Bioavailability of Micronutrients- Iron and Zinc: 
Analysis of Akshaya Patra’s Mid-day Meals

I. Concept of Bioavailability and Bio-accessibility

Bioavailability includes the term Bio-accessibility. Bioactive compounds must be assessable (released from food matrix and modified in the gastrointestinal tract), before becoming bioavailable.

- Bio-availability refers to the nutritional effectiveness. It is the fraction of the nutrient that is stored or being available in physiological functions. It expresses the fraction of ingested nutrient that reaches the systemic circulation and ultimately utilized effectively by the organism\(^1\).

- Bio-accessibility is defined as the quantity of a compound that is released from its matrix in the gastrointestinal tract, becoming available for absorption\(^1\).

Study by Palafox Et al., on plant-based antioxidants defines bio-availability as the proportion of an antioxidant that is digested, absorbed, and utilized in normal metabolism. Palafox further highlights that the measurement of bioavailability relies heavily upon estimates of amounts of antioxidant absorbed\(^2\). Bio-accessibility is defined as the amount of an ingested nutrient that is available for absorption in the gut after digestion\(^2\). In these terms, the bio-availability strictly depends on the bio-accessibility.

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\(^1\) http://scitechconnect.elsevier.com/bioavailability-bioaccessibility-bioactivity-food-components/


II. Bio-availability of micronutrients in plant based diet

Bioavailability of micronutrients Iron and Zinc was found to increase through dietary sulphur-containing amino acids\(^4\). In vegetarian diet, foods that contain the sulphur amino acids are soy products and other legumes, nuts, seeds, grains, garlic, onions, milk, whole grains, molasses, green leafy vegetables, etc.

Literature on Bioavailability of Micronutrients from Plant Foods shows that, certain cooking practices and use of ideal combinations of food components can significantly improve micronutrient bioavailability\(^5\). Further, the bioavailability of every nutrient differs in the terms of its cooking process, the type of ingredients used, temperature & vessel used for cooking. Various food groups have the biochemical properties to enhance or reduce the nutrient value of the food cooked together.

Micronutrients specially iron & zinc are considered to be the trace elements, but plays an essential role in the growth and development of the child. Iron plays a crucial role in building Heme – ions contributing to development of RBC in the body, while zinc plays an important role in the cognitive & other important metabolic process in the body. These micronutrients, since are found in the trace amount in various food groups, have a tendency to lose or gain their functional properties, when used in combination with other groups.


\(^5\) https://www.ncbi.nlm.nih.gov/pubmed/25748063
iron, zinc$^6$ and $\beta$-carotene from these test vegetables in many instances. Such an improved bio accessibility was evident in both raw and heat-processed vegetables. The effect of lime juice was generally more pronounced than that of amchur. Turmeric significantly enhanced the bio accessibility of $\beta$-carotene from all of the vegetables tested, especially when heat-processed”.$^7$ Further, pungent spices—pepper as well as ginger are identified as enhancers of micronutrient bioaccessibility.$^8$

Cumin seeds, which are an integral part of every recipe, enhances the taste & bioavailability of iron and zinc in the food. One such study conducted by K.S. MuthammaMilan in 2008 shows that, “that phytase (ratio of 1:1000), in the presence of 20 mM citric acid, increased iron and zinc bioavailability significantly. Thus, the spent cumin can find potential use in various health food formulations, showing improved digestibility and a good nutrient composition.”$^9$

Grains, cereals, pulses and legumes are also a large group of ingredients in Akshaya Patra menu. Bioaccessibility of iron and zinc from cereals and pulses consumed in India was investigated by Hemalatha et al. (2007a). Rice, finger millet, sorghum, wheat, maize whole and decorticated chickpea, greengram, decorticated blackgram, red gram, cowpea and french bean were selected for the study. The bioaccessibility of zinc and iron was lowest in sorghum (5.51% and 4.13%, respectively) and highest in rice (21.4% and 8.05%, respectively). Whereas in pulses it ranged from 1.77 to 10.2 per cent lowest in cowpea and highest in french beans.$^{10}$

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$^7$ https://www.jstage.jst.go.jp/article/fstr/18/1/18_127/_pdf/-char/en  
$^{10}$ http://krishikosh.egranth.ac.in/bitstream/1/83530/1/th9985.pdf
III. Conclusion

Diets predominantly vegetarian are composed of components that enhance as well as inhibit mineral bioavailability. Evidences from literature report, improvement in micronutrient bioavailability by certain cooking practices like heat treatment, sprouting, fermentation and malting. Further, use of ideal combinations of food components\textsuperscript{11} also improves the micronutrient bioavailability from plant based food sources.

Green leafy Vegetables having low oxalate value such as fenugreek, amaranth, drumstick leaves, curry leaves and other vegetables rich in ascorbic acid such as tomato, lemon, capsicum, green chillies increases the bioavailability of iron & zinc in the food in the adequate amount. Food acidulants like lime and spices like cumin, pepper are also shown to enhance the bioavailability of not only iron and zinc, but also of β-carotene. Bioaccessibility was also found high in rice and french beans. These food components evidenced to improve the bioavailability of micronutrients are key ingredients of Akshaya Patra MDM, ensuring bioavailability of Iron and zinc. The presence of these food combinations enhance our recipes in the context of deriving maximum nutrition from the vegetable sources.

Hence, we can infer that, other than onion and garlic, a range of plant based sources including green leafy vegetables, other vegetables, foods rich in ascorbic acid (Vitamin – C), spices, cereals, etc as proved in the various research studies, increases the bio-availability of iron & zinc in our recipes. Awareness of the beneficial influence of these common dietary ingredients on the bio-availability of micronutrients helps Akshaya Patra in devising dietary strategies to improve the bio-availability of these vital nutrients in Mid-day Meal programme.

\textsuperscript{11} https://www.ncbi.nlm.nih.gov/pubmed/25748063
Note on Akshaya Patra’s Efforts into Mid-Day Meal Scheme Implementation

The Akshaya Patra Foundation, since its inception in 2000, has been serving hot, cooked nutritious meals to children studying in class I to VIII in the Government and Government-aided schools across the country, and supporting their ‘Right to Food’. The Foundation serves as an implementing agency of the Mid-Day Meal Scheme, working closely with the Government of India and State Governments in a collaboration based on the Public Private Partnership (PPP) model. Through Akshaya Patra’s feeding programme, children studying in the primary classes get access to 450 Kcal of energy and 12 grams of protein, while children studying in the upper primary classes get access to 700 Kcal of energy and 20 grams of protein in accordance to the prescribed standards for the Mid-Day Meal Programme. Akshaya Patra, through its meals, provides 1/3rd of the Recommended Dietary Allowance (RDA) for macronutrients and micronutrients to children. Further, to comply with the prescribed Government standards and regional suitability, it has scientifically designed its meal menus taking into consideration the diversity and regional palate along with the local taste and seasonal food availability. Akshaya Patra recipes are in accordance with the MDM Guidelines’ nutrition compliance norms as well as with the menu shared in Schedule-II, Karnataka State MoU. The Foundation also takes feedback from the children to decide the components of food. This ensures nutrition, diversity as well as taste and local acceptability. Cyclic menu is implemented to cover diverse food groups and reduce the menu fatigue that might set in children. The diverse menu with a cyclic mix of various combination supports better combination. Enhanced menu with innovative recipes, are designed by experts in state-of-the-art laboratories to ensure nutrition and flavour. The energy, protein, and micronutrients in Akshaya Patra’s mid-day meals are higher or at par with the Government norms for every category. The organisation's standardized recipes include majorly all the stipulated and seasonal vegetables. As per the RDA for children, the Foundation’s standardized recipes provide 30% of the RDA for both macro and micronutrients. The menu diversity including a range of vegetables and spices ensures a well-balanced meal.