ISBN: 978-81-971650-6-1

5. Food Fortification: Innovation to Nutrient Enrichment

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Abstract:

Food fortification is the process of adding essential nutrients, mainly micronutrients, in various commonly consumed food ingredients to enhance its quality and nutritive content. It is the most economical way to fight against micronutrient deficiency disorders, such as goiter and neural tube defects. It also helps in reducing folic acid deficiency in pregnant women and iron, iodine, vitamin A deficiency in adult women and children.

The Food and Drug Administration and the Codex Alimentarius proposed their policies for food fortification, based on six and ten foundational principles, respectively; both mainly focusing on the desirable characteristics of the nutrient which needs to be incorporated to the food. Depending on the method used, food fortification can be divided into industrial fortification, bio-fortification and home fortification.

Depending on the technique used, food fortification can be done through dry mixing of ingredients, spraying, adhesion, coating, extrusion and dissolution (in water or oil). Food fortification has its own several advantages such as, locally available foods are selected for this process, it does not change the usual characteristics of the food and fortified foods are much more efficient than over-the-counter supplements. Besides these benefits, food fortification possesses some drawbacks also. They can be because of low availability of fortified foods, can lead to vitamin toxicity if consume in excess and can increase weight as they are richer in calories than non-fortified foods.

Keywords:

Characteristics, micronutrient, quality, technique.

5.1 Introduction:

Food fortification is the practice of incorporating micronutrients (vitamins and minerals) into the foods that are most commonly consumed by people. It is done to enhance the nutritive value of the ingredients. It is a well-established, secure and economical method for improving diet and for preventing and managing micronutrient deficiencies (Horton et al., 2008; Hoddinott et al., 2012). According to the World Health Organization (WHO), food fortification can be defined as "*The practice of deliberately increasing the content of one or more micronutrients (i.e., vitamins and minerals) in a food or condiment to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health*" (World Health Organization, 2024). According to the Codex Alimentarius Commission which was formulated as a central part of the joint FAO/WHO Food Standards Program, food fortification can be defined as "*The addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups*" (Kellogg's, 2023). Since the time first salt was iodized in Europe and North America in the 1920s, mandatory food fortification has been used as a strategy to prevent micronutrient deficiencies in high-income countries (HICs) (Sprohrer et al., 2013; Rowe and Dodson, 2015). In such developed countries, dairy products, beverages, cereal and cereal products and processed foods are being fortified, whereas, in low or moderate-income countries (LMICs), fortification applies on starchy crops like wheat, rice and maize, sugar, salt, oils and fats, sauces and various condiments that have poor micronutrient content and people used to consume them as a staple ingredient in their meals (Mannar, 2003). Over the last twenty years, the process of food fortification has gained popularity in low or moderate-income countries (LMICs) due to many reasons, such as accelerated urbanization and raised household spending capacity, leading to a higher proportion of people depending on packaged/processed foods (Sprohrer et al., 2013; Rowe and Dodson, 2015). There is substantial evidence to support the effectiveness of food fortification in HICs in addressing micronutrient deficiencies but for LMICs, the work is

still in progress. Recent systematic reviews and meta-analyses of large-scale food fortification (LSFF) programs have confirmed the impact of food fortification on certain nutritional inadequacies such as decreased rate of goiter and neural tube defects (NTDs) in children, enhanced serum folic acid levels in pregnant women and reductions in vitamin A, iron and iodine deficiency in women and children (Keats et al., 2019). This is done by fortifying the staple food ingredients. The ingredients are selected in such as manner that they can be afforded by the maximum population due to their local availability and cheaper prices. Thus, iodization of salt was initiated to combat iodine deficiency and similarly, folic acid was introduced in wheat flour to reduce the rate of NTDs and iron and vitamins were incorporated in cereals to reduce the rate of anemia (Liyanage and Hettiarachchi, 2011). In the year 1980, the Food and Drug Administration (FDA) designed a food fortification policy that was based on six fundamental principles (Food and Agriculture Organization of the United Nations/World Health Organization, 1987):

a. For a significant portion of the population, the nutrient intake is lower than the desirable ranges when the food is not fortified
b. The fortified food should be consumed in a quantity that significantly increases the population's nutrient intake
c. The intake of additional nutrients from fortified foods should not cause the body to become out of balance with essential nutrients
d. The fortifiers that have to be incorporated in the food should remain stable in storage as well as usage conditions
e. The nutrients that have to be added to the food must be biologically available
f. The fortifiers added to the food should not cause toxicity in the body

5.2 Need of Food Fortification:

The micronutrient deficiencies are the major public health concern. The WHO defined micronutrients as the components which are needed by the body in very small quantities, that is, <100 mg/day. Vitamins and minerals fall into this category. These nutrients are required by the body in the production of enzymes and hormones. Along with this, they are essential components in growth and development of the body (World Health Organization, 2021a; World Health Organization, 2021b).

In the condition of deficiency of either one or more micronutrients, these functions deviated from the normal. The most common deficiency disorders are night blindness (vitamin A deficiency), anemia (iron deficiency), goiter and hypothyroidism (iodine deficiency) (Venkatesh et al., 2021). These deficiencies can be prevented if intake of required micronutrients is up to the optimal level. For this purpose, a combined strategy needs to be framed, including promotion of consuming a diet with all essential food groups, enhancing availability of healthier food options and supplements and food fortification. Among all these strategies, the process of food fortification plays a significant role in fulfilling the nutrients demand in the population. As this process targets the most commonly consumable and locally available foods and enriches them with one or more essential nutrients, food fortification is the most cost effective and advanced way to incorporate required nutrients in the food (Mannar, 2003).

5.3 Considerations for Planning a Food Fortification Intervention:

The Codex Alimentarius proposed certain basic principles for the incorporation of nutrients in food (Mannar, 2003):

a. The added nutrient should present in neither insufficient nor excess amount. The amount should be balanced in terms of daily dietary allowance.
b. The added nutrient should not interfere with metabolism of other nutrients.
c. The added nutrient should be stable in storage, packaging and distribution phases.
d. The added nutrient should be biologically available from the food.
e. The added nutrient should not impose undesirable characteristics in food like texture, taste, color and flavor and should not reduce the durability of the food.
f. For satisfactory incorporation of nutrient, processing facilities and technology should be provided.
g. The added nutrient should not be used to promote or advertise the food.
h. The added nutrient should not increase the cost of the food beyond the affordability limit of the customer
i. The methods or techniques to quantify the added nutrient should be available.
j. Certain guidelines were framed for food fortification and these guidelines should also identify the right nutrient for specific food ingredient.

5.4 Types of Food Fortification:

Food fortification can be done through various methods and on this basis, they can be categorized into three main types:

a. ***Large-Scale Food Fortification (LSFF) / Industrial Fortification***: This refers to the process of incorporating additional micronutrients at the processing phase of many commonly consumed food ingredients such as sugar, salt, oil, flour and condiments. LSFF programs are classified into two: mandatory and voluntary. Mandatory LSFF are directly initiated and regulated by the government, whereas, voluntary LSFF is a method where food processors freely choose to incorporate nutrients but it is still governed by regulatory limits. Mandatory LSFF programs are more common, especially in terms of fortification of salt and flour. The iodization of salt is the most common form of fortification among all and between the years 1990 and 2008, the consumption of iodized salt rose at household level increased from 20% to 70% (UNICEF, 2008). Over 130 nations are consuming mandated iodized salt at present (Iodine Global Network, 2016). Similarly, wheat flour has been fortified using the mandatory LSFF program since 1942. In North and South America, folic acid addition in wheat flour is mandatory to reduce the chances of NTDs. Over 85 nations are consuming mandated wheat flour at present (Osendarp et al., 2018).

b. ***Bio-Fortification***: In contrast to LSFF, bio-fortification is a process in which food crops are grown in such a manner that they are grown with higher nutritive value. This method helps to improve mainly the zinc, iron and pro-vitamin A content of the crops (cereals and tubers). It is done through plant breeding or agronomic bio-fortification techniques (use of mineral fertilizers). Zinc bio-fortification is mainly done on rice, wheat, sweet potato, corn and beans; iron bio-fortification is done on beans, sweet potato, rice and maize and vitamin A bio-fortification is done on corn, cassava and sweet potato (Olson et al., 2021). However, through genetic engineering, it is possible to incorporate multiple micronutrients in a single crop at the same time (Van Der Straeten et al., 2020).

c. ***Point-of-use / Home Fortification***: This method indicates the incorporation of additional micronutrients in cooked food, which is ready to be eaten. It was formerly known by the term “home fortification”. To reflect the variety of contexts in which this fortification technique can take place, like schools and refugee camps, the World Health

Organization (WHO) coined the term "point-of-use" to replace "home fortification" in the year 2012. In 2016, WHO recommended the use of this technique in fortifying complementary foods with micronutrient powders (MNPs) to improve iron status in children aged 6 to 24 months (WHO, 2016).

MNPs are single-dose small packets enriched with multiple vitamins and minerals in powder form that can be used to sprinkle on food without compromising the color or taste (De-Regil et al., 2011).

The core purpose of formulating the MNPs is to provide essential micronutrients such as iron to children below the age of five. This will prevent the children from diseases such as iron deficiency anemia (World Food Programme, 2014).

Many countries use the 15 micronutrient MNP formula for children aged between 6 and 59 months which costs around USD 0.2. This formula is designed to provide one Recommended Nutrient Intake (RNI) for each micronutrient per dose (UNICEF, 2020). These MNPs are suggested in conditions when locally available foods have low nutritive value, children have low dietary diversity or a child is suffering from some infectious disease (worms, diarrhea, malaria) (World Food Programme, 2014).

5.5 Technologies in Food Fortification:

Certain technologies are present for food fortification, depending on the manner in which foods are being processed, as described below (Mannar, 2003):

a. *Dry mixing*: This method is used for the fortification of cereal and cereal products, powder beverages and powder milk.
b. *Dissolution in water*: This method is used for the fortification of drinks, liquid milk, fruit juices, pasta, bread and cookies.
c. *Spraying*: This method is used for the fortification of salt and cornflakes.
d. *Dissolution in oil*: This method is used for the fortification of oily foods such as margarine.
e. *Adhesion*: This method is used for the fortification of sugars.
f. *Coating*: This method is used for the fortification of rice.

g. *Extrusion*: This method is used for the fortification of rice flour with micro-nutrients and stabilizers.

5.6 Advantages and Limitations of Food Fortification:

There are several advantages of food fortification over other interventions (Liyanage and Hettiarachchi, 2011; Food Safety and Standards Authority of India, 2024):

- It does not change the usual dietary pattern of the population, that is, socio-culturally acceptable foods are selected for the fortification process
- It helps in delivering a sufficient proportion of recommended allowances of micronutrients continuously
- It does not modify the basic characteristics of food such as aroma, texture and taste of the food
- It can easily fit into the existing food production and distribution system and thus can be sustained for a longer period
- The method of fortifying the food is cost-effective, thus can reach the majority of the population at once
- Consumption of fortified foods regularly will help in maintaining nutrient stores in the body more efficiently and effectively than over-the-counter supplements
- The risk of multiple micronutrient deficiencies can be best prevented in children with the help of food fortification method
- It helps the women in reproductive age group in the administration of a sufficient number of micronutrients altogether

In contrast, the food fortification method possesses certain drawbacks as well (Liyanage and Hettiarachchi, 2011):

- The chances of vitamin overuse are higher if fortified foods are consumed in excess
- In the condition of less availability or affordability of fortified foods in a particular region, the residents may still suffer from micronutrient deficiencies
- If the deficiency is severe, the food fortification method alone cannot fulfill the nutrient needs

Fortified foods have more calories as compared to whole foods. As a result, processed fortified foods may lead to weight gain.

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