Journal of Nutrition and Dietetics

Expert Review Open Access

Bioavailability: Factors, and Implications in Drug Development and Nutrition

Argon Madera*

Department of Analytical Chemistry, University of Valencia, Spain

Abstract

Bioavailability refers to the proportion of an ingested substance that enters the systemic circulation and becomes available to the target tissues for therapeutic effect. It is a critical factor in pharmacology, nutrition, and drug development, influencing the efficacy of medications, supplements, and nutrients. This article explores the concept of bioavailability, its measurement, and the various factors that affect it, including physiological, chemical, and formulation-related variables. It also examines the significance of bioavailability in both clinical settings and nutritional science, highlighting its importance in ensuring optimal therapeutic outcomes and the efficient absorption of essential nutrients. The role of advanced drug delivery systems and novel formulations aimed at improving bioavailability is also discussed.

Keywords: Bioavailability; Drug absorption; Pharmacokinetics; Systemic circulation; Drug formulation; Nutrient absorption; Therapeutic efficacy; Drug delivery systems

Introduction

Bioavailability is a fundamental concept in pharmacology and nutrition that refers to the fraction of an administered dose of a substance that reaches the bloodstream and is available for use by the body's tissues. In drug development, bioavailability is crucial for determining [1] the appropriate dosage, formulation, and administration route of pharmaceuticals. In nutritional science, bioavailability impacts the efficiency with which the body absorbs and utilizes nutrients from food or supplements. Understanding the factors that affect bioavailability is vital for optimizing drug therapies and ensuring that essential nutrients are adequately absorbed.

Understanding Bioavailability

Bioavailability can be quantified as the percentage of an administered dose that enters the systemic circulation in an active form. The process of bioavailability is typically assessed using pharmacokinetic studies, which measure how a substance moves through the body following its administration.

In the case of oral medications, bioavailability is influenced by several stages, including absorption from the gastrointestinal (GI) tract, first-pass metabolism (the liver's initial breakdown of the substance), and the rate at which the substance is distributed and eliminated [2]. For intravenous administration, bioavailability is typically considered 100%, since the substance directly enters the bloodstream.

Factors Affecting Bioavailability

Physiological Factors

Several body-related factors influence the bioavailability of a substance:

Gastrointestinal (GI) pH and Motility: The acidic environment in the stomach can impact the solubility of drugs, while the rate of gastric emptying can affect how quickly a substance is absorbed.

Enzyme Activity: Enzymes present in the digestive tract, liver, and intestines can metabolize substances before they reach the systemic circulation [3], reducing bioavailability. This is especially true for oral drugs that undergo extensive first-pass metabolism.

Intestinal Transporters: Specialized proteins, such as P-glycoprotein, can actively pump drugs out of cells in the intestine, reducing absorption.

Blood flow: Variations in blood flow to the GI tract, liver, and other organs can influence the rate and extent of absorption.

Chemical Properties of the Substance

The physical and chemical properties of a drug or nutrient play a significant role in its bioavailability:

Solubility: Compounds that are poorly soluble in water tend to be absorbed more slowly and may exhibit low bioavailability [4].

Stability: Some substances are prone to degradation in the acidic environment of the stomach or during the first-pass metabolism in the liver.

Molecular size and lipophilicity: Larger molecules or those that are highly lipophilic (fat-soluble) may struggle to cross biological membranes, leading to lower bioavailability.

Formulation and Route of Administration

The formulation of a drug or nutrient greatly affects its bioavailability. Tablets, capsules, suspensions, and injectable forms all have different absorption profiles [5]. For example:

Solid dosage forms: Tablets or capsules must dissolve before absorption, which can delay or reduce bioavailability.

Nanoparticle and liposomal formulations: Advances in drug delivery systems, such as the use of nanoparticles or liposomes, can enhance the bioavailability of poorly soluble drugs by improving their dissolution and absorption.

***Corresponding author:** Argon Madera, Department of Analytical Chemistry, University of Valencia, Spain, E-mail: margon@gmail.com

Received: 02-Sep-2024, Manuscript No: jndi-24-155214; **Editor assigned:** 04-Sep-2024, PreQC No. jndi-24-155214 (PQ); **Reviewed:** 18-Sep-2024, QC No. jndi-24-155214; **Revised:** 23-Sep-2024, Manuscript No. jndi-24-155214 (R); **Published:** 30-Sep-2024, DOI: 10.4172/jndi.1000251

Citation: Argon M (2024) Bioavailability: Factors, and Implications in Drug Development and Nutrition. J Nutr Diet 7: 251.

Routes of administration: Intravenous (IV) administration delivers a substance directly into the bloodstream, offering 100% bioavailability, while oral administration typically results in partial bioavailability due to the challenges of absorption and first-pass metabolism.

Clinical Implications of Bioavailability

In clinical settings, bioavailability directly affects the therapeutic efficacy of drugs. Low bioavailability can lead to suboptimal drug concentrations in the bloodstream [6], potentially resulting in treatment failure. Understanding the bioavailability of a drug is crucial in determining the correct dosage regimen and improving patient outcomes.

For instance, certain medications, such as antihypertensives, antidepressants, and pain relievers, may require higher or more frequent dosing when their bioavailability is low. Conversely, drugs with high bioavailability may achieve therapeutic concentrations with smaller or less frequent doses.

Bioavailability in Nutrition

In the field of nutrition, bioavailability refers to the efficiency with which the body absorbs and utilizes essential nutrients, including vitamins, minerals, and macronutrients. The bioavailability of nutrients can be affected by a variety of factors, such as:

Food matrix: The physical structure of food can impact nutrient release during digestion. For example, nutrients in whole [7] foods may be less bioavailable than those in processed foods or supplements.

Nutrient interactions: The presence of certain compounds can either enhance or inhibit the absorption of nutrients. For instance, vitamin C [8] enhances the absorption of non-heme iron, while calcium can inhibit the absorption of iron.

Nutrient deficiencies: In some cases, deficiencies in one nutrient may impair the absorption of others. For example, a lack of vitamin D can reduce calcium absorption in the intestines.

Strategies to Enhance Bioavailability

In both drug development and nutrition, there are strategies to enhance bioavailability, particularly for substances that are poorly absorbed or metabolized:

Prodrug approach: Some drugs are designed as inactive compounds that are converted into their active form once absorbed, improving their bioavailability [9,10].

Nanotechnology: Nanoparticles, liposomes, and micelles can improve the solubility and absorption of poorly bioavailable compounds, making them more effective.

Food and drug synergy: Combining nutrients or drugs with specific foods or excipients can enhance their bioavailability. For example, fatty acids can improve the absorption of fat-soluble vitamins, while piperine (found in black pepper) is known to enhance the bioavailability of certain drugs.

Conclusion

Bioavailability is a cornerstone of drug development, nutrition, and therapeutic efficacy. A comprehensive understanding of the factors that influence bioavailability—ranging from physiological and chemical properties to formulation techniques—enables healthcare professionals to optimize therapeutic strategies and nutritional intake. As research advances, particularly in drug delivery technologies and nutrition science, enhancing bioavailability remains a central focus for improving health outcomes and treatment efficacy.

References

1. Jomezadeh N, Babamoradi S, Kalantar E, Javaherizadeh H (2014) Isolation and antibiotic susceptibility of Shigella species from stool samplesamong hospitalized children in Abadan, Iran. Gastroenterol Hepatol Bed Bench 7: 218.
2. Sangeetha A, Parija SC, Mandal J, Krishnamurthy S (2014) Clinical and microbiological profiles of shigellosis in children. J Health Popul Nutr 32: 580.
3. Ranjbar R, Dallal MMS, Talebi M, Pourshafie MR (2008) Increased isolation and characterization of Shigella sonnei obtained from hospitalized children in Tehran, Iran. J Health Popul Nutr 26: 426.
4. Zhang J, Jin H, Hu J, Yuan Z, Shi W, et al. (2014) Antimicrobial resistance of Shigella spp. from humans in Shanghai, China, 2004–2011. Diagn Microbiol Infect Dis 78: 282–286.
5. Pourakbari B, Mamishi S, Mashoori N, Mahboobi N, Ashtiani MH, et al. (2010) Frequency and antimicrobial susceptibility of Shigella species isolated in children medical center hospital, Tehran, Iran, 2001–2006. Braz J Infect Dis 14: 153–157.
6. Von-Seidlein L, Kim DR, Ali M, Lee HH, Wang X, et al. (2006) A multicentre study of Shigella diarrhoea in six Asian countries: Disease burden, clinical manifestations, and microbiology. PLoS Med 3: e353.
7. Germani Y, Sansonetti PJ (2006) The genus Shigella. The prokaryotes In: Proteobacteria: Gamma Subclass Berlin: Springer 6: 99-122.
8. Aggarwal P, Uppal B, Ghosh R, Krishna Prakash S, Chakravarti A, et al. (2016) Multi drug resistance and extended spectrum beta lactamases in clinical isolates of Shigella: a study from New Delhi, India. Travel Med Infect Dis 14: 407–413.
9. Taneja N, Mewara A (2016) Shigellosis: epidemiology in India. Indian J Med Res 143: 565-576.
10. Farshad S, Sheikhi R, Japoni A, Basiri E, Alborzi A (2006) Characterizationof Shigella strains in Iran by plasmid profile analysis and PCR amplification of ipa genes. J Clin Microbiol 44: 2879–2883.