Power of Supplements and Food Additives: How to maximize Nutrition

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Abstract

Food additives are artificial or natural substances that are added to foods to improve their safety, appearance, taste, or durability. The food additives preserve quality, enhance flavour and nutrient profiles and supplements provide essential components that are sometimes missing from regular meals and are available in various forms such as tablets, capsules and liquids, primarily include vitamins, minerals, amino acid and additional advantageous elements. Numerous supplements, such as vitamins, probiotics and herbal medicines, offer specific health benefits like improved immunity, energy and cognitive function. The strategic use of food fortification is also emphasized as a means of preventing malnutrition. The awareness of the hazards associated with dietary additives and supplements, including potential drug interactions, highlights the need for professional guidance. This chapter discusses the importance of food additives and supplements in improving nutrition and overall health. The key to maximizing advantages is bioavailability and appropriate integration. Athletes, the elderly and expectant mothers are among the groups with specific nutritional requirements.

Keywords: Functional foods, Drug-nutrient interactions, Probiotics, Prebiotics, Food insecurity

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Introduction

Food and nutritional requirements are the primary means by which people obtain the energy required to carry out different tasks and activities. Every person, regardless of their age group, class, or origin, requires some essential nutrients to maintain energy and growth. The correct intake of these nutrients is important for wholesome growth, healthy aging, and increased resistance to diseases. It is projected that there are a lot of new products that have a range of benefits. Health interventions, more precise diets and new products will facilitate the enhancement of health via nutrition policies. Apart from individual nutrition, new food items and health interventions are also crucial to enhancing the overall diet quality. Food and nutritional requirements are the primary means by which people obtain the energy required to carry out different tasks and activities (Morani et al., 2023).

Nutrition is the process by which the body receives, breaks down, absorbs and utilizes food for growth, energy and health. There are seven main classes of nutrients, including carbohydrates, proteins, water, vitamins, minerals, dietary fibre, fats (Morris & Mohiuddin, 2023). Macronutrients must be taken in larger amounts, while micronutrients must be taken in much smaller amounts, both are required to maintain health. Obtaining the proper balance of nutrients is essential to ensure general well-being and health. This is because good health is one of the key aspirations of every person. Nutritional status is the physiological state of the individual as affected by the diet, which is generally classified as fair, bad or good (Ebrahim, 2022).

A. Role of Food Additives and Supplements to Enhance Nutrition

Artificial or natural materials are added to food as food additives to increase their safety, appearance, taste, or durability. They perform several functions, such as preventing spoilage and bacterial contamination, enhancing colour, and flavour and improving texture and shelf life. While food additives enhance food quality and safety, they are controlled so as not to adversely affect health (Emerton & Choi, 2020). Intensive risk assessments primarily involve animal studies and are carried before new food additives are approved for use. The potential danger of food additives because of many factors cannot be completely dismissed, but food safety practitioners are in consensus concerning this risk being reasonable.

The process of assessing the risks posed by food additives is a complicated, scientific exercise and common consumers do not always have

sufficient time or incentive to engage in such exercise beyond what is provided (Gurtler, 2021). However, earlier studies indicate that they are quite concerned and willing to be more educated about the health risks posed by the consumption of food additives: Food or drink which has a physiological advantage improving health, reducing or curing disease conditions or enhancing either physical or mental performance through the inclusion of a functional ingredient, a process modification or use of technology.

B. Strategic Use of Food Additives and Supplements

US legislation known as the Dietary Supplement Health and Education Act (DSHEA) in 1994 provides a framework within which the term "dietary supplement" is applied. Among the criteria are the following:

- A product that is designed to complement the diet and that includes a dietary material, one or more vitamins, minerals, herbs and amino acids or any ingredient that is an extract, component, metabolite, concentration, or a mixture of these ingredients.
- A pill, capsule, and liquid for ingestion.
- Any product claiming to be a dietary supplement.
- A product that is not a usable representation as a normal food and not as the only food or diet component.

Several pieces of evidence are supporting the idea that functional foods that have active components, which could be plant or animal in origin, may promote good health (Dixit et al., 2023). Since food has taste, it is obvious that all foods have a purpose, aroma, or nourishment. Excellent or poor diets exist, but there are no "superb" or "terrible" foods. It is worth mentioning that certain dietary supplements may also include the non-recommended and possibly harmful elements as additives. Seek the advice of any healthcare professional before using supplements incorporating food additives, as there may be risks involved. It is essential to remember that there is no conclusive evidence on the relation of food additives to cancer

1. Understanding Supplements

Dietary supplements provide essential nutrients that are not present in the typical diet. These supplements, accessible in different forms such as pills, cover and liquor, primarily include amino-acids, vitamins and minerals and other beneficial components (Morani et al., 2023). The classification of dietary supplements along with its types and functions is given in Table 1.

Table 1: Classification of Dietary Supplements its Types and Functions

Sr.#	Category	Examples	Function	References
1	Vitamins	A, B, C, D, E, K	Supports immunity, metabolism and overall health	(Johnson & Bales, 2022)
2	Minerals	Ca, Mg, Fe, Fe, Zn, Na, Se, Cu, Mg	Crucial for immune system function.	(Weyh et al., 2022)
3	Herbal Supplements	Tulsi, Neem, Turmeric Kalonji, Safron, Ginkgo	Help prevent diabetes and provide relief from issues like constipation and acne.	(NIH, 2020)
4	Protein & Amino acids	Animal-based & Plant-based proteins	Vital tissue growth.	(Li et al., 2021)
5	Omega 3- fatty acids	EPA, DHA	Omega-3 fatty acids benefit mental, Cardiovascular issues.	(Serefko et al., 2024)
6	Probiotics & Prebiotics	Inulin, Lactobacillus, Bifidobacterium, Streptococcus, Bacillus	Manage chronic diseases and improve gut health	(Oniszczuk et al., 2021)
7	Antioxidants	Vitamins (C, E), Polyphenols (Flavonoids, Phenolic acids), Carotenoids	neutralize free radical, used in food, cosmetics	(Hoang et al., 2021)

A. Benefits and Potential Risks of Supplement Use

Vitamin D supplementation may help avoid preeclampsia. Supplementing with folate and omega-3 may lower an adult's risk of some cardiovascular consequences. Vitamin D and calcium together may raise the risk of stroke (Khan et al., 2019). Resveratrol, curcumin have been shown to have several positive cardiovascular effects in preclinical research and human clinical trials. In healthy and at-risk groups, the analysis shows that B vitamin supplements are beneficial for stress but not for anxiety or depression symptoms (Young et al., 2019). Hundreds of biological activities depend on minerals and trace elements (MTEs), which are micronutrients.

B. Factors to Consider while Choosing Supplements

The rules set forth by the FDA about dietary supplements as foods were established by (DSHEA): To guarantee a specific procedure for the preparation, packing, labelling, and storage of supplements. Components are recorded and guarantee purity, composition and strength (Bailey, 2020). Manufacturers must adhere to general guidelines to guarantee the safety and quality of dietary supplement products. When food-based strategies like dietary modification, fortification or food provision cannot reach adequate consumption, supplementation is advised.

C. Essential Supplements for Optimal Health

Vitamins are vital micronutrients that our systems need in minimal quantities to execute several operations: Supplements including vitamins, minerals, protein powders and herbal extracts are marketed as immediate remedies for inadequate dietary practices and as a means to improve performance, increase energy or avert chronic illnesses. They participate in activities like energy synthesis, metabolism, immunological function, and the preservation of healthy bones, skin and organs (Bertuccioli et al., 2021).

D. Supplements for Energy and Vitality

For both humans and animals, food serves as the main energy source while maintaining the systemic biochemical and physical integrity.

A loss of energy or reduced vitality is a common perception of tiredness. Energy deficit, decreased strength and endurance, mood swings and memory and attention problems were among the physical symptoms (Engberg et al., 2017).

2. Cellular Energy Generation

Dietary macronutrients in humans provide energy for biochemical and structural integrity, physical activity, and tissue formation. Enzymes break down carbs, lipids and proteins into monosaccharides, fatty acids, amino acids, which undergo sequential oxidation in the cytosol and mitochondria, resulting in ATP, a molecular energy used within the cell (Alberts et al., 2017).

A. Role of B vitamins in Cellular Energy Metabolism

Every B vitamin is implicated, with the exception of folate in the mechanism that produces energy in cells. Sufficient quantities are essential for healthy operation since insufficient amounts might impair energy production and cause serious metabolic and health problems. Both free and phosphorylated forms of vitamin B1 support dehydrogenase activities, contributing to the Sugar-CoA in the citric acid cycle and pyruvate and amino acid decarboxylation. B2 is a crucial part of FDA and FMN, which are necessary for the action of flavoprotein enzymes and redox activities in the metabolism of carbs, proteins and lipids.

Nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) are precursors of niacin, a vitamin B3 that is obtained from nicotinamide. It is essential for the citric acid cycle, glycolysis and mitochondrial oxidative phosphorylation, which produces malate and isocitrate from succinyl-CoA. A crucial enzyme in cellular metabolism, is dexol (B5) which is a precursor of Coenzyme A. The vitamin B7 biotin cofactors with carboxylases to transform bicarbonate into a substrate, which is essential for gluconeogenesis, amino acid catabolism and fatty acid synthesis (Mock, 2013).

B. Energy-Yielding Metabolism

Vitamin C is necessary for both the production of carnitine, a cofactor for the movement of long-chain fatty acids into mitochondria and the production of energy by beta-oxidation. (Johnston, 2012). Heme enzymes, such as iron, are necessary for the synthesis of cellular energy. Cytochromes change ferrous iron into ferric iron by transferring electrons. The reason magnesium is necessary for the synthesis and use of ATP is because it forms physiologically active ATP complexes with magnesium ions. The cofactor kinases and citric acid cycle enzymes involved in glycolysis are regulated by these complexes. In order to export mitochondrial ATP into the cytosol and distribute energy throughout the cell, ATP-Mg complexes are present in the mitochondria.

C. Immune System Support

Magnesium is essential for the production and use of ATP because it forms physiologically active ATP complexes with magnesium ions. The body is protected against disease-causing microbes by the immune system, which is made up of both innate and adaptive responses. White blood cells and physical barriers make up the innate immune system, which is general and ineffective against particular illnesses (Volpe, 2012).

D. Impact of Vitamin Deficiencies on Immune Function

Vitamin shortages arise when the body fails to get sufficient quantities of a certain vitamin. These deficiencies may occur owing to several circumstances, including insufficient food intake, impaired absorption, certain medical conditions, or lifestyle choices. These vitamins, which include vitamins A, C, D, E, selenium and zinc. Table 1 shows classification of Dietary Supplements explain about their function. Folate deficiency affects thymus and spleen function, T-lymphocyte numbers, and neutrophil phagocytic ability. Vitamin A deficiency increases infection vulnerability, alters immunological responses and compromises epithelial tissue barrier function. Vitamin E deficiency reduces natural killer cell activity.

E. Impact of Mineral Deficiencies on Immune Function

Particularly in young children and the elderly, copper deficiency is associated with altered immunological responses and heightened susceptibility to infections. Reduced immune cell function and elevated oxidative stress and inflammation, including elevated levels of inflammatory cytokines like interleukin-6, are all consequences of magnesium shortage (Maier et al., 2021). Dietary supplements comprising the vitamins and minerals under investigation have an impact on humoral immunity, a crucial part of the adaptive immune system.

F. Cognitive Function

As the world population ages, dementia and cognitive impairment are major health issues in today's society. One common type of the disease Alzheimers (AD) is dementia, a disorder marked by cognitive decline and loss of functional abilities. According to (Iadecola et al., 2019), WHO estimates that over 50 million individuals in the European Union suffer from dementia, with a 28.5% prevalence of the disease at age 90. Both AD and vascular cognitive impairment are common conditions that put a heavy burden on families, workplaces and healthcare systems, resulting in lower productivity and higher medical expenses. Older people tend to be less active and spend less time outside, which reduces their exposure to sunlight and the production of vitamin D (Czako et al., 2020).

4. Food Additives: Enhancing Nutrition and Functions

Food Additives and their Types

Food additives are substances that are included in food to preserve flavour or enhance its taste or other qualities and are certain in packaged food. Primarily, food additives not only function in food preservation but also assist in increasing certain conditions of food, such as colour, flavour and flexibility, as well as enhancing the nutrition of food (Zhang et al., 2021). The International Life Sciences Institute of North

America (ILSI) defines functional foods as foods that under physiologically active food items that provide health ease beyond basic nutrition.

These substances have antioxidant or antibacterial properties or both. They either destroy or inhibit the growth of molds, bacteria, insects and other microbes. Antimicrobials prevent the growth of bacteria, yeasts and molds, whereas antioxidants prevent food from going bad or developing black spots. Sweeteners food additives are the effect of common or synthetic birth, with a sweet flavour and without notable vitality service, which are utilized to restore active sugars. Antioxidant food additives are compounds that can be included to eatables in minor quantity. To abstain from oxidation of food products, by that increasing its longevity. A flavour enhancer is representative to be a substance which, when added to eatables, increases the common taste of the food.

Benefits of Food Fortification

Food fortification is a low-cost method of improving population's nutritional status and is associated with more significant economic advantages. Food fortification is explained as the fortification of one or different vital nutrients to a food, whether it is normally present in the food or not, to improve its nutritional value and help prevent nutrient deficiencies in the population consuming it.

Examples of Beneficial Food Additives

Probiotics in Yoghurt

Probiotics are typically taken as dietary supplements or as a component of fermented foods that primarily include live, active cultures, including yoghurt and soy yoghurt. Gut microbiota is probably changing, with probiotics beneficial bacteria replacing pathogenic germs. Taking probiotics on a daily basis may improve life quality. Probiotics have been shown to improve the immune system, improve skin function, protect DNA and preserve each person's intestinal microbiota in patients receiving antibiotic treatment.

Omega 3 Enriched Eggs

The role of chicken nutrition in enhancing the lipids in their egg yolks with omega-3 fatty acids has been thoroughly studied detailed over 300–500: mg of omega-3 fatty acids. Greater levels of omega-3 PUFA in eggs lead to improve in lipid oxidation products, resulting the overall quality of eggs, including palate, taste and nutritional worth. This experience is deposited during storage, which influence overall organoleptic facts as well as nutrient value of enriched eggs.

Fortified Plant-based Milk

Fortify plant-based milk matched with vitamin D, various volumes of vitamin D-enhanced Nano emulsion and almond milk were blended together, independently. Fortification of Plant-Based Milk accompanied Calcium (Zhou et al., 2021).

5. Optimizing Nutrition with Food Additives and Strategic Supplements

Food additives aid in extending the shelf life (Medhi et al., 2022). The terms nutrients and pharmaceutical, which refer to substances that can be obtained from food or food components and are used to prevent or cure illnesses or to enhance health status are the synonyms for nutraceuticals, i.e., dietary supplements, novel foods, herbal products and processed food ingredients. Table 2 shows advantages of nutraceuticals for health over conventional medicine.

Table 2: Advantages of Nutraceuticals for Health over Conventional Medicine

Sr. #	Aspect	Nutraceuticals	Traditional Medicine	References
1.	Approach and Basis	Bioactive food-based compounds to improve health and wellbeing.	a comprehensive strategy that considers how the body, mind, and spirit are all intertwined.	(Chopra et al., 2022)
2.	Mode of action	Reducing oxidative stress and neutralising dangerous free radicals. Lowering inflammation and modulating the inflammatory response. Fostering gut health and a wholesome gut environment. Boosting defences against infections and infections.	Plant-based active ingredients used to achieve therapeutic Restoring equilibrium among the body's systems, including organ function and dysfunctions or imbalances that lead to disease is known as "addressing root causes".	(Williamson et al., 2020; AlAli et al., 2021)
3.	Examples	Green tea, garlic, citrus fruits, soy protein, and fortified dairy products.	Spiritual therapy, massage, acupuncture, and herbal treatments	
4.	Health benefits	Aid in the prevention of chronic diseases. They can boost immunity, encourage a healthy gut microbiome, and improve general well-being	Given the connection between the body and mind, traditional medicine frequently adopts a holistic approach, illnesses that can be treated using traditional medicine.	
5.	Side effects	Interact with drugs bone health caused by excessive vitamin A intake, Male smokers who took beta-carotene supplements were more likely to get lung cancer.	Can result in liver damage-related liver function tests (LFT). Chinese herbal remedies that include aristolochic acid is linked to an elevated risk of urothelial carcinoma.	(Ekor, 2014; Ronis et al., 2018)
6.	Regulation and approval	Lack premarketing stringent testing manufacturing, and labelling requirement. Cannot sold without first proving their efficacy and safety to consumers.	Some governments regulate traditional herbal treatments like medications, requiring licensure and pre-market approval. Clinical trials and other types of proof are frequently needed to prove the safety and effectiveness of traditional herbal remedies (Regulation and Regulatory Science).	(Program, 2024)

Supplements and Additives in Daily Nutrition

Nutritional intake and general health can be considerably improved by skillfully integrating food additives and supplements into everyday routines (Djaoudene et al., 2023). When choosing supplements, bioavailability, the body's capacity to absorb and use nutrients efficiently is an important consideration. Selecting supplements with increased bioavailability guarantees that nutrients are absorbed more effectively, resulting in the greatest possible health advantages (Martin-Rodriguez et al., 2024). Many variables, including generation, sex, fitness and way of living affect dietary requirements. Taking supplements with meals or at specific times of the day can improve both absorption and compliance.

Optimizing Nutrient Absorption through Food

Certain dietary supplements and nutrients are more effectively absorbed when consumed with complementary foods. For example, vitamin D is fat-soluble and should be taken with a fat-containing meal to improve absorption. Similarly, iron absorption can be enhanced by consuming it alongside vitamin C-rich foods, such as orange juice, which facilitates its uptake in the gastrointestinal tract (Iron Supplements for Anaemia Ferrous Sulphate, NHS). For those seeking to increase their B-vitamin intake, especially vitamin B12, dietary sources or supplements are commonly recommended, particularly for individuals with restricted diet. Additionally, plant-based sources of omega-3 fatty acids, such as chia seeds and flaxseeds, are excellent additions to the diet, helping to meet essential fatty acid requirements.

Resolving Absorption-Inhibiting Factors

Optimizing nutrients is one of the elements that affects bioavailability. Together, certain nutrients increase efficacy and absorption (Townsend et al., 2023). Vitamin D, C, calcium and iron are significant examples. Considering the formulation of supplements. The makeup of supplements influences their absorption. The Protein and Exercise BHF found that liquids were more effective at absorbing vitamins and minerals than solids. Minerals such as calcium, zinc, and iron can have their absorption of nutrients inhibited by certain substances (Petroski & Minich, 2020). For instance, proton pump inhibitors may reduce vitamin B12 absorption. Figure 1 shows strategies for optimizing effectiveness and absorption.

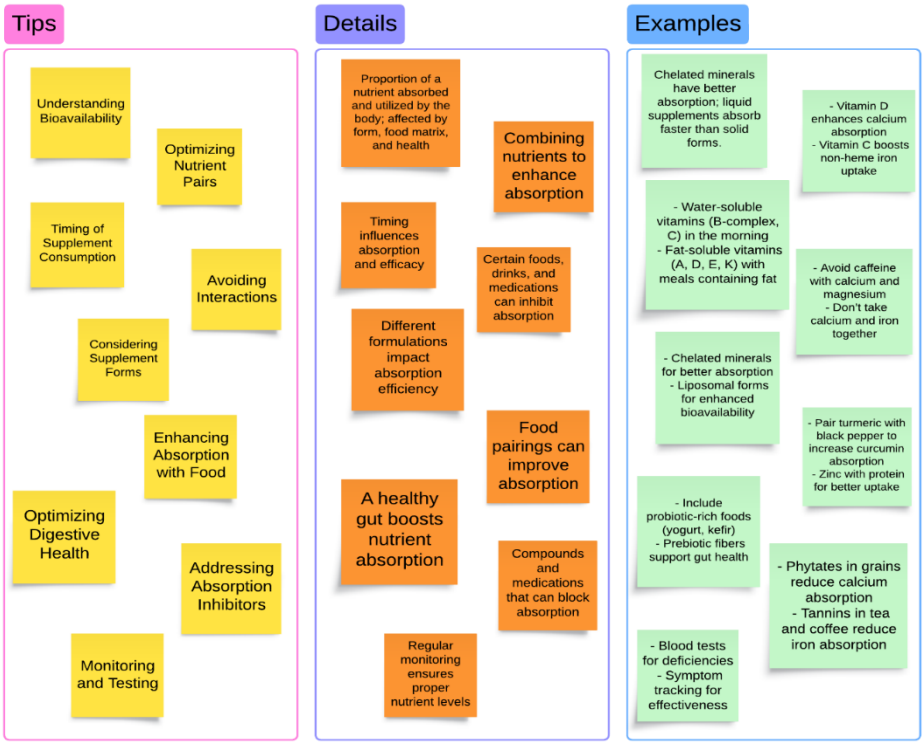

Figure 1: Strategies for Optimizing Effectiveness and Absorption

Taking Special Populations into Considering: Understanding the unique demands of these populations is necessary to develop specialist dietary strategies that promote health and well-being (Ordovas et al., 2018).

Pregnant Women

Pregnancy increases the need for certain nutrients to support the growth of the fetus and the mother (Marshall et al., 2021); iron helps prevent maternal anemia by supporting the fetus increasing requirements and increased blood volume (Donker et al., 2021); calcium and vitamin D consumption during pregnancy may reduce the risk of complications and preterm birth. Studies have shown that infants whose mothers took Omega-3 Fatty Acids DHA supplements during pregnancy exhibited improved cognitive outcomes (Khandelwal et al., 2020).

Athletes

Because of the increased physical and metabolic demands placed on their bodies, athletes have higher nutritional needs (Amawi et

al., 2024). Muscle growth and repair require protein, especially after resistance training. Carbohydrate supplements can improve endurance performance and replenish energy stores. With appropriate electrolyte replacement, cramping can be prevented and performance preserved (Armstrong, 2021). Creatine supplements are commonly used by athletes that engage in high-intensity, brief workouts in order to improve their performance and power output (Wax et al., 2021). Figure 2 shows comparison of the unique nutritional needs of athletes and pregnant women.

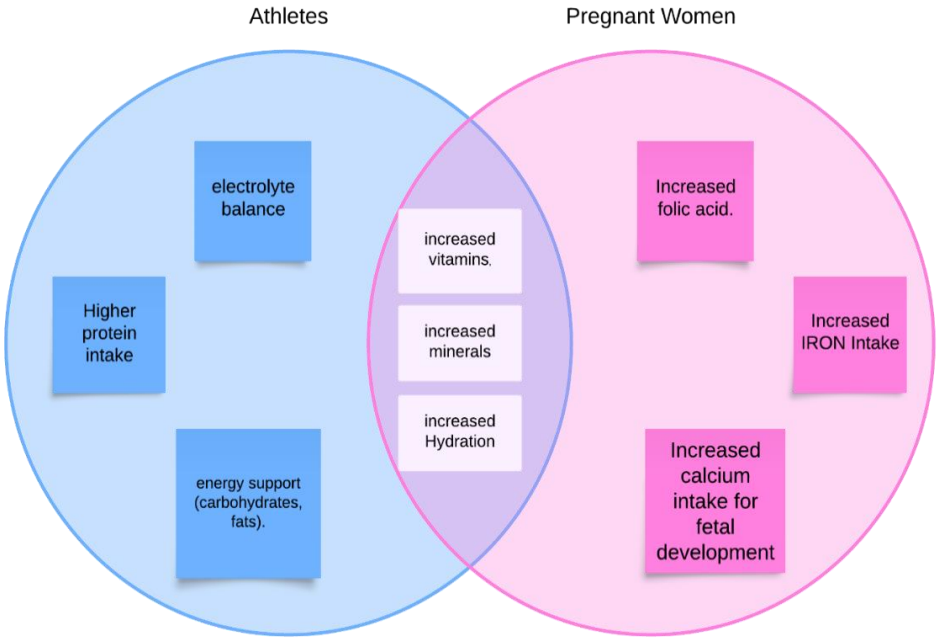

Figure 2: Comparison of the unique nutritional needs of athletes and pregnant women

Older Adults

When it comes to preventing deficiencies and encouraging healthy ageing, supplements can help meet the demand for particular nutrients. Protein keeps muscle mass from declining with age (Putra et al., 2021). Protein supplements have also been shown to increase strength and muscular growth (Hou et al., 2019). Better heart and cognitive health (Dighriri et al., 2022) and the prevention of cardiovascular illnesses have been linked to omega-3 fatty acids.

6. Potential Interaction and Safety Considerations

Supplements have the potential to cause negative drug interactions in the body. However, recently, a number of investigations have been carried out to confirm the risk of potential interaction between supplements and medications.

Types of Interactions

1. Supplement-drug interaction
2. Supplement-food additive interaction
3. Supplement-supplement interaction

Mechanism of Interaction: Supplements have the potential to cause negative drug interactions in the body. Recently, a number of investigations have been carried out to confirm the danger of potential interaction between supplements and medications. Interactions between drugs and dietary supplements may involve the suppression or stimulation of:

1. P450 enzymes that are involved in drug metabolism
2. Transferases of UDP-glucuronosyl
3. Additional phase I and II enzymes
4. Drug-efflux proteins and drug transporters. Drug-dietary supplement interactions may result from the inhibition or induction of the enzymes that are responsible for the metabolism of medicinal drugs or their transporters by natural products

Pharmacokinetic Interactions

Pharmacokinetic alterations, particularly those resulting from the regulation of drug-metabolizing enzymes and transporters, are the main mechanism behind drug-supplement interactions. To maximize treatment results and guarantee patient safety, it is essential to comprehend these interactions. There have been reports of possible interactions between certain supplements, such as glucosamine and certain arthritis drugs; however, some studies indicate that the risk of interactions is low (Kim et al., 2023).

Cytochrome P450 Modulation: The cytochrome P450 (CYP) enzymes, which are critical for drug metabolism, can be affected by a variety of dietary supplements.

Toxicity and Health Risks: Certain supplements have a substantial potential for toxicity, especially when taken with prescription drugs. For

example, taking herbal supplements with NSAIDs, such as ginkgo and garlic, can increase the risk of bleeding (Ozturk, 2023).
CNS Depression: Taking opioid analgesics along with sedative herbal supplements can result in a higher potential of CNS depression.
Vulnerable Populations: Elderly and Polypharmacy include patients who are older or who take more than one medicine run the risk of experiencing negative interactions, especially when taking pharmaceuticals that are processed by cytochrome P450 enzymes.

Importance of Consulting Healthcare Professionals

Understanding supplement-drug interactions is essential for healthcare professionals to deliver safe and efficient therapy. Advice that is clear and supported by data is especially important for individuals with complicated illnesses, like cancer (Dini & Mancusi, 2023).

Conclusion

The functional foods and dietary supplements prescribe to be used under the supervision of the healthcare professional, indicating that they are potentially safe and effective. To maximize nutrition through the application of food additives and supplements is a dynamic and customised process that necessitates a deep comprehension of each person's unique nutritional requirements, the calibre of supplements and appropriate integration techniques. Evidence-based methods and customised tactics will further hone the role of supplements in boosting health across a range of demographics as research progresses.

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