

9. Bioavailability of Nutrients

Kapil Tyagi, Shweta Tyagi

Assistant Professor,
Department of Chemistry,
Greater Noida Institute of Technology,
Gr. Noida, U.P.

Ankita Tyagi

Assistant Professor,
Govt. Women PG College,
Kandhla, Shamli, U.P.

Abstract:

This chapter focuses on the bioavailability of calcium (Ca), zinc (Zn), iron (Fe), and vitamins in food. Bioavailability is defined as the proportion of ingested nutrient that is absorbed and utilized by the body. The availability of these nutrients varies greatly depending on multiple factors, including food processing, nutrient interaction, food structure and individual differences. Adequate intake of these micronutrients is essential for the proper functioning of various physiological systems, and deficiencies can lead to severe health problems. In this chapter, we aim to summarize the current understanding of the factors that affect the bioavailability of Ca, Zn, Fe, and vitamins from food sources and their implications for optimal human nutrition. We discuss evidence-based strategies to optimize the bioavailability of these nutrients and ensure adequate intake from dietary sources, which can ultimately improve health outcomes.

Keywords:

Bioavailability, Antioxidants, Nutrients, Inhibitors, Phytate.

9.1 Introduction:

Bioavailability is the measure of nutrient absorption, which means how easily a nutrient can be absorbed by our body (Nancy F. Krebs, 2001). Before, the nutrients after consumed first need to be broken down, by our digestive system, into small similar forms that our body can use then they can be used for their health benefits. The nutrients that can be easily broken down are called 'bioavailable'. Bioavailability refers to the proportion or fraction of a nutrient, in the diet, that is consumed, absorbed and then utilized by the body for functioning. Bioavailability is influenced by several factors like our diet, nutrient concentration, nutritional status, health, gender, age, and life stage. Diet-affecting foods include the structure of food, the chemical form of a food nutrient, interactions between nutrients and foods, and food processing methods or treatment.

Some nutrients are readily absorbed and quickly utilized to work in the body, while others may be a little slower in absorption and utilization. Macronutrients e.g., carbohydrates, proteins, and fats generally have high bioavailability. More than 90% of the amount of these nutrients we consume gets absorbed and used by our body. (Hettie Schonfeldt et.al., 2016)

On the other hand, micronutrients e.g. vitamins, minerals, and antioxidants, can vary in the extent to which they are absorbed and used once consumed. (Alida Melse-Boonstra, 2020).

9.2 Factor Affecting the Bioavailability:

A. Life-Stage:

There is a normal decline in gastric acid according to age, so younger individuals can have a higher bioavailability of micronutrients while it is slower in older individuals. This means our body ability to absorb micronutrients is reduced as we age.

B. Food Structure:

Nutrients in foods with less complex tissue structures can easily absorb so more bioavailable than Nutrients from plant foods or other foods that have complex tissue structure take longer to digest such as corn or meat are less bioavailable. This type of Foods first must be broken down or cooked so that certain micronutrients to be available for absorption.

C. Chemical Form:

Heme iron is more bioavailable than non-heme iron. Heme iron is available in meat, fish or poultry foods and non-heme iron is available in plants. Since plant food is not easy to absorb or digest, the non-heme iron in plants is less bioavailable. So recommendations for iron intake for vegetarians are higher than for those who eat meat.

D. Interactions with Compounds in Foods:

Antioxidants (polyphenols or phytates) have the ability to bind with certain micronutrients in the gastrointestinal tract and they prevent absorption into the body. Polyphenols are found in plants that can prevent mineral absorption in the intestines. Phytates are found in the outer layer of plants and bind with minerals like zinc, calcium or iron, which interfere and prevents their absorption in the intestines. (<https://extension.msu.edu/newsletters>)

On considering all of the different factors that affect the bioavailability of nutrients, for healthy individuals, eating food with proteins, whole grains, plenty of fruits, and vegetables is the most simple and effective way to ensure you're taking a healthy and balanced diet.

9.3 Different Influences:

So, The factors that might positively or negatively affect bioavailability varies from nutrient to nutrient because every vitamin and mineral is unique. Such as

A. Vitamin C and Iron:

Vitamin C effects the iron absorption in a positive way and increase nutrient bioavailability (Lynch, S, et. al. 2003 and Schonfeldt, H & Hall, 2011). Vitamin C converts non-haem iron which is the less easily absorbed form of iron into a more bioavailable form that the body prefers to absorb in gut. which helps absorption.

B. Vitamin D and Calcium:

Vitamin D effects the absorption of calcium helps to increase the bioavailability (Patwardhan, UN, et. al. 2001).

C. Fats and Fat-Soluble Vitamin:

Vitamins A, D, E and K are stored in the body within the fat cells. They are called fat soluble vitamins. Fat soluble vitamins are more easily absorbed by the body in the presence of fat. Some 'healthy' fats such as the monounsaturated fats found in avocados may help to increase the absorption of vitamins A, D, E and K.

9.4 Some Nutrients:

A. Iron:

There are two forms of dietary iron; haem and non-haem. Haem iron is present in animals and can be easily absorbed in humans, while non-haem iron is present in plants. While the absorption of haem iron depends only on our stored amount of iron, the absorption of non-haem iron is depend upon the diet and may influenced by other factors. For example, Haem iron found in animal sources have the ability to increase the absorption of non-haem iron. Phytates found in certain vegetables and cereals, polyphenols found in tea and coffee and dietary calcium are inhibitors of non haem iron bioavailability. So it's important to be aware of how to increase your iron absorption.

While non-haem iron found in plant sources may be less easily absorbed, Research suggests that this can be increased by increasing the consumption of vitamin C with plant-based iron sources. Many studies have shown that ascorbic acid (vitamin C) may reduce the negative effects of all of the inhibitors like phylates and polyphenols. (Gibson, 2007), So it is very important to include a source of vitamin C with plant-based meals to ensure you're absorbing iron from the foods you're eating. Drinking tea or coffee in-between mealtimes rather than at the meal time may also limit the inhibiting effect certain compounds on the absorption of iron from plant-based sources.

B. Calcium:

Bioavailability of Calcium which is another important mineral can be affected by various factors. Calcium is present in adequate amount in Dairy, eggs and fish foods and calcium is more readily absorbed from milk and dairy products so if you're following vegan diet it is important to include plenty of alternative sources of calcium in your diet.

Some , naturally occurring compounds like oxalates, found in spinach rhubarb and beetroot as well as phytates found in plant foods, can inhibit the absorption of calcium as they bind with calcium and may prevent its absorption into the blood. Broccoli, kale, calcium-set tofu, Brussels sprouts, and calcium-fortified milks are some examples of plant-based foods where calcium can easily be absorbed. Many studies have shown that Vitamin D promotes the bioavailability of calcium so must include Vitamin D supplements in your diet (Connie M Weaver, 1999).

C. Zinc:

Zinc is a nutrient that is highly bioavailable from animal sources and therefore the bioavailability of Zinc from non-vegetarian diets is more than that of vegetarian diets. Animal protein may enhance Zinc absorption and its bioavailability while Plant foods such as cereals, seeds, legumes and nuts which are the major part of of vegetarian diets are high in phytates, which inhibits the absorption of Zinc, while. Unlike Iron, how much a person can intake Zinc from diet is the principle determinant of a person's Zinc status, rather than how much of a store your body may have (Hambidge et al., 2010), i.e. we can ideally be consistent in consuming enough Zinc from our diet to avoid deficiency. Phytate content can be reduced by Consuming fermented foods such as miso or tempeh, fortified breads and cereals or soaking dried beans before cooking to include great sources of Zinc in your diet. If not possible to soak dried beans for hours on end, try using miso paste as a base for noodle soups and choose fortified breads and cereals where possible – kimchi, sauerkraut and sourdough bread are all great fermented options that can increase Zinc bioavailability.

D. Cooking & Processing:

It is general assumed and suggested that cooking foods lowers the nutrient content and while this can sometimes be opposite, is often also true. Research has shown that bioavailability of beta-carotene from carrots and green leafy vegetables, including spinach is improved through cooking. Similarly, a beneficial nutrient lycopene found in tomatoes is more bioavailable in pureed and canned (cooked or processed tomatoes) than fresh, uncooked tomatoes.

In the case of plant sources of Zinc and Calcium, processing (such as milling, soaking, germination and fermentation) can lower the phytate content and reduce their inhibiting effect on bioavailability of nutrients (Rosalind S Gibson, 2018).

E. Importance of Bioavailability of Nutrients:

The bioavailability of the nutrients you are consumed is directly referred to the positive effects they have on your overall health. If a nutrient is not bioavailable, it won't be absorbed, which caused its insufficiency or become a deficiency in the long run.

For example, spinach is the most calcium rich leafy green. but, only few amount nearly 4-5 percent of its calcium content is absorbed and used by the body. This is due to the presence of certain anti-nutrients called 'oxalates' (interfere with the absorption of other nutrients) present in spinach (Weston Petroski et. al. 2020 and R P Heaney et. al. 1989).

Thus, the calcium is low bioavailable in spinach. It means, if you're largely depend on spinach for getting calcium, you cannot absorb at an optimum level, resulting in an inadequate intake. Consistent low absorption of, inadequate amounts of calcium can result in weak bones (osteoporosis) (Gabriela Cormick and Jose M Belizán, 2019). This doesn't mean to avoid spinach, it must be because it contains other valuable nutrients, but to consume a variety of sources of calcium where calcium is more bioavailable like dairy, soybean, chickpeas, almonds, etc.

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