INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 15, No. 3, p. 59-66, 2019
http://www.innspub.net

REVIEW PAPER OPEN ACCESS

Food fortification: A strategy to combat with malnutrition

Abdul Majid[*1], Farah Naz[1], Abdul Rahman Phul[1], Aamir Hassan Khaskheli[1], Sanaullah Abbasi[1], Muzafar Husain Sirohi[2], Israr Ahmed[3], Safdar Hussain Ujjan[4], Sham Lal[4], Imdad Ali Jokhio[5], Waqar Ahmed[6]

[1*]*Department of Biochemistry, Shah Abdul Latif University, Khairpur, Pakistan*

[2]*Department of Botany, Shah Abdul Latif University, Khairpur, Pakistan*

[3]*Department of Mathemetics, Shah Abdul Latif University, Khairpur, Pakistan*

[4]*Department of Zoology, Shah Abdul Latif University, Khairpur, Pakistan*

[5]*Department of Public Administration, Shah Abdul Latif University, Khairpur, Pakistan*

[6]*School of Mathematics and Physics, University of Lincoln, Lincolnshire, UK*

Article published on September 30, 2019

Key words: Food fortification, Vitamin, Micronutrients deficiencies, Nutrient intake

Abstract

Insufficient nutrients from agriculture output in some way create malnutrition. A better knowledge of requirement of sustainable and healthier diet from agriculture to food processing is critical. This study investigated the influence of food fortification in dealing with malnutrition related disorders. Various factors influencing the effectiveness of the strategy; include bioavailability of the nutrient, product acceptance, accessibility and edibility. In developing fortified food, these factors need to be considered for the selection of the fortifiers and the vehicle food. Mass fortification can only be effective in commonly consumed food items. Specific product level fortification found to be effective only dealing with the target population with similar food habits. Corrective actions needed to be taken for reducing or controlling the health problems in developing and developed countries. Though, the problem is more intense in developing countries, developed countries are also affected by nutritional issues. Food fortification have greater applicability for dealing with malnutrition related chronic issues that are less severe and do not require instant action, however in acute deficiency medical or supplements are required. The bioavailability of nutrients can be controlled with increased half-life in fortified foods in comparison to other strategies like direct supplementation, clinical interventions.

***Corresponding Author:** Abdul Majid ✉ amajid.ansari@salu.edu.pk

Introduction

Malnutrition related health issues are a major concern across the world. Nutrition deficiency ailments are mostly prevalent in women and children and are basically the result of improper intake of micronutrients in diet. Reduction in vitality, difficulty to accomplish greater academic levels, weakening of the immune system and greater incidences of disability and ill health appear to be the common nutritive malfunction (Huysentruyt *et al.*, 2018).

The nutritive contents of whole grains or food products are affected during processing. This leads to inadequate nutrient intake, hence the need for fortification arises. Supplementation of nutrients in common foods appear to be a major means for dealing with malnutrition and related issues (Ashraf, Ashraf, & Ozturk, 2018; El-Mesery & Mao, 2017; Pisa *et al.*, 2018). Food fortification is considered as excellent approach of supplementation of micronutrients in the diet. Complications associated with malnutrition might be crop up if proper strategies are not devised in due times. Naturally occurring micronutrients are far more effective compared to fortified foods. However, fortified foods have reduced the incidences of deficiency related abnormalities (Majid, *et al.*, 2019). Food fortification or enrichment has a major role in ensuring balanced diet, especially to the less privileged areas. The development of fortified foods or enriched foods forms can be an effective solution to reduce micronutrient deficiency and associated disorders (Phull *et al.*, 2017). Generally, fortifications are carried in specific refined products such as cereals or high fat and sugar pastes; fortified with vitamins and minerals. An understanding on the production and processing of fortified foods appear to be highly relevant as it would provide insights on the usefulness and effectiveness of the process of fortification.

United Nations Children's Fund, World Food Program and World Health Organization (WHO) indicated about two billion population around the world are found to be deficient in various vitamins and minerals, especially vitamin A, iodine, iron and zinc (Webb *et al.*, 2018). Nutritional deficiencies are a major concern for developing nations. Vitamin A deficiency was found to affect significant proportion (>50%) of the population of the developing countries (Fig. 1) (Ritchie & Roser, 2019). Malnutrition influences both poor and rich populations; however there might be differences in the nature and extent of the issue. Improper intake of micronutrients can result in a wide array of functional issues or damages; hence decisive strategizing food policies at national and global levels are need of time (Ruia, Gupta, & Bandyopadhyay, 2018). Food fortifications have a crucial role in dealing with nutritional issues, affecting the world. The normal fortified diet of individuals is the most economical, secure and cost effective way to deal with malnutrition related issues (Darus, Yunus, & Rahman, 2017). Though food fortification helps in supplementing micronutrients in the diet, daily requirement for each individual varies depending on the physiological condition and lifestyle status of the individual (Underwood & Smitasiri, 1999). Hence the diet for each individual, containing fortified food need to be designed based on expert assessments. The use of fortification for the purpose of value addition to foods is also prevalent in today's world.

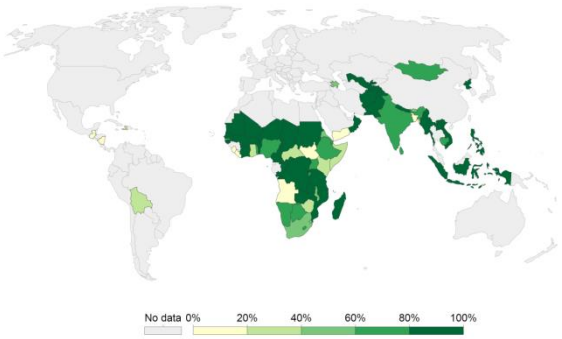

Fig. 1. Global prevalence of vitamin A deficiency, with intakes below physiological requirement (adopted from (Ritchie and Roser, 2019).

Many studies showed positive influence of fortification on the nutritional status of individuals; there are some isolated reports from different parts of the world indicating negative effects of fortified foods on individuals. Reports from Chile, US and Canada during the late 1990's or early 2000's indicated increase of "colorectal cancer" after making enrichments of wheat

flour by folic acid to be compulsory in these regions (Ahmed *et al.,* 2010). Continuous use of fortified food products or a particular nutrient enriched food might lead to other unrelated complications. Excess intake of micronutrient like iron could cause unintended impacts. There is need to monitor food fortifications and its intake as there is possibility for adverse effects due to excessive intake of micronutrients (Bruins *et al.*, 2016).

Though fortification or enrichment of food is considered as an effective way for dealing with nutritional issues at national and global levels, there is still need for getting more insights on the process and its impacts to use it beneficially. The nature and degree of fortification and its impacts would be highly relevant, which would be effective in devising appropriate strategies for dealing with nutritional issues that is affecting the world. Statistics on the micronutrient deficiencies are pointers on the intensity of the problem on a global scale. Worldwide prevalence of anaemia in pregnant women reported as >40% (Ritchie & Roser, 2019). Food fortifications can be helpful in increasing the nutritive value of the foods and if such fortifications or enrichments are done in regular use of foods. It further encourages the industries to include more of those nutritive foods in their diet (Das *et al*., 2017). Decisions with regard to fortification can be taken only based on different factors like the specific nutrient requirements and its nature, efficiency of fortification, intake of micronutrients by individuals, impact of fortification. The nutritive value of some of the foods is reduced during the manufacturing and processing stages. Normal trend for diet is seen towards less functional food and high in calories. This scenario for international organizations such as UNICEF, WHO, WFP, make crucial to devise appropriate strategies.

The aim of this review is to presents a complete picture of multifaceted issues pertaining to food fortification. The focus has been paid to detail the Food fortification processes, the regulation on food fortification, the prevalence of micronutrients deficiencies, the selection of appropriate fortificants and delivery vehicles (their acceptability, bioavailability and storage stability). This review is targeted primarily to food scientists; bridging the gap between public health and agricultural sectors and secondarily to academic scientists filling the some of the void.

Food fortification processes

Fortification mainly involves addition of selected minerals and vitamins called the "fortifiers" to the specific food categories that act as "vehicle foods". The common vehicle foods used for fortifications include; wheat flour, maize flour, rice, sugar, and oil" (Table 1). The effectiveness of the process depends on the compatibility of fortifiers with vehicle foods. Ideally, Fortifiers should not produce any of its own flavour, colour or smell when added to vehicle foods. Another major factor that needs to be considered for food fortification is the absorptive capability of the supplemented nutrient and its capability to blend with the different components of the vehicle food (Roni, 2017). The optimal dosage required for fortification can be decided based on the nutrient requirements and the quality of the vehicle food. The process of fortification involves proper assessment on the different additives and its compatibility with the vehicle foods prior to the fortification process. Food fortifications done in the industry might prove more effective in reaching out to the needed levels as well as for tackling nutrient deficiency related issues. There are various chronic and severe disorders associated with malnutrition. Fig. 2, shows the malnutrition related abnormalities in different age groups. Pregnant and lactating women need more micro- and macronutrient. During these stages, inadequate nutrition leads children born with impaired mental and physical conditions, stunting, more prone to infections and delayed growth (De Onis, 2017).

The malnutrition occurs as a result of inadequate intake of nutrients and this can be rectified by fortification. The amount of the fortifiers need to be used depends on the specific nutritional requirements of the target population. Food fortifications enhance essential nutrient consumption, which improves the nutritive status of individuals and society. The nutrient added during fortification does not increase the calorific values of the food, considerably. These fortified foods form as a major nutritional supplement.

Common types of fortification include the addition of micronutrients to whole grain products, like wheat flour, ordinary flour, etc. Around 18 to 32% of ingested thiamine, riboflavin, niacin and iron have been the result of cereal grain enrichment and fortification (Garci-Casal *et al.*, 2018). Different studies indicated that intake of fortified foods have reduced deficiency related disorder or malfunctions. Cereals such as wheat, rice, corn and condiments are included in the customary nutritional regime of people from different area; these foods provide extra benefits when selected as fortification vehicles.

Table 1. Commonly used fortified foods (Majid, Naz, *et al.*, 2019).

Food Vehicle	Fortifying agent
Salt	Iodine, iron
Oils	Tocopherols
Wheat and corn flours, bread. pasta, rice	Vitamin B complex, iron, folic acid, Vitamin B12
Milk, margarine, yoghurts, soft cheeses	Vitamins A and D
Sugar, monosodium glutamate, tea	Vitamin A
Infant formulas, cookies	Iron, vitamins B1, B2, niacin, vitamin K, folic acid, zinc
Vegetable mixtures amino acids, proteins	Vitamins, minerals
Soy milk, orange juice	Calcium
Juices and substitute drinks	Vitamin C
Ready-to-eat breakfast cereals	Vitamins and minerals
Diet beverages	Vitamins and minerals
Enteral and parenteral solutions	Vitamins, minerals

Malnutrition, poverty, eating habits, accessibility problems, life style issues, climatic and geographical conditions, etc. are major contributors to nutrient deficiency, globally. Excessive consumption of high calorie food has less nutritive value leading to nutrient deficit disorders (Fig. 2). Recently, healthcare industry has introduced diverse types of enriched and fortified products and it has become a necessity to identify the real time benefits and relevance of these products in delivering nutritive value (Table 1). The demand for fortified foods have been increased considerably, perhaps the impact of many promotional or popularizing activities in nutritional and health benefits (Weng & Khin, 2017). Understanding on the role played by fortified foods in the nutritive status of individuals and groups would be of great help for the common man to take appropriate and useful decisions on their diet. Recognition of need for regulating the indiscriminate increase in the production of fortified is imperative to control its usages in line with the nutritional requirements.

Fig. 2. The theoretical structure of micronutrient inadequacies for the life span.

Regulations

Excessive consumption of enriched foods could result in disorders of nutrients. The importance of developing a proper regulatory framework, different organisations have developed regulations in view to create awareness among the society. For European Union (EU) have made it mandatory for the states to fortify or enrich certain categories of foods with specific nutrients, which was purely based on region specific requirement. In order to regularize the diet by introducing fortified foods based on the specific regional requirements, there is need to understand precise relationship between fortified foods and nutritional status. The nature and extend of food fortification requirements are different for different regions (see Table 2). The food used for fortification also changes depending on the specific requirement of the region. For example, people in developed countries receive vitamin A through enriching foods like margarines and vegetable or canola oil.

Central American countries like Guatemala or Honduras, have successful programmes enriching sugar with vitamin A (Osendarp *et al.,* 2018).

Table 2. Details of countries that have implemented folic acid fortification.

Country	Fortification level	Date of implementation
United States	140 µg/100 g	1998
Canada	150 µg/100 g	1998
Costa Rica	180 µg/100 g	1998
Chile	220 µg/100 g	2000
South Africa	150 µg/100 g	2003

Over the years, the purpose of fortification has changed from "prevention of classic nutrient deficiency diseases to optimization of nutrient intakes to prevent chronic disease and for overall health and well-being". Food fortification as a process has acquired significance even during the early twentieth century, when this process was used for reducing or controlling nutrient deficiencies and associated nutritional dysfunctions. Rickets were found to have been controlled through enrichment of milk by vitamin D; deficiency diseases like pellagra and beriberi were reduced through fortification of wheat or cereals with thiamine and niacin; Vitamin A and D is frequently used for enriching margarine in order to prevent complications due to their low intake (Mannar & Hurrell, 2018). The efficacy of fortification can be further improved if locally available foods are fortified or enriched with nutrients in relation with the specific requirements. Effectiveness of fortification might depend on the selection of the food item and the fortifier used for enrichments.

Different types of food fortification and its impacts

Considering the importance of folic acid in dealing with Neural Tube Birth Defect (NTD), various food fortification activities were designed by WHO and FAO to make it mandatory for the world to fortify wheat flour with folic acid. Regulations for the same are in place in over fifty three nations though it has not been fully implemented in certain countries. International organizations have also provided guidelines for the countries on the minimum and maximum permissible limits. Reports from different countries like Canada, South Africa and other countries have implemented food fortification programs (Table 2) indicated that there were sharp reductions in the incidence of NTD and it is believed to have relation to the food fortification programs (Williams *et al.,* 2015). There is lot of apprehensions regarding the negative impacts of regular exposure to folic acid fortified foods. The main concerns associated with folic acid fortifications are "masking of B12 deficiency anaemia", "cancer and epigenetic changes" and presence of "un metabolized folic acid", which might create negative impacts on the fortification process (Wiens & DeSoto, 2017). Studies from UK, Australia, New Zealand have indicated that no substantiating evidences to confirm the linkages between exposure to folic acid fortification and resultant malfunctions or complications hence there is need for more information or data to verify the authenticity of such claims (Wiens & DeSoto, 2017). On the contrary, some isolated cases that clearly consider folic acid fortification as the cause for some dangerous ailments like cancer (Bjelakovic *et al.,* 2017).

Fortification has not just done to the raw materials like wheat flour, rice flour, etc. Food fortification has been extended to food products like fortified biscuits, breakfast cereals, chocolates, milk drinks etc (Table 1). The fig. indicates different levels at which food fortification can be done and the capability of the process ensuring nutritional wellbeing. The purpose of tackling micro nutrient deficiencies that are prevalent among children and young adults such as iron fortified biscuits could be effective in tackling iron deficiencies in children. Positive impacts will be made on food products like biscuits fortification micronutrients or with citrus peels. Soy fortified biscuits were considered as important sources of iron, calcium, protein, fat, etc. and could be used for supplementary purposes (Salim *et al.,* 2017). In acute and severe malnutrition related abnormalities, fortification seems less effective in relation to supplementation and medicines (Ponce *et al.*, 2018).

Iron fortified breakfast cereals were considered as a means for supplementing essential nutrients in the diet (Dwyer & Bailey, 2017). Fortification of ready to

eat or pre-cooked foods is a good option especially to deal with nutritional issues associated with children and young adults. Bioavailability of the nutrient in fortified breakfast cereal is low, such initiative would have greater applicability for dealing with nutrition related activities. Different processes like supplementation and clinical interventions for dealing with nutritional issues, food fortification is considered for ease of administering, cost effectiveness, manufacturing, processing.

The success of the food fortification process in delivering desirable outcome rely a lot on bioavailability of the nutrient, product acceptance, product shelf-life, and effectiveness in improving nutrient status. These should be considered prior to the development of the product. But for fortification at raw material levels, like fortifying wheat flour, corn flour, etc. factors like bioavailability and consumer preference appear to be the major criteria in selecting the fortifiers and the technology.

Food fortification is generally done to locally consumed food products for their accessibility and acceptability for target population which could imbibe the benefits of fortification for enhancing the nutritional well-being. Nutritional diseases are basically the result of insufficient intake of nutrients and specially developed fortified diet could provide greater opportunity for more and more individuals of the society to have access to the food item and thereby ensure nutritional wellbeing. The bioavailability of nutrients in fortified foods is relatively lower when compared to the supplementing nutrients or use of tablets and so other strategies might prove to be more effective in dealing with severe nutrient deficiencies or malfunctions. On the contrary, fortified foods would be more effective in ensuring the nutritive wellbeing of individuals and would have the capability to bring about long standing nutritive wellness in individuals and societies.

Conclusion

Food fortification is an important strategy for dealing with nutritional issues. This work was based on existing literature related to the food enrichment. This study provided some insights both practical and academic relevance of food fortification. Food fortification strategies have potential in delivering nutritional well-being in individuals as well as in societies and this also recognize the need for further research inputs for developing highly focused plan for dealing with malnutrition, globally. The effectiveness of the process of fortification is reliant on the compatibility of fortifiers and the vehicle food; bioavailability of the nutrient; acceptability, accessibility. The common vehicle foods used are wheat flour, flour, rice flour, and the fortifiers utilised for preparing enriched foods include macronutrients and micronutrients depending on the requirements. Fortification of commonly consumable food items is more effective as greater numbers of people would have access to the fortified food item. In places where access to balance diet is difficult, food fortification form the major means for supplementing nutrients through the diet of individuals. Food fortification as a strategy in dealing with nutritive issues has advantages over other strategies like supplementation, clinical interferences, etc. The advantages of food fortification are the ease of administering, capability to reach out to the target population, cost effectiveness, production and processing capabilities, to name a few. As in the case of academic researches, time and finance formed the major limitation for conducting in depth research on the topic, but the research study was designed in such a way that it yielded fresh insights on the topics, which could form the baseline data for further extensive researches in future.

References

Ahmed S, Wakil W, Saleem, HMS, Shahid M, Ghazanfar MU. 2010. Effect of iron fortified wheat flour on the biology and physiology of red flour beetle, Tribolium castaneum (Herbst). International Journal of Insect Science **2,** 29-33.

Ashraf MY, Ashraf M, Ozturk M. 2018. Underutilized Vegetables: A Tool to Address Nutritional Issues, Poverty Reduction and Food Security. In: Global Perspectives on Underutilized Crops: Springer **(pp. 1-23)**.

Bjelakovic G, Stojanovic I, Stoimenov TJ, Pavlovic D, Kocic G, Bjelakovic GB. 2017. Polyamines, folic acid supplementation and cancerogenesis. Pteridines **28,** 115-131.

Bruins MJ, Kupka R, Zimmermann MB, Lietz G, Engle-Stone R, Kraemer K. 2016. Maximizing the benefits and minimizing the risks of intervention programs to address micronutrient malnutrition: Symposium report. Maternal & child nutrition **12,** 940-948.

Darus NM, Yunus AR, Rahman NW. 2017. Factors enhancing the performance of SMEs' services sectors: A conceptual framework. International Journal of Advanced and Applied Sciences **4,** 160-166.

Das JK, Salam RA, Thornburg KL, Prentice AM, Campisi S, Lassi ZS, Bhutta ZA. 2017. Nutrition in adolescents: physiology, metabolism, and nutritional needs. Annals of the New York Academy of Sciences **1393,** 21-33.

De Onis M. 2017. Child growth and development. In: Nutrition and Health in a Developing World Umana Press 119-141.

Dwyer JT, Bailey RL. 2017. The Role of Fortification and Dietary Supplements in Affluent Countries: Challenges and Opportunities. In: Sustainable Nutrition in a Changing World, Springer 389-406.

El-Mesery HS, Mao H. 2017. Theoretical and experimental analysis of drying kinetics of tomato slices by using infrared dryer. International Journal of Advanced and Applied Sciences **4,** 137-142.

Garcia-Casal MN, Peña-Rosas JP, De-Regil LM, Gwirtz JA, Pasricha SR. 2018. Fortification of maize flour with iron for controlling anaemia and iron deficiency in populations. Cochrane Database of Systematic Reviews **12,** 1-6

Huysentruyt K, Hulst J, Bian F, Shamir R, White M, Galera-Martinez R, Gerasimidis K. 2018. Opinions and practices of healthcare professionals on assessment of disease associated malnutrition in children, Results from an international survey. Clinical Nutrition **38,** 708-714

Majid A, Naz F, Phull AR, Abbasi S, Abbasi S, Khaskheli AH, Sirohi MH, Ahmed I, Ahmed W, Narejo GF. 2019. Extraction and quantification of tocopherols from edible oils using high performance liquid chromatography. International Journal of Biosciences **14,** 181-187.

Majid A, Phull AR, Khaskheli AH, Abbasi S, Sirohi MH, Ahmed I, Ujjan SH, Jokhio IA, Ahmed W. 2019. Applications and opportunities of supercritical fluid extraction in food processing technologies: A review. International Journal of Advanced and Applied Sciences **6,** 99-103.

Mannar MGV, Hurrell RF. 2018. Food Fortification: Past Experience, Current Status, and Potential for Globalization. In: Food Fortification in a Globalized World: Academic Press 3-11.

Osendarp SJM, Martinez H, Garrett GS, Neufeld LM, De-Regil LM, Vossenaar M, Darnton-Hill I. 2018. Large-Scale Food Fortification and Biofortification in Low-and Middle-Income Countries: A Review of Programs, Trends, Challenges, and Evidence Gaps. Food and Nutrition Bulletin **39,** 315-331.

Phull A, Ali A, Ahmed M, Zia M, Haq I, Kim S. 2017. In vitro antileishmanial, antibacterial, antifungal and anticancer activity of fucoidan from Undaria pinnatifida. Internaional Journal of Biosciences **11,** 219-227.

Pisa PT, Landais E, Margetts B, Vorster HH, Friedenreich CM, Huybrechts I, Leclercq C. 2018. Inventory on the dietary assessment tools available and needed in africa: a prerequisite for setting up a common methodological research infrastructure for nutritional surveillance, research, and prevention of diet-related non-communicable diseases. Critical reviews in food science and nutrition **58,** 37-61.

Ponce MC, Polman K, Roos N, Wieringa FT, Berger J, Doak CM. 2018. What Approaches are Most Effective at Addressing Micronutrient Deficiency in Children 0–5 Years? A Review of Systematic Reviews. Maternal and child health journal 1-14.

Ritchie H, Roser M. 2019. Micronutrient Deficiency. Our World in Data. Retrieved from https://ourworldindata.org/micronutrient-deficiency

Roni M. 2017. Sustainable manufacturing drivers and firm performance: Moderating effect of firm size. International Journal of Advanced and Applied Sciences **4,** 243-249.

Ruia A, Gupta RK, Bandyopadhyay G. 2018. Implication of Malnutrition on Human Capital: Bridging the Inequality through Robust Economic Policies. Indian Journal of Public Health Research & Development **9,** 75-79.

Salim R, Nazir F, Amin F. 2017. Blending of wheat and soybean for development of high protein biscuits. Journal of Pharmacognosy and Phytochemistry **6,** 2241-2244.

Underwood B A, Smitasiri S. 1999. Micronutrient malnutrition: policies and programs for control and their implications. Annual review of nutrition **19,** 303-324.

Webb P, Stordalen GA, Singh S, Wijesinha-Bettoni R, Shetty P, Lartey A. 2018. Hunger and malnutrition in the 21st century. BMJ **361,** 1-9.

Weng TF, Khin AA. 2017. Consumer attitude towards intention to purchase green foods in chicken meat industry. International Journal of Advanced and Applied Sciences **4,** 155-158.

Wiens D, DeSoto M. 2017. Is High Folic Acid Intake a Risk Factor for Autism?—A Review. Brain sciences **7,** 149.

Williams J, Mai CT, Mulinare J, Isenburg J, Flood TJ, Ethen M, Kirby RS. 2015. Updated estimates of neural tube defects prevented by mandatory folic Acid fortification-United States, 1995-2011. MMWR. Morbidity and mortality weekly report **64,** 1-5.