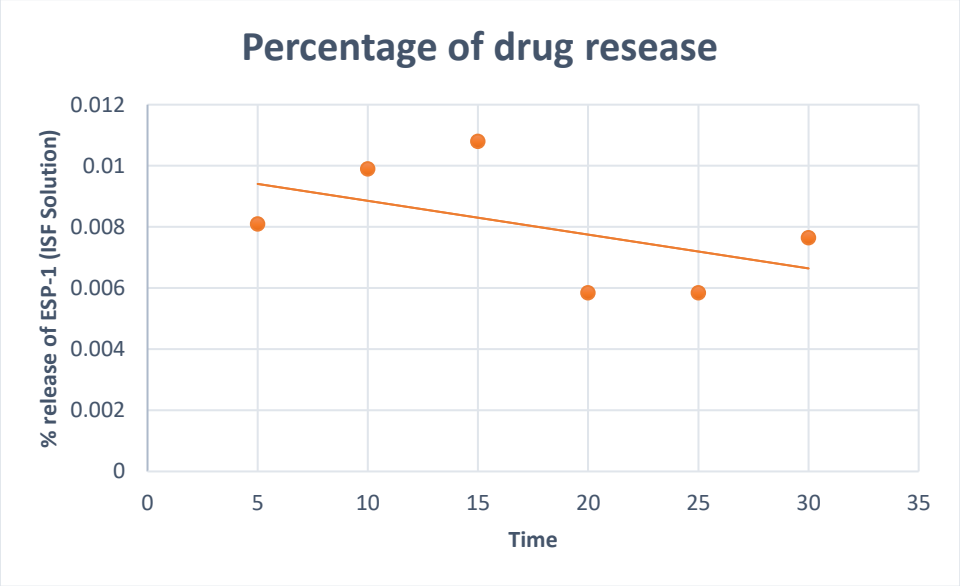

Figure 33: Drug release percentage of ESP-1 40 mg tablet in ISF solution (after 60 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.3 ESP-2 40 mg Tablet (GSF Solution)

Table 27: ESP-2 40 mg GSF solution dissolution test absorbance data.

Time	Absorbance	% Drug Release
5	0.006	0.27%
10	0.009	0.405%
15	0.010	0.45%
20	0.004	0.18%
25	0.006	0.27%
30	0.008	0.36%

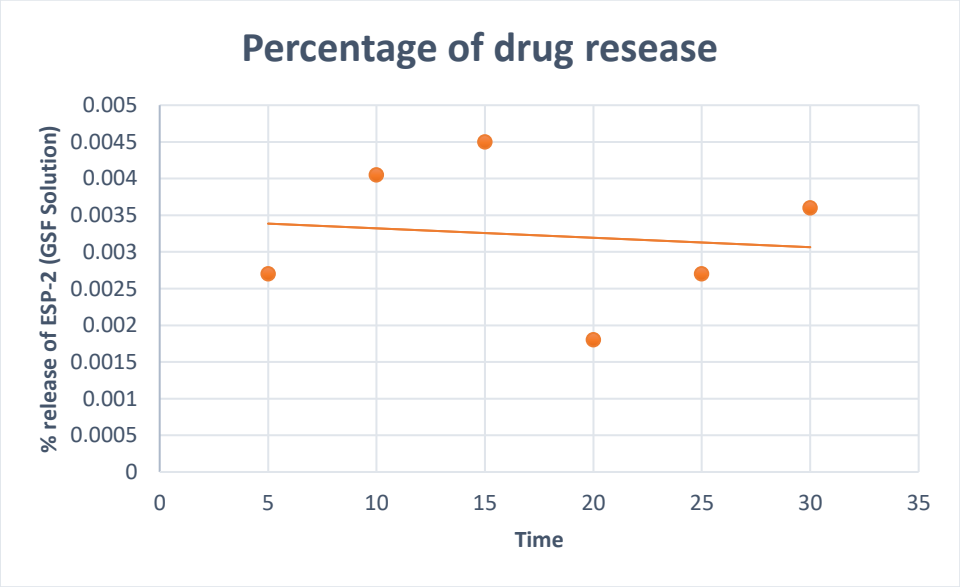

Figure 34: Drug release percentage of ESP-2 40 mg tablet in GSF solution

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.4 ESP-2 40 mg Tablet (ISF Solution)

Table 28: ESP-2 40 mg ISF solution (30 min) dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.006	0.27%
10	0.009	0.405%
15	0.020	0.90%
20	0.022	0.99%
25	0.012	0.54%
30	0.018	0.81%

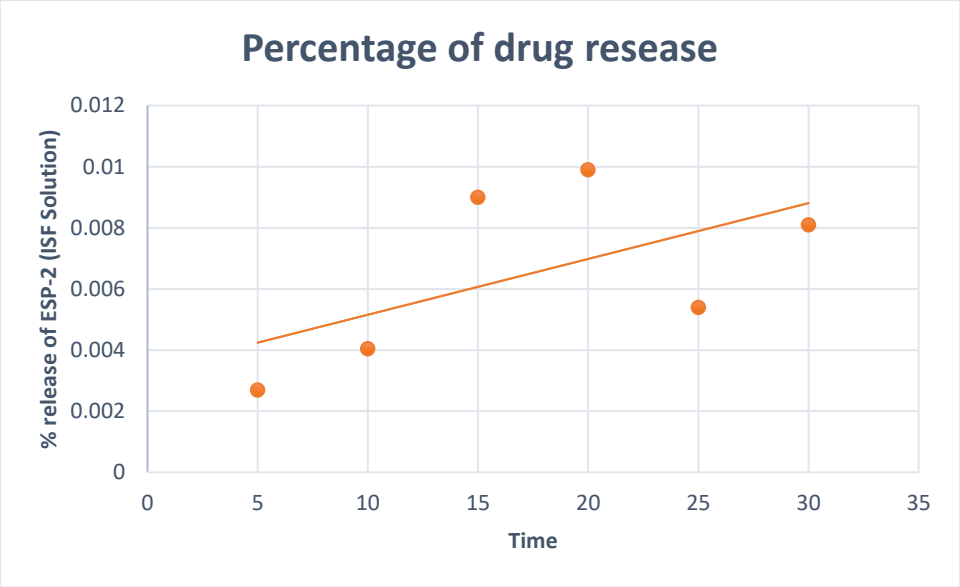

Figure 35: Drug release percentage of ESP-2 40 mg tablet in ISF solution (30 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

Table 29: ESP-2 40 mg ISF solution (after 60 min) dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.024	1.08%
10	0.033	1.485%
15	0.035	1.575%
20	0.020	0.90%
25	0.034	1.53%
30	0.036	1.62%

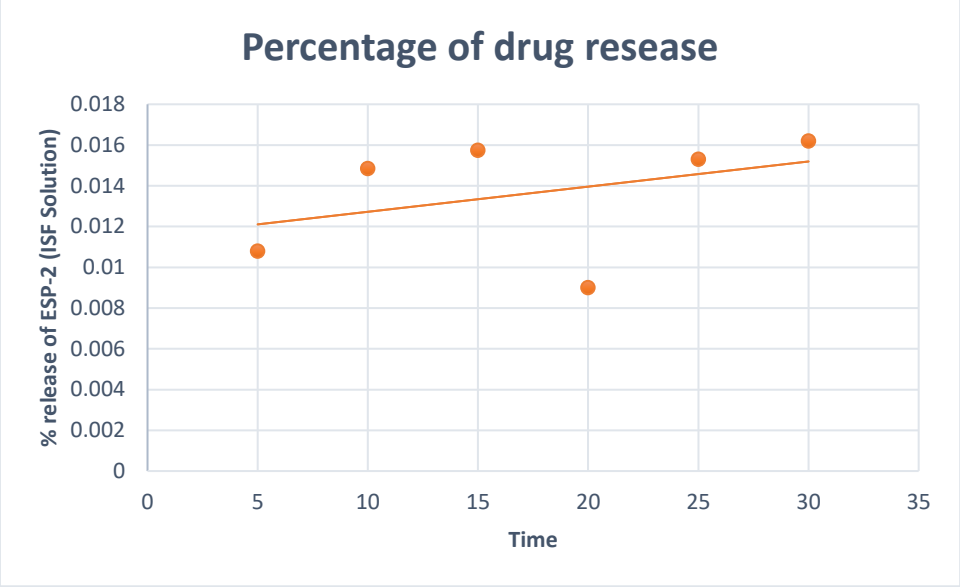

Figure 36: Drug release percentage of ESP-2 40 mg tablet in ISF solution (after 60 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.5 ESP-3 50 mg (GSF Solution)

Table 30: ESP-3 40 mg GSF solution dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.001	0.045%
10	0.002	0.09%
15	0.005	0.225%
20	0.007	0.315%
25	0.002	0.09%
30	0.005	0.225%

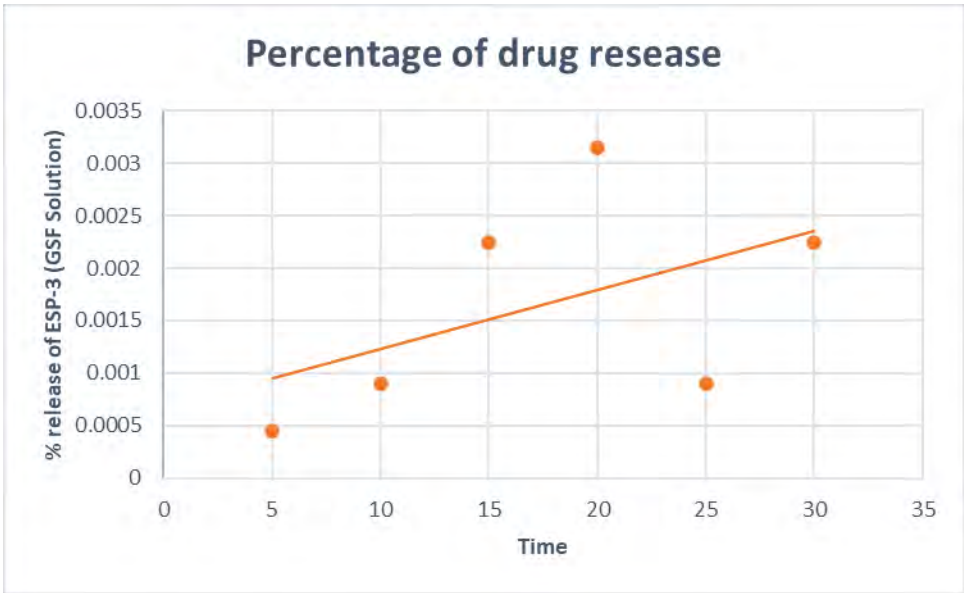

Figure 37: Drug release percentage of ESP-3 40 mg tablet in GSF solution

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.6 ESP-3 50 mg (ISF Solution)

Table 31: ESP-3 40 mg ISF solution (30 min) dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.003	0.135%
10	0.004	0.18%
15	0.002	0.09%
20	0.007	0.315%
25	0.008	0.36%
30	0.010	0.45%

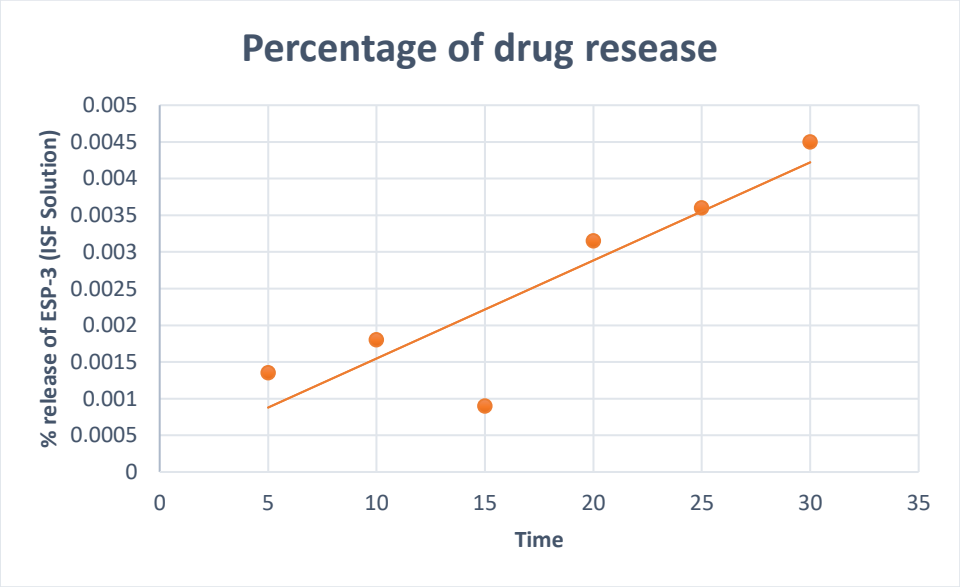

Figure 38: Drug release percentage of ESP-3 40 mg tablet in ISF solution (30 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

Table 32: ESP-3 40 mg ISF solution (60 min) dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.011	0.495%
10	0.020	0.90%
15	0.024	1.08%
20	0.015	0.675%
25	0.018	0.81%
30	0.022	0.99%

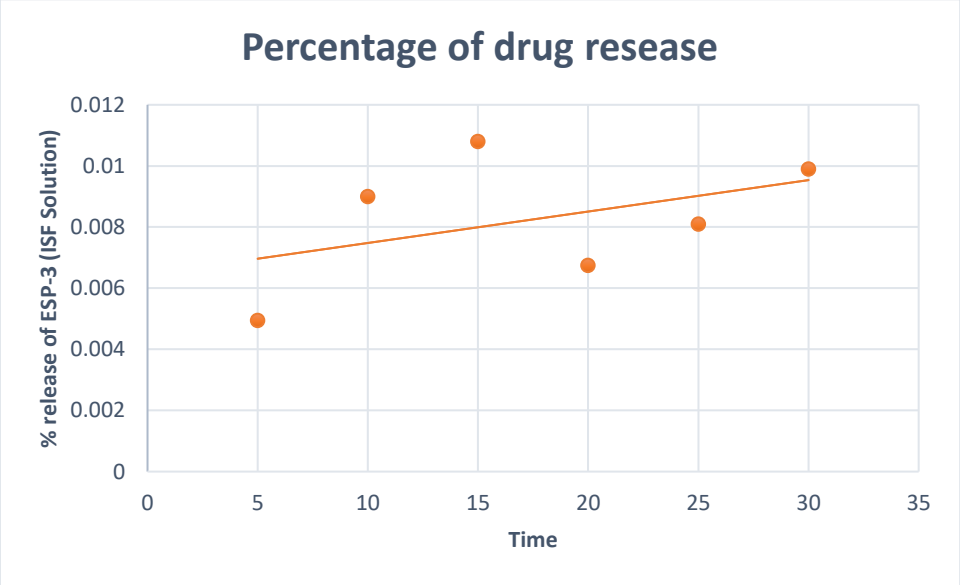

Figure 39: Drug release percentage of ESP-3 40 mg tablet in ISF solution (after 60 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.7 ESP-4 40 mg Tablet (GSF Solution)

Table 33: ESP-4 40 mg GSF solution dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.001	0.045%
10	0.002	0.09%
15	0.005	0.225%
20	0.004	0.18%
25	0.006	0.27%
30	0.004	0.18%

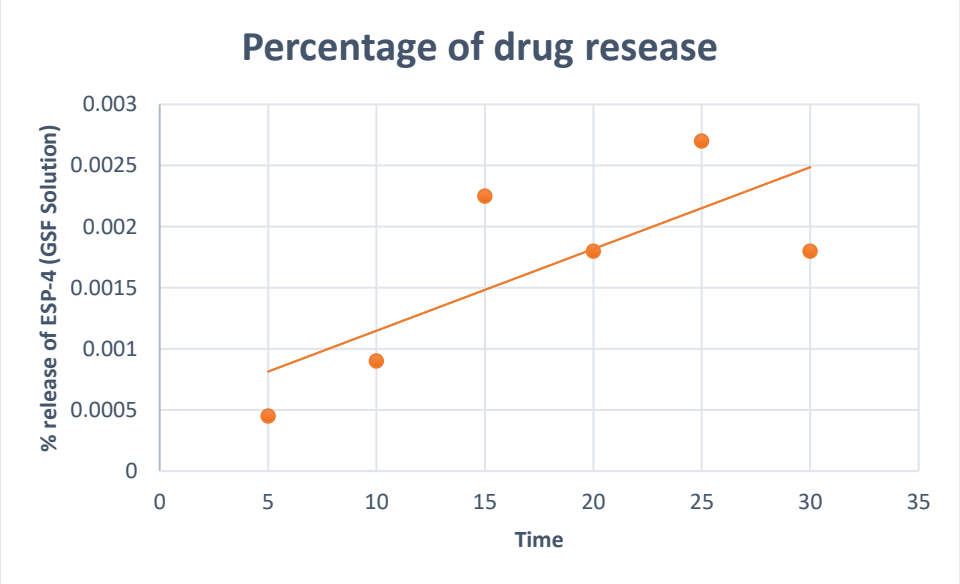

Figure 40: Drug release percentage of ESP-4 40 mg tablet in GSF solution

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.8 ESP-4 40 mg Tablet (ISF Solution)

Table 34: ESP-4 40 mg ISF solution dissolution test absorbance data (30 min)

Time	Absorbance	% Drug Release
5	0.010	0.45%
10	0.005	0.225%
15	0.010	0.45%
20	0.006	0.27%
25	0.008	0.36%
30	0.012	0.54%

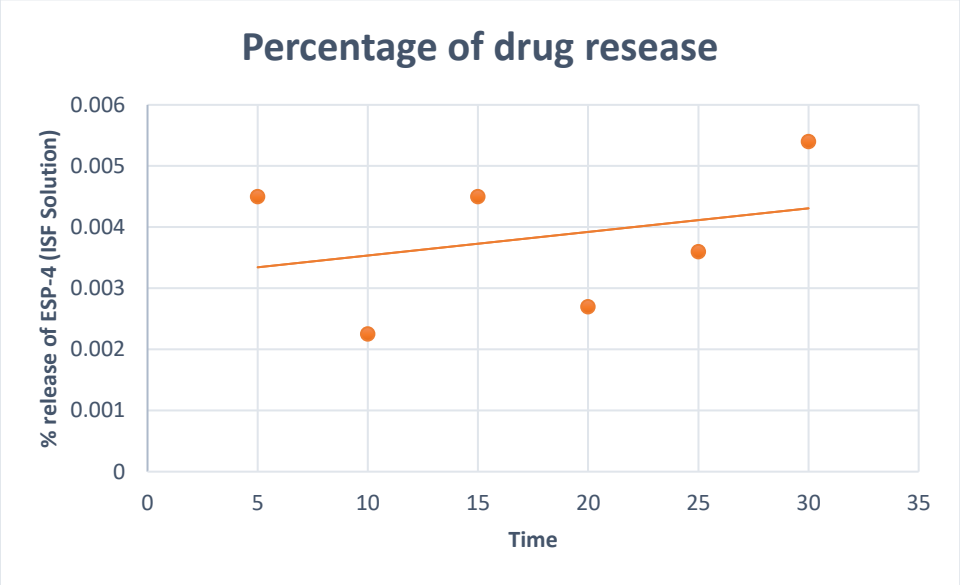

Figure 41: Drug release percentage Of ESP-4 40 mg tablet in ISF solution (30 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

Table 35: ESP-4 40 mg ISF solution dissolution test absorbance data (60 min)

Time	Absorbance	% Drug Release
5	0.022	0.99%
10	0.022	0.99%
15	0.018	0.81%
20	0.020	0.90%
25	0.016	0.72%
30	0.024	1.08%

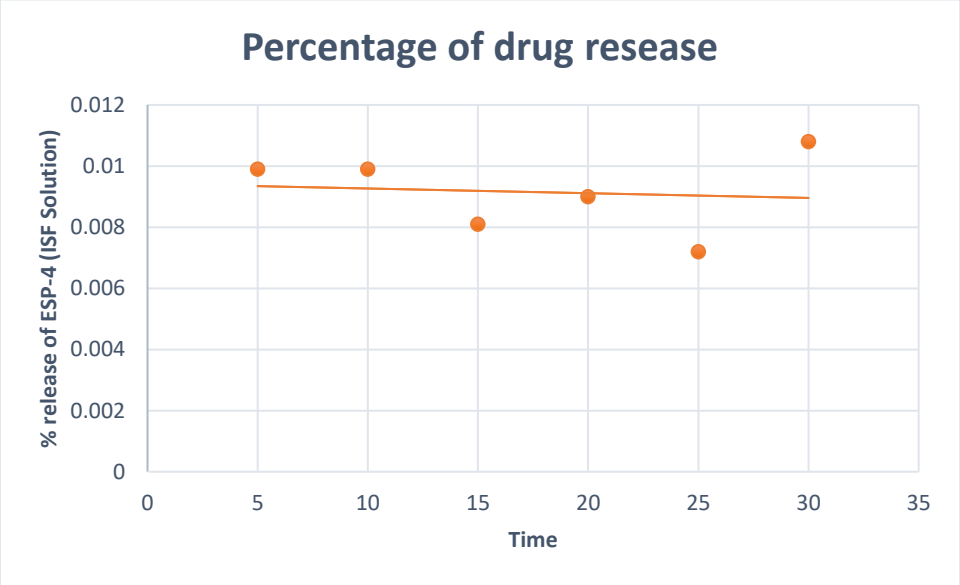

Figure 42: Drug release percentage of ESP-4 40 mg tablet in ISF solution (60 min)

3.5.9 ESP-5 40 mg (GSF Solution)

Table 36: ESP-5 40 mg GSF solution dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.001	0.045%
10	0.002	0.09%
15	0.004	0.18%
20	0.006	0.27%
25	0.001	0.045%
30	0.003	0.135%

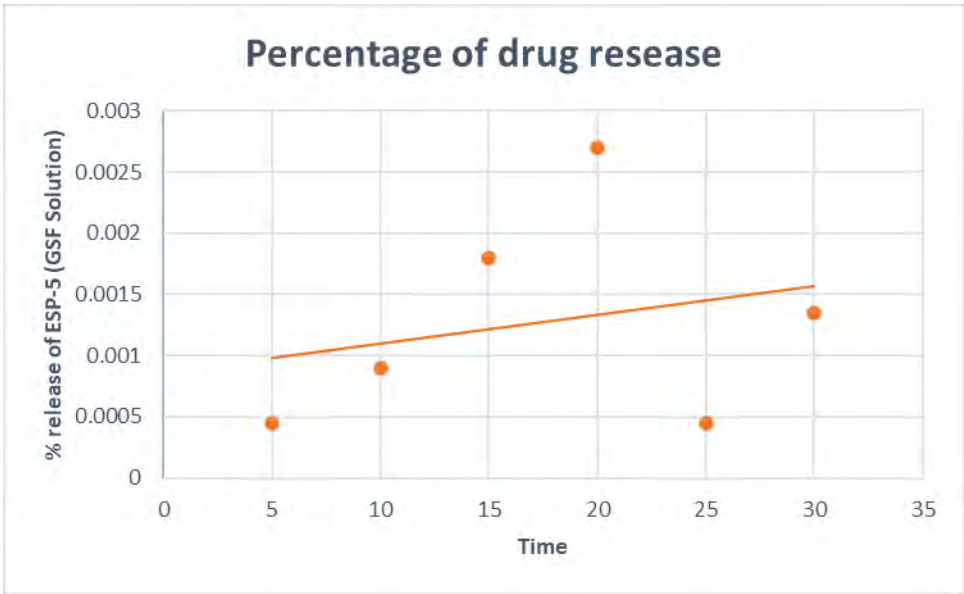

Figure 43: Drug release percentage of ESP-5 40 mg tablet in GSF solution

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.10 ESP-5 40 mg (ISF Solution)

Table 37: ESP-5 40 mg ISF solution dissolution test absorbance data (30 min)

Time	Absorbance	% Drug Release
5	0.010	0.45%
10	0.008	0.36%
15	0.013	0.585%
20	0.010	0.45%
25	0.006	0.27%
30	0.009	0.405%

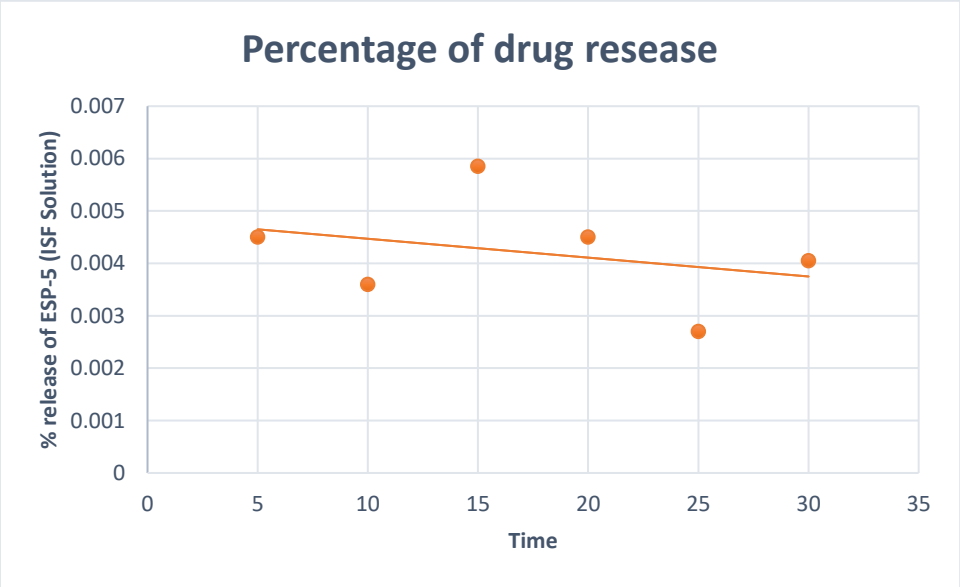

Figure 44: Drug release percentage of ESP-5 40 mg tablet in ISF solution (30 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

Table 38: ESP-5 40 mg ISF solution dissolution test absorbance data (60 min)

Time	Absorbance	% Drug Release
5	0.037	1.665%
10	0.034	1.53%
15	0.032	1.44%
20	0.033	1.485%
25	0.025	1.125%
30	0.032	1.44%

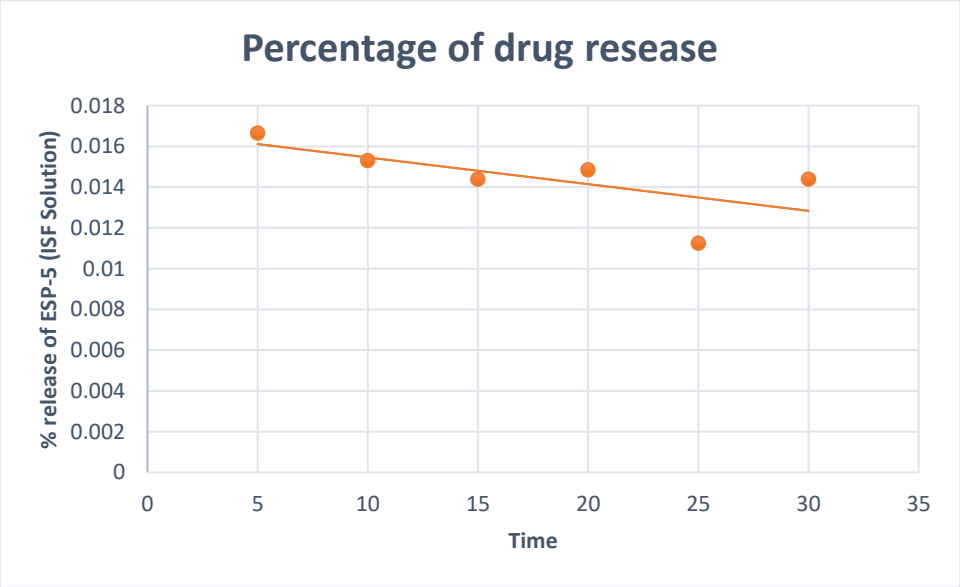

Figure 45: Drug release percentage of ESP-5 40 mg tablet in ISF solution (60 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.11 ESP-6 40 mg (GSF Solution)

Table 39: ESP-6 40 mg GSF solution dissolution test absorbance data

Time	Absorbance	% Drug Release
5	0.001	0.045%
10	0.002	0.09%
15	0.003	0.135%
20	0.004	0.18%
25	0.001	0.045%
30	0.003	0.135%

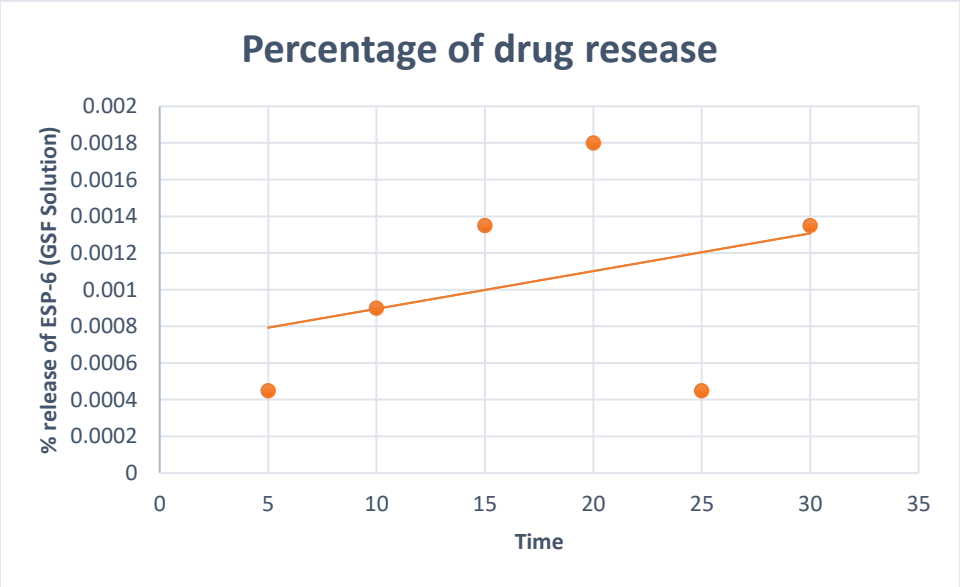

Figure 46: Drug release percentage of ESP-6 40 mg tablet in GSF solution

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.12 ESP-6 40 mg (ISF Solution)

Table 40: ESP-6 40 mg ISF solution dissolution test absorbance data (30 min)

Time	Absorbance	% Drug Release
5	0.017	0.765%
10	0.018	0.81%
15	0.020	0.90%
20	0.024	1.08%
25	0.018	0.81%
30	0.022	0.99%

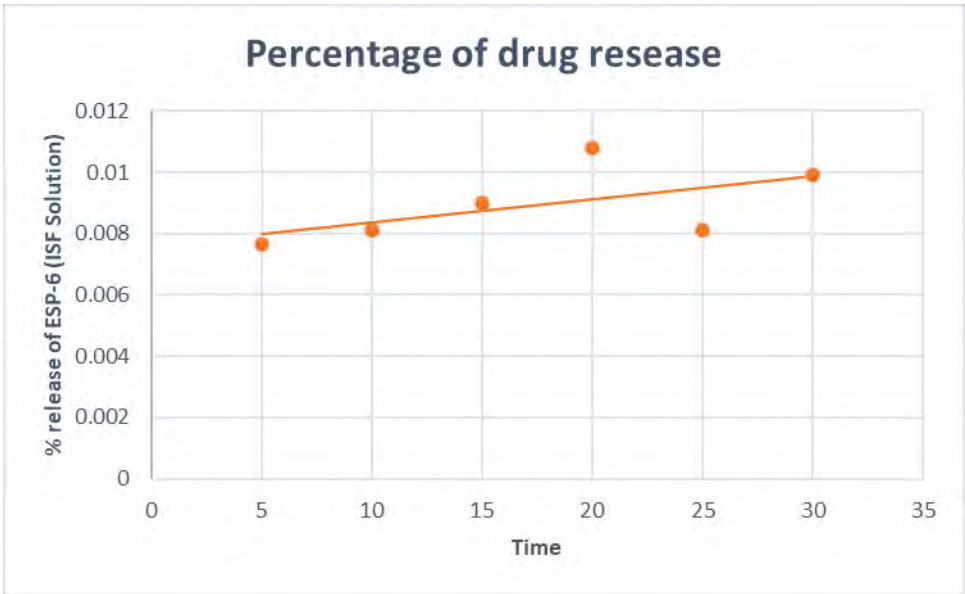

Figure 47: Drug release percentage of ESP-6 40 mg tablet in ISF solution (30 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

Table 41: ESP-6l 40 mg ISF solution dissolution test absorbance data (60 min)

Time	Absorbance	% Drug Release
5	0.035	1.575%
10	0.033	1.485%
15	0.032	1.44%
20	0.037	1.665%
25	0.036	1.62%
30	0.034	1.53%

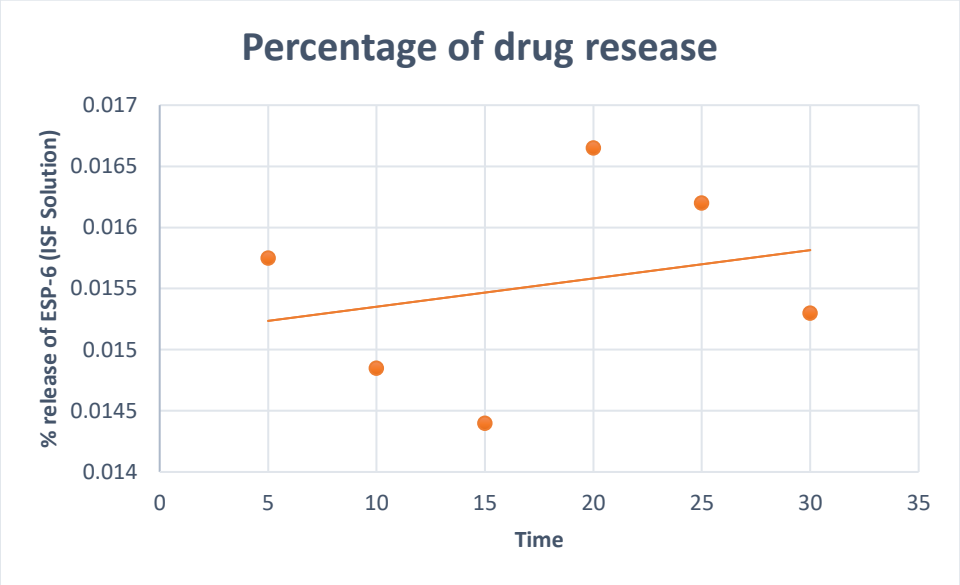

Figure 48: Drug release percentage of ESP-6 40 mg tablet in ISF solution (60 min)

X- axis shows the time interval and the Y- axis shows the absorbance.

3.5.13 Different Brands % of Drug Release GSF Solution

Table 42: Different Brands % of Drug Release GSF Solution

	% of drug release					
Time	ESP-1	ESP-2	ESP-3	ESP-4	ESP-5	ESP-6
5	0.315%	0.27%	0.045%	0.045%	0.045%	0.045%
10	0.36%	0.405%	0.09%	0.09%	0.09%	0.09%
15	0.135%	0.45%	0.225%	0.225%	0.18%	0.135%
20	0.405%	0.18%	0.315%	0.18%	0.27%	0.18%
25	0.72%	0.27%	0.09%	0.27%	0.045%	0.045%
30	0.90%	0.36%	0.225%	0.18%	0.135%	0.135%

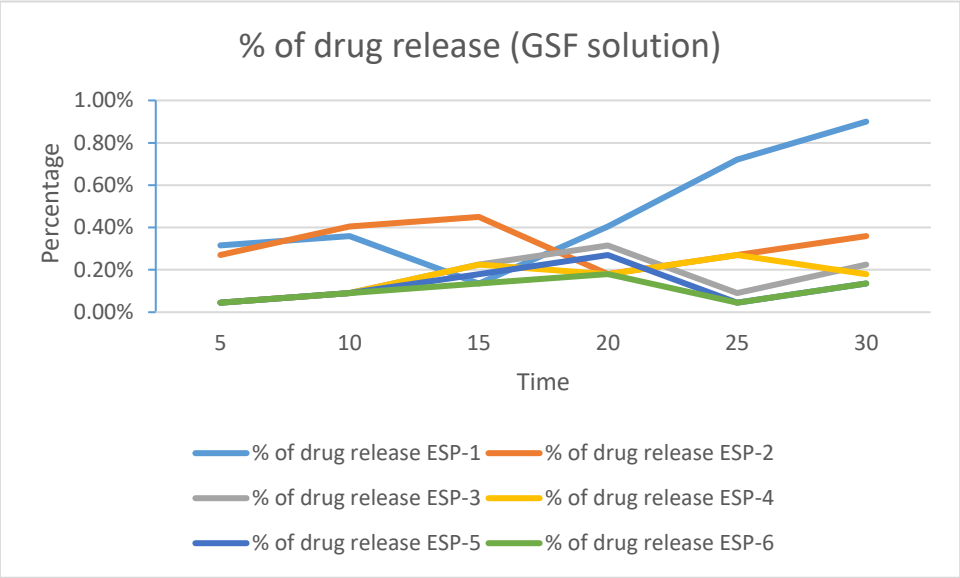

Figure 49: Different Brands % of Drug Release GSF Solution

3.5.14 Different Brands % of Drug Release ISF Solution (30 min)

Table 43: Different Brands % of Drug Release ISF Solution (30 min)

	% of drug release					
Time	ESP-1	ESP-2	ESP-3	ESP-4	ESP-5	ESP-6
5	0.36%	0.27%	0.135%	0.45%	0.45%	0.765%
10	0.36%	0.405%	0.18%	0.225%	0.36%	0.81%
15	0.135%	0.90%	0.09%	0.45%	0.585%	0.90%
20	0.18%	0.99%	0.315%	0.27%	0.45%	1.08%
25	0.225%	0.54%	0.36%	0.36%	0.27%	0.81%
30	0.315%	0.81%	0.45%	0.54%	0.405%	0.99%

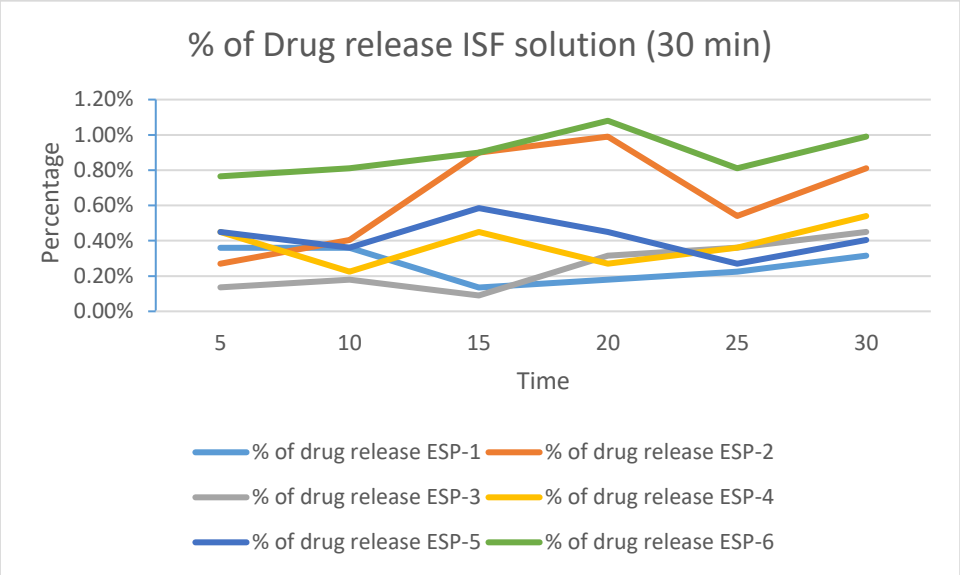

Figure 50: Different Brands % of Drug Release ISF Solution (30 min)

3.5.15 Different Brands % of Drug Release ISF Solution (60 min)

Table 44: Different Brands % of Drug Release ISF Solution (60 min)

	% of drug release					
Time	ESP-1	ESP-2	ESP-3	ESP-4	ESP-5	ESP-6
5	0.81%	1.08%	0.495%	0.99%	1.665%	1.575%
10	0.99%	1.485%	0.90%	0.99%	1.53%	1.485%
15	1.08%	1.575%	1.08%	0.81%	1.44%	1.44%
20	0.585%	0.90%	0.675%	0.90%	1.485%	1.665%
25	0.585%	1.53%	0.81%	0.72%	1.125%	1.62%
30	0.765%	1.62%	0.99%	1.08%	1.44%	1.53%

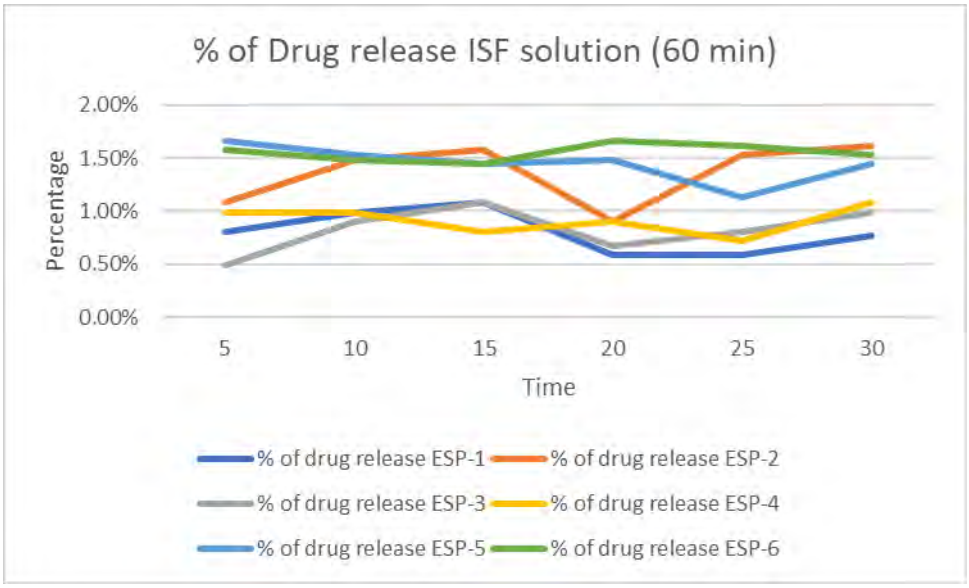

Figure 51: Different Brands % of Drug Release ISF Solution (60 min)

Chapter 4

Discussion

4.1 Weight Variation Test

The weight variation test is a critical quality control parameter that ensures dose uniformity and therapeutic consistency across all tablet units. According to USP guidelines, tablets weighing more than 324 mg should not deviate more than ±5% from the average weight. And tablets weighing between 130-324 mg are allowed a deviation of ±7.5% (Navya Sri & Reddy, 2023). In this study, all six brands of Esomeprazole 40 mg tablets were evaluated for weight uniformity. The results demonstrated that all brands complied with USP specifications. ESP-1 40 mg showed weight variations ranging from -2.37% to +2.89% with a standard deviation of 0.004111 g (Table 8). This indicates excellent manufacturing consistency. Similarly, ESP-2 40 mg exhibited variations between -4.85% to +4.48% (SD: 0.006717 g) (Table 9). This also remained within acceptable limits. ESP-3 40 mg demonstrated the most consistent performance with variations from -2.15% to +1.41% and the lowest standard deviation of 0.004122 g (Table 10). This suggests superior process control during manufacturing. ESP-4 40 mg showed variations from -4.21% to +3.71% (SD: 0.00599 g), and ESP-5 40 mg ranged from -2.31% to +3.99% (SD: 0.006684 g), and ESP-6 40 mg displayed -4.85% to +2.25% variation (SD: 0.007471 g). Despite these variations, all brands maintained weight uniformity within pharmacopeial limits according to USP guidelines. This ensures that each tablet contains the intended dose of active pharmaceutical ingredient, which is essential for therapeutic efficacy and patient safety.

4.2 Hardness Test

Tablet hardness is a fundamental quality to determine the mechanical strength and handling characteristics of solid dosage forms. The USP recommends that uncoated tablets should typically exhibit hardness values between 4-8 kg (40-80 N), while film-coated tablets generally require 6-10 kg (60-100 N) to withstand manufacturing, packaging, and transportation stresses without compromising disintegration and dissolution properties (Navya Sri & Reddy, 2023). In this study, the hardness values of all six Esomeprazole brands significantly exceeded these conventional ranges. This indicates characteristics of enteric-coated formulations designed to resist gastric acid and release the drug in the intestinal environment. ESP-3 40 mg demonstrated the highest average hardness of 17.553 kg (SD: 1.524803), followed by ESP-5 40 mg at 13.837 kg (SD: 1.939702),ESP-4 40 mg at 12.763 kg (SD: 1.063318), ESP-6 40 mg at 13.071 kg (SD: 0.86386), ESP-1 40 mg at 12.092 kg (SD: 1.6937), and ESP-2 40 mg at 11.384 kg (SD: 1.097555). The elevated hardness values observed across all brands are intentionally maintained to protect the acid-labile esomeprazole molecule from degradation in the acidic gastric environment. However, excessively high hardness in ESP-3 40 mg, may potentially impact the disintegration time and subsequent drug release profile.

4.3 Friability Test

The friability test evaluates the mechanical resistance of tablets to abrasion and physical stress encountered during manufacturing, packaging, transportation, and handling. According to USP guidelines, a maximum weight loss of 1.0% is considered acceptable for most tablet formulations. This guideline ensures adequate mechanical strength without compromising patient safety or therapeutic efficacy (Navya Sri & Reddy, 2023). In this study, all six brands of Esomeprazole 40 mg tablets demonstrated good friability performance. ESP-2 40 mg, ESP-5 40 mg, ESP-4 40 mg, and ESP-6 40 mg showed 0.00% weight loss. ESP-3 40 mg exhibited a negligible loss of 0.027% (from 3.653 g to 3.652 g). This result demonstrates superior tablet

robustness across all tested brands. The excellent friability performance can be directly attributed to the high hardness values observed in these formulations. The enteric coating applied to these tablets also contributes significantly to their mechanical integrity by providing an additional protective layer that prevents surface erosion and fragmentation.

4.4 Disintegration

In this study, the disintegration behavior of six Esomeprazole 40 mg brands revealed significant variations in performance. ESP-1 40 mg and ESP-4 40 mg demonstrated the fastest disintegration times of 19 minutes 24 seconds and 19 minutes 25 seconds respectively. This indicates an efficient coating design. ESP-6 40 mg (24 minutes 5 seconds) and ESP-2 40 mg (25 minutes 40 seconds) showed moderately longer disintegration times but remained well within acceptable ranges. However, ESP-3 40 mg and ESP-5 40 mg both failed to disintegrate completely within the 45-minute observation period. This indicates potential formulation issues related to excessive coating thickness, inappropriate coating polymer selection, or overly compressed tablet cores. From this work, the correlation between tablet hardness and disintegration time was evident. Here, ESP-3 40 mg exhibits the highest hardness (17.553 kg), also demonstrates the longest disintegration time. This may suggests that while high mechanical strength is desirable for handling and stability, excessive hardness may compromise the tablet's ability to break down efficiently in the gastrointestinal tract. Also temperature and buffer making process can alter the standard result of disintegration.

4.5 Dissolution

The dissolution apparatus available for this lab work was a 4-chamber model. This is insufficient capacity to accommodate the six tablets required by USP specifications for simultaneous testing. To address this limitation, dissolution testing was performed in two sequential stages with three tablets tested in each run. This procedural modification from

standard protocol may have introduced several sources of variability. Also temperature and buffer making process can alter the standard result of disintegration.

Chapter 5

Conclusion

In conclusion, all tested brands of Esomeprazole 40 mg tablets demonstrated acceptable performance in basic physical quality parameters such as weight variation, hardness, and friability. But their failure to meet dissolution requirements represents a failure to maintain the standard process. Due to equipment limitations, a 4-chamber dissolution apparatus was utilized. For these reasons, two-stage testing is required to accommodate the USP-mandated six tablets. This departure from standard single-batch testing protocols.

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